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FORESTS AND SOCIETY:
THE ROLE OF RESEARCH

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VOLUME 1

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Introduction

This volume of Congress proceedings includes the full text or summaries of oral presentations in Sub-Plenary sessions received by 31 May 2000. Minor changes may have occurred since that date. The session moderator will mention them when opening the session.

The following Sub-Plenary sessions include posters:

Tuesday 8th August:

•A2 Sustainable management of natural resources. Fire and Forest

Wednesday 9th August:

•A5 Sustainable management of natural resources. Sustainable forest management and productivity

•B4 Forest and society needs. Evaluation of technologies for society needs

Corresponding poster summaries are not only in this volume; they are also published in the last section of the poster summary volume of the proceedings

Special thanks to authors for their contributions to the scientific programme of this Congress.

Enjoy your stay in Malaysia

Eric Teissier du Cros, Chairman of CSC

Abdul Rahim Nik, Chairman of the COC

Note: The full papers and summaries have been published as received from the authors and reviewers, respectively, who have sole responsibility for their contents

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Sub -Plenary Session : A1

Sustainable Management of Natural Resources:

Water and Forest

Coordinators:

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Effects of Forest Cover on Catchment Water Balances and Runoff Dynamics

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Abstract

There is now broad agreement amongst researchers that forestry activities have the potential to alter catchment water balances and thus change the amount and timing of catchment streamflows. Paired catchment experiments from around the world have provided a robust data base on which to found theories about the effects of forest cover on catchment water balances and runoff dynamics. However, it has been shown that different catchments respond to changes in forest cover in a variety of ways. Climate, topography, soils and the forest type each exert particular influences on the hydrologic function of catchments and their response to forest cover change. This review examines the findings of a variety of studies and seeks to develop generalisations about the effects of forest cover on catchment water balance and runoff dynamics. We focus on water yield or the amount of streamflow, streamflow seasonality and flow frequency, and the magnitude of peak flows.

There is strong evidence to show that forest cover tends to enhance evapotranspiration and reduce water yields, relative to what would arise from catchments under grass or crop cover. The extent to which yields are affected by forest cover change seems to vary primarily as a function of annual rainfall and forest type, and to a lesser extent by local climatic conditions. The greatest changes in water yield following forest disturbance tend to occur in the wettest areas, primarily because of the important effect of rainfall interception by forest canopies. Generally speaking, the lowest yields are generated by conifer forests, followed by evergreen hardwoods and then deciduous hardwoods. These differences are attributable to differences in the amount of leaf area and the effect that this exerts on transpiration and rainfall interception. There are some special types of forest in low radiation environments which tend to yield very high amounts of runoff, relative to the rainfall they receive, because of low evapotranspiration rates. Examples include tropical cloud forests and temperate native forests in the uplands and coastal areas of New Zealand. Alternatively, on the coastal margins in tropical areas, evapotranspiration rates are higher than normal because of advection of energy from the ocean, leading to lesser runoff from forests sited in these areas.

Some studies indicate that forest age also affects evapotranspiration and water yield, with old growth forests tending to produce more runoff than actively regenerating forest. Whilst the occurrence of this phenomena has only been conclusively demonstrated for some Australian eucalypt forest catchments, recent north American research has shown that photosynthesis and water use per unit leaf area decline as forest ages. These findings imply that catchment water yields should increase as forests age.

We review the fledgling literature linking forest cover to runoff seasonality and flow frequency. This is an important issue as the temporal distribution of flows has important consequences for the security of water for downstream enterprises (in the case of low flows), and the safety of dams, roads, culverts and bridges (in the case of high flows). Almost all catchment studies have noted that low, medium and high flows decrease as a consequence of afforestation, and increase as a result of forest clearance. However, low flows and high flows do not always change by the same amount as annual flows, with different parts of the streamflow range being more affected than others, depending on site factors such as soil depth and properties, and forest type.

We conclude our review by highlighting gaps in the field of research linking forest cover to catchment water balance and runoff dynamics.

Keywords: Forest cover, Water catchment, Runoff dynamics

Hydrological Flowpaths and Water Chemistry in Key Forested Environments

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Abstract

With the expansion of forest hydrology research from mid-latitudinal areas to tropical and boreal forests, a diversity of hydrological process patterns began to emerge that has since been tentatively explained along geographical lines. Our much improved knowledge of runoff generation processes, however, allows us to discard geographical straitjackets and explain the quite diverse hydrological functioning of forests world-wide in terms of those soil, meteorological, and geomorphological factors that control the movement of water on landscapes. Hence, we propose a functional approach to the classification of forest ecosystems based on those factors.

This approach entails a two-tiered screening of forested catchments based on adequate data. We first differentiate according to geomorphological criteria between catchments with low relief or wide valley floors and catchments of high relief that are deeply incised (e.g. small or no valley floors). The basic tenet underlying this differentiation is that groundwater plays a more important role in the former than in the latter. Next, we differentiate according to the interaction between soil and rainfall characteristics that controls the partitioning of rainfall into vertical and horizontal hillslope flowpaths, and therefore determines the degree of hillslope-channel coupling. High rainfall intensities, normalized to soil saturated hydraulic conductivity, or high rainfall amounts, normalized to depth to an impermeable layer, favor horizontal, near-surface hillslope flowpaths, and hence a tight hillslope-channel coupling; the reverse is true for low rainfall intensity or rainfall amount environments. This functional classification based on flowpaths that are controlled by soil, landscape and meteorological factors has necessary implications for stream water chemistry as it implies different kinds of water-regolith interactions in hydrologically different environments.

Our proposed evaluation and classification scheme is consistent for forested catchments across the spectrum of humid tropics, mid-latitudes, and boreal regions. In each case, we weigh our classification in each case by the quality of the published data. To avoid scaling issues, we restrict our survey to ‘small’ catchments; this restriction excludes hillslope- and landscape-scale studies.

We conclude our review by highlighting previously under-studied forest ecosystems and gaps in our process knowledge.

Keywords: Forest environment, Water chemistry, Hydrological flowpaths

Effects of Forestry Activities on Surface Erosion and Slope Stability

by
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Abstract

High levels of sediment discharge into forest streams and rivers as well as resulting degradation of aquatic habitat have widely been blamed on intensive and extensive forest management activities. Additionally, reductions in site productivity of forest lands can also be related to accelerated erosion processes, both surface erosion and mass wasting. The burden of these environmental impacts that has been placed on forestry management may be overstated in many cases but, depending on the particular practice and region, may be partially or totally justified. In assessing the potential impacts of forest management activities, an important distinction needs to be drawn between surface erosion processes and mass wasting or landslide processes. This paper will attempt to link particular management activities with each of these erosion processes. We will focus on the Pacific Rim region because of its steep terrain, predominant forest cover, regionally active tectonics, high precipitation (total amounts and intensities) associated with mountainous and maritime zones, past and recent patterns of settlement, and widespread land use changes over the past few centuries.

In managed forest terrain where the infiltration capacity of soils is maintained, surface erosion is generally not a problem. Infiltration capacity of forest soils is reduced when soils are compacted or if organic horizons are removed in certain environments allowing the mineral soil to be exposed to forces of high intensity raindrop impact. Soil compaction related to forestry operations occurs on skid and haul roads, trails, landings, and other areas where heavy machinery operates. Excessive disturbance that exposes large areas of forest soil can be associated with certain types of ground skidding and site preparation practices. Other significant contributors to soil compaction and disturbance include intense grazing, recreational use, and residential development in forested areas. These impacts are magnified if they occur near stream channels and can generate increased peak flows, channel instability, and resultant high sediment loads. Riparian forest buffers around streams can minimize the sediment delivery to channels, promote infiltration and subsurface flow, and provide exchange sites for nutrients and pollutants. Forest roads and drainage systems in particular provide efficient conduits (as well as sources) for sediment delivery to streams during storm events. Short-term increases in surface erosion can result from burning and the creation of a hydrophobic layer in the surface soils. Surface erosion becomes a particular concern in steep terrain when agricultural or intense forestry practices are conducted which result in the removal or destruction of significant portions of the soil organic horizon. Such anthropogenic actions expose the more erodible underlying mineral soils to raindrop impact and, depending on soil and site conditions, may initiate rill and gully erosion on steep slopes. Modeling surface erosion in steep managed forest terrain is difficult because most databases used in the development of empirical models (e.g. USLE) have not historically included such sites and complex topography complicates the application of more theoretical models.

Factors that control the stability of steep forested terrain may be in a tenuous state of equilibrium that can easily be upset by human activities. Steep hillslopes with shallow soil mantles are typically unstable especially in regions of high precipitation and recent tectonic activity. In many of these areas worldwide, shallow landslides are the dominant erosion and sediment delivery processes. Timber harvesting activities in steep terrain can affect the stability of hillslopes by reducing the cohesion associated with tree roots. Rooting strength is typically at a minimum 3 to 15 years following clearcutting; however the recovery of rooting strength is dependent on the regeneration techniques used

at the site, available soil nutrients and moisture, and a host of other environmental and cultural factors. Additionally, the probability of a landslide occurring in a harvested site is partly controlled by local hydrogeomorphic and topographic attributes as well as influenced by silvicultural methods. All of these factors act together in establishing the conditions of site stability; however, an episodic rainstorm or snowmelt event must occur that generates a critical pore water pressure in the soil mantle to trigger the landslide. Deep-seated slope failures, such as rotational slumps and earthflows, are typically less associated with timber harvesting because tree roots rarely penetrate deep into the unstable soil mantle.

However, effects of roads and road drainage have been known to trigger or accelerate deep-seated mass movements by short-circuiting water to the failure surface. Progress is being made on developing predictive methods for landslides, especially for shallow mass movements, that are physically based and distributed. However, such models require rather intensive data inputs and may be difficult to apply in remote areas. Alternative approaches to landslide hazard assessment in more remote areas have been developed using digital terrain data, geological information, climatic data, land use maps, and other remotely sensed data. Successful application of such GIS-based models is contingent upon using terrain indicators that are closely linked with processes that control slope stability.

Keywords: Forestry activities, Surface erosion, Scope stability

Sediment Delivery Pathways in Managed Forestry Environments

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Abstract

Forest harvesting activities, such as road construction and the associated disturbance of soil and vegetation on logged hillslopes are widely considered as potential 'non-point sources' (NPS) of stream water pollution. Research over the past three decades has been conducted with the general aim of improving our ability to protect water resources in forested catchments. In many instances our knowledge is restricted because much of this work has focused on plot scale on-site soil erosion processes or subcatchment monitoring of turbidity or suspended sediment concentrations before and after a specific treatment. Both approaches have serious limitations that are commonly overlooked in our interpretation of the research findings and in assessing the most effective pollution control practices. The major aim of this chapter is to introduce a framework that investigates the potential impacts of forestry activities on water resources using concepts of sediment delivery and connectivity. The framework explicitly considers the transfer and delivery of material from a sediment/pollutant source to the stream network via processes of overland and channeled flow.

A state-of-the-art review of the international literature points to an abundance of data on processes and rates of sediment detachment and related on-site erosion impacts. These studies are unanimous in their findings; forest activities, in particular roading, track construction, cause increased soil compaction, decreased hydraulic conductivity, increased runoff and soil erosion at the point of disturbance. Roads and tracks are recognised as the dominant sources of both runoff and sediment and the general logged area occupying much of the catchment by area, is both a localised source and sink depending upon such factors as the degree of soil disturbance and the intensity and duration of rainfall. Studies on off-site impacts present no consistent message regarding post-logging sediment loads or the precise relationship to forestry-related disturbances on the hillslopes. In-stream data from paired catchment studies are best viewed as the summation of sediment detachment, delivery, storage and transfer processes and rates from the specific catchment outlet. The missing link between these two types of research approaches is quantification of the connection or delivery pathway between sources of sediment and the stream network. In developing this conceptual framework, we propose that the delivery and routing of sediment and associated pollutants from key sources such as roads, tracks, and general harvesting areas to streams depends upon, and reflects the interaction of two key factors. These are; (1) surface runoff rates at source, and (2) the characteristics of the delivery pathway, including the distance between runoff source and the stream network. Proximity to the stream network is well-represented using 'available hillslope length' as an index of overland flow path length. Recognition of the dominant runoff pathway over the dominant sediment source is an important distinction over previous approaches. The characteristics of the delivery pathway are broadly categorised as extensions of the stream network (new gullies) and diffuse overland flow pathways on vegetated hillslopes.

The second part of this chapter provides a structured consideration of source to stream connection by introducing a design approach that guides road or track drainage spacing for the combined inputs of rainfall intensity, distance to stream and road/track outfall gradient. This framework provides guidelines for road and track design in forestry environments with the objective of minimising the connection of road, tracks and other compacted areas to streams.

Keywords: Managed forest, Environment, Sediment delivery pathways

New Remote Measurement Tools in Forest Hydrology

by
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Abstract

Remote sensing data have traditionally been difficult to use directly for management purposes, or as inputs to hydrologic models. Correlation models are often required for the conversion from remotely sensed data to key variables used in forest hydrology applications, such as terrain attributes, vegetative cover, vegetation function, aerodynamic or canopy resistances, increasing the cost of data acquisition by remote measurement. The density of information provided by these instruments, however is unequalled, when compared to other spatial representations of landscape variables, often derived from point measurements.On board aircraft or satellite platforms, they provide catchment-scale or regional measurements with 100-percent coverage. Sensors used in aircraft usually offer higher spatial resolution, while their larger, satellite-borne counterparts are used for wider coverage and routine revisits.

A number of hydrologic models are currently using remotely sensed data as inputs in their vegetation cover sections. With further refinements, these types of models will soon be able to include more accurate forest cover information such as the spatial distribution of the different forest regrowth stages, currently being produced from multi-spectral satellite data. In addition, new systems are coming online, which offer more direct measurements of variables of interest and a capability for 'precision forest measurement'. These new sensors are also better calibrated and more sensitive for detection of increasingly subtle changes in the environment below.

Topographical data can now be collected by laser scanning systems and radar interferometers at sub-metre resolution and with high geopositional accuracy. Operational airborne laser systems in use today measure the distance between the aircraft and the ground directly, using very accurate measurements of aircraft position and fast digitising of the return light pulse, thus creating three-dimensional descriptions of the terrain below. In addition, prototype systems, developed by NASA are now capable of very high frequency digitisation of the return signal, hence providing the opportunity for detailed vegetation structure and biomass mapping. Spaceborne missions with laser profiling sensors onboard are already planned for deployment within the next 12 months. In addition to laser systems, radar interferometers allow for 'all-weather' topography, and soon vegetation structure mapping, using analogous methods to stereo photogrammetry, but using the microwave part of the electromagnetic spectrum. A spaceborne radar interferometer was deployed in early 2000 on the NASA Space Shuttle for global topographic mapping.

New imaging spectrometer systems, on the other hand, allow for more detailed chemical analysis of the objects below, and derivation of aspects of vegetation function. Using the principles of spectroscopy, traces of light reflectance from the vegetation or soil (termed spectral signatures) are matched against a 'spectral library' for pure specimens (termed 'endmembers'). This allows for use of new 'Imaging Specrometers' (also termed hyperspectral imagers), to create 2-dimensional maps of the presence and relative concentration of different compounds on the surface below. In other uses, specific regions of the plant reflectance spectrum are used for quantification of the composition of the samples, including nitrogen and water content. A number of narrow-band 'spectral indexes' have also been recently proposed, which are closely linked to pigment dynamics in plants, and in turn can be associated to their photochemical efficiency and stress levels. New forest growth and function models are expected to use this type of data as input or as validation of their sub-daily plant function predictions. In addition to highlighting new methodologies applied to traditional remote sensors, this review provides a technical background of new remote sensing systems, techniques and some examples of their use.

Keywords: Remote sensing, Forest hydrology

The Use of Stable Isotopes of Water and Carbon for Investigating Plant Water Use Strategies

by
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Abstract

There has been an increase in the use of isotopes in determining the sources of plant water and the water use efficiencies of species and genotypes. Studies have encompassed a variety of plants including agronomic species (wheat, alfalfa, wheatgrass), mangroves, halophytes, deciduous trees and evergreen species. Increasingly, studies are integrating isotopes into ecological and water balance studies, of which the isotope component is only one part. Isotopes can provide information that can not be supplied by other techniques, provided appropriate care is taken with the errors and vagaries of isotopic techniques.

The principle of the stable isotope technique for sourcing plant water is the isotope composition in the plant conducting tissue is the same as that of the sources. Perhaps, the greatest potential source of the error with the technique is the extraction of water from soils. This can exceed the variation in ^{2}H and ^{18}O of water sources and hence make the technique unworkable. It is important that extraction procedures are verified, and inexperienced personnel receive training in specialist laboratories or alternatively have analyses done in those laboratories. It is also important how and where the plant sample is collected to minimise sampling errors and temporal changes must be considered in any sampling regime. There is a need to avoid evaporation on all soil, groundwater, rain and plant sampling. An intensive field study in SE Australia found that the difference between expected isotopic values of sources and that found in the plant xylem was less than 5‰ for ^{2}H and 1‰ for ^{18}O. This experiment was conducted over a range of extreme conditions and hence we believe that the method is robust.

Isotopes in the wood cellulose of tree rings can also provide a historical chronology of water use for trees. This can be useful in attempting to understand hydrological dynamics throughout the life span of the forest or understanding land use change impacts within the catchment. Unlike isotopic investigations of environmental and plant waters, there are small errors associated with the extraction of isotopes from the wood sample. However, there are a number of other limitations in using this approach such as 1) the degree of variability between plant physiological processes and the environmental variation of isotopes, 2) not all tree rings are grown annually, and 3) what are the age and population effects with regard to isotopic variability? These issues will be discussed in this chapter along with specific examples related to plant water sources and plant water use. Despite the possible limitations of this technique, it can provide a valuable insight into the longterm dynamics of forest hydrology.

The isotope method is an inverse method, i.e. the isotopic composition in the plant is used to infer information about the sources. It should be remembered that there is limited information contained in the isotope measurements. Hence, isotopes used by themselves represent a relatively blunt instrument. The integration of isotopes with other data such as piezometric data, transpiration fluxes, soil and leaf water potential, etc. allows more sophisticated interpretations of plant water use strategies. In particular, the use of isotope data to test the calibration and assumptions in a model that has been calibrated independently of the isotope data brings forth many possibilities. Models, whether conceptual or quantitative is a means of bringing prior knowledge into the interpretation of plant processes.

With the experimental basis described in this chapter, there are no reasons why isotopes can not be used more in agronomic, forestry and ecological studies. Isotopes allow measurements of processes that can not be obtained in any other way, provided some of the difficulties with the method are not

underestimated. The advances in soil moisture monitoring and transpiration measurements, as well as vegetation-soil models, together with isotopes, should see large advances in our understanding of plant water strategies over the next ten years.

Keywords: Water and carbon isotope, Plant water use

Hydro-Ecological Modelling of the Impacts of Environmental Change on Forested Ecosystems at the Watershed Scale

by
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Abstract

The past few decades have seen unprecedented public concern for the sustainability of terrestrial ecosystems over a range of scales. Remote sensing has alerted us to the extent to which we are changing the usage and cover of the land surface, and through both experiments and modelling at local scales, it is clear that these changes significantly affect water resources. Current concerns about watersheds have gone beyond water yield, and now include issues of water quality, sedimentation, wood production, fisheries, nutrient cycling, recreation, and biodiversity. Understanding human impacts on watersheds, including land use change, direct addition or extraction of water and chemicals, and flow path alteration, is critical. Most of our current knowledge about forest ecosystem processes is derived from plot scale studies, and models which look at one dimensional water, carbon, and nutrient cycling. However, most of our knowledge and experience in hydrology are based on applications at the hillslope to watershed scale, and on models which focus on runoff production and routing. The issues which we have defined require interactions between these two approaches. A convenient intersection of plot level and watershed scales occurs at the hillslope level. Hillslopes have closed boundaries (drainage divides), a lower absorbing boundary (stream channel), and fairly uniform slope and aspect. In this paper, we review current approaches which tightly couple carbon/water/nutrient cycling with hydrologic routing at the hillslope to watershed level. Such approaches address a range of watershed management issues including the effects of riparian buffer strips, silvicultural practices, road construction, forest senescence, acid deposition, and global climate change on water quantity, water quality, sedimentation, productivity, and nutrient cycling. Coupled approaches usually rely on established, pre-existing models as their basic components. Therefore, we also review the key lines of model evolution in the component areas of watershed hydrology, ecosystem growth, biogeochemical cycling, and sediment and nutrient transport. Linkages between these areas occur over varying spatio-temporal scales. A spatio-temporal framework is erected, and each modelled process and linkage is located within this framework. This facilitates a better understanding of the importance of coupled hydro-ecological modelling, particularly with respect to interactions which are only observed at long time scales (> 10 years). Case studies selected for closer examination include modelling the effects of forestry on water yield, modelling the effects of land use / land cover change on water quality and quantity, and modelling the effects of global environmental change on large-scale hydro-ecological and biogeochemical cycles. A number of important conceptual limitations to the advance of hydro-ecological modelling are discussed. Many long-term studies are limited by the lack of a universal, mechanistic understanding of the processes governing forest ageing. Scaling issues are also pertinent. Many established models do not adequately address the gap between the experimental scale at which physical governing equations were derived and the scale at which they are used to make predictions of watershed behaviour. There are also practical limitations, which do not necessarily require a fundamental advance in knowledge, just better technology. These include the low standard of software engineering in many models, restrictive spatial structures (e.g. grid cells), and a reluctance to apply existing landscape partitioning technology. In our discussion, we look to the future of hydro-ecological modelling. A greater level of model integration seems certain, but this must be accompanied by concomitant elucidation of the dominant governing forces if it is not to be lost in a miasma of improperly combined equations and computer code.

Keywords : Environmental change, Modelling forested ecosystem, Watershed

Sub-Plenary Session : A2

Sustainable Management of Natural Resources:

Fire and Forest

Coordinators

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The Fire and Smoke Episodes of 1983 to 1998 in South East Asia: Ecological Background, Socio-Economic and Environmental Implications, and Challenges for Regional and Global Fire Research Programmes

by

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Abstract

The environmental and socio-economic consequences of application of fire in land-use systems and occurrence of wildfires in forests and other vegetation in South East Asia have long been ignored. Long-lasting regional smoke-haze episodes during the extreme droughts associated with the El Niño-Southern Oscillation (ENSO) phenomenon have occurred repeatedly between 1983 and 1998. The situation in 1998 triggered unprecedented awareness of the science community and on the political arena at national and international levels. This paper summarizes the state-of-knowledge on the fire environment in South East Asia, particularly basics of fire ecology, fire occurrence, and fire-generated smoke problems in SE Asia. It also provides a summary of international research and development projects and programmes.

Keywords: Fire ecology, Wildfire, Land-use fire, Forest conversion, Climate variability, El Niño-Southern Oscillation (ENSO)

Introduction

At the occasion of the IUFRO World Congress in Malaysia, a country embedded in one of the most diverse fire regions of the globe, this paper aims to provide a summary on the fire environment in South East Asia, particularly basics of fire ecology, fire occurrence, and fire-generated smoke problems in SE Asia. This paper is an updated and shortened version of earlier analyses of the author.

Fire has been present in the SE Asian biota since the Pleistocene. Long-term climate variability (glacial vs. non-glacial climate) and short-term climate oscillations caused by the El Niño-Southern Oscillation (ENSO) event have repeatedly created conditions that make even rain forest subjected to wildfires. The occurrence of wildfires is increasing with modern land-use changes. Forest degradation and repeated fires lead to the formation of fire climax grasslands of low productivity and short-return interval fires. In monsoon forests of mainland South Asia annual fires during the dry season have shaped the composition and productivity of this forest environment by selecting fire-tolerant species. Severe problems of land degradation (erosion, loss of nutrients) are the consequence of fires in these seasonally dry forests. Fire protection (fire exclusion) leads to a progressive development towards a more species-rich forest ecosystem. Fire climax pine forests are found in all SE Asian mountain regions. Burning of agricultural crop residuals, especially rice straw burning, add to the smoke generated by conversion fires and wildfires. These emissions influence the regional atmosphere and global biogeochemical cycles.

Fire in the Lowland Dipterocarp Rain Forest

Impacts of Climatic Variability on Fire Regimes: Prehistoric, Historic and Contemporary Events

It has been suggested that during the last Ice Age the drop of ocean water levels has caused the development of an overall arid climate at that time. Although palynological evidence from the tropical lowlands is still very scarce, it must be assumed that lowland vegetation was generally that of areas with a more pronounced dry season. First evidence of ancient wildfires in East Kalimantan was found by Goldammer and Seibert (1989, 1990). Radiocarbon (^{14}C) dates of soil charcoal recovered along an East-West transect between Sangkulirang at the Strait of Makassar, and about 75 km inland, showed that fires had occurred between ca. 17,510 and ca. 350 before present (BP). The fire dates between 1280 and 350 BP, as presented in the study, reveal that wildfires occurred not only during the dry Pleistocene, but also after the present wet, rain forest climate stabilized, at about 10,000 to 7000 BP. These fires can be explained by periodic droughts such as those caused by the modern El Niño-Southern Oscillation (ENSO) complex. The ENSO phenomenon is regarded as one of the most striking examples of inter-annual climate variability on a global scale. The event is initiated by the Southern Oscillation, which is the variation of pressure difference between the Indonesian low and the South Pacific tropical high. During a low pressure gradient, the westward trade winds are weakened, resulting in the development of positive sea surface temperature anomalies along the coast of Peru and most of the tropical Pacific Ocean. The inter-tropical convergence zone and the South Pacific convergence zone then merge in the vicinity of the dateline, causing the Indonesian low to shift its position into that area. Subsequently, during a typical ENSO event, the higher pressure over Malesia leads to a decrease in rainfall. The severity of the dry spells depends on the amplitude and persistence of the climate oscillations.

In the rain forest biome these prolonged droughts drastically change the fuel complex and the flammability of the vegetation. Once the precipitation falls below 100 mm per month, over periods of two or more weeks without rainfall, the forest vegetation sheds its leaves progressively with increasing drought stress. In addition, the moisture content of the surface fuels is lowered, while the fallen woody material and loosely packed leaf-litter layer contribute to the build-up and spread of surface fires. Aerial fuels such as desiccated climbers and lianas become fire ladders potentially resulting in crown fires or "torching" of single trees.

Peat swamp forests found in the lowlands of Borneo represent another fuel type. With increasing precipitation deficit and a lowering of the water table in the peat swamp biome, the organic layers progressively dry out. During the 1982-83 ENSO, various observations in East Kalimantan confirmed a desiccation of more than 1 to 2 m; preliminary estimates during the 1997 ENSO reveal that desiccation was less than 1982-83. While the spread of surface and ground fires in this type of organic terrain is not severe, deep burning of organic matter leads to toppling of trees and a complete removal of standing biomass. It is further reported that smouldering organic fires may persist throughout the subsequent rainfall period, to be reactivated as an ignition source in the next dry spell.

Long-lasting fires in coal seams extending to, or near, the surface are found in various rain forest sites in East Kalimantan and are another important natural fire source (Goldammer and Seibert 1989). It has been assumed that all of the ca. 150 coal seam fires known to be burning before the 1997-98 fire episode were ignited by the 1982-1983 wildfires. This was questioned by Goldammer and Seibert (1989), since there are numerous oral reports of burning coal seams made before in 1982-1983 drought. In the late 19th century the Norwegian explorer Bock (1881) reported that Modang people consider burning of coal seams going on "since the memory of man".

Goldammer and Seibert (1989) focused their research on dating ancient coal seam fires by investigating the "baking" effects of subsurface fires on sediment or soil layers on top of the coal seams. These effects of old, meanwhile extinguished, coal seam fires can still be seen today. Thermoluminescence analysis of burnt clay, collected on top of an extinguished coal seam in the vicinity of active coal fires, proved a fire event 13,200 to 15,300 years BP. It is assumed that ancient coal fires were ignited by lightning.

Historic and Modern ENSO Events and Wildfires

Berlage (1957) found that between 1830 and 1953, about 93% of all droughts in Indonesia occurred during an ENSO event. According to an evaluation of precipitation data since 1940 (Leighton, 1984), most of the 11 droughts recorded in 1941/42, 1951, 1957, 1961, 1963, 1969, 1972, 1976, 1979/80, 1982/83, and 1987 accompanied an ENSO. The worst droughts during that period were in 1941/1942, 1972, and 1982-1983, while the 1961 drought occurred independently of an ENSO event, and the 1965 ENSO did not cause drought in Indonesia. A recent thorough analysis of ENSO variations and drought occurrence in Indonesia and the Philippines are given by Harger (1995a,b).

The first documentation of the impact of an extreme drought in East Kalimantan is provided by Bock (1881). The Norwegian zoologist travelled through the lowlands of the Kutai district of East Kalimantan 1878 and reported drought and famine which had occurred in the year before his visit. He noted that about one third of the tree population in the forests around Muara Kaman in the Middle Mahakam area died due to the drought. More recent observations in various peat swamp forests of the Middle Mahakam Area of East Kalimantan confirm that significant disturbances of this ecosystem must have occurred around 80-100 years ago (Weinland 1983). The rainfall records of Jakarta (Java) 1877/78 explain these observations: between May 1877 and February 1878, rainfall in Jakarta was reduced by two thirds; a second severe precipitation deficit followed from July to December 1878 (Kiladis and Diaz 1986).

Bock (1881) did not report any forest fires. Nevertheless, there is evidence of historic forest fires in East Kalimantan by narrative tradition (Goldammer and Seibert 1990). In 1914-15, forest fires were again reported from Borneo. Published records were found for Sabah, where an area of 80,000 ha of rain forest and its superficial peat soil layer were destroyed by fire after an exceptionally dry period. This area now forms the Sook plain grassland of Sabah. Severe forest fires in Brunei following a drought of six weeks in 1958 were observed by Brünig (1971). Smaller fires in lowland dipterocarp forests and in *Dacrydium elatum* forests were recorded for 1969 and 1970 in Sabah and Brunei.

The Wildfires of 1982-83

The 1982-1983 drought in the "Maritime Continent" was the result of an extreme ENSO (Philander 1983). In north and east Borneo, the decrease in rainfall began in July 1982 and lasted until April 1983, interrupted only by a short rainy period in December 1982. The wildfire scene in Borneo in 1982/83 was set by a combination of the extreme drought and by numerous slash-and burn land-clearing activities, resulting in fires burning out of control. The extent and the immediately visible impact of these fires have been described by several authors and teams (summary and sources in Goldammer et al. 1996). It is assumed that the overall land area of Borneo affected by fires exceeded $5x10^6$ ha (Goldammer et al. 1996).

A series of studies on the regeneration of the fire-affected rain forest were conducted in the mid-1980's and reviewed by Goldammer and Seibert (1990). In 1988-89 a comprehensive research project on the cause and effects of the forest fires of the 1982-83 fire season in East Kalimantan was carried out by the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) on behalf of the International Tropical Timber Organization (ITTO). The results are summarized by Goldammer et al. (1996). Within the study area (totalling $4.7x10^6$ ha) the actual area affected by fire was ca. $3.2x10^6$ ha of which $2.7x10^6$ ha were tropical rainforests. Forests on sites with low water retention capacity were most seriously affected by fire. This refers especially to peat swamp forests, heath forests (Kerangas), forests on limestone hills and rocks and all other forests on shallow soils. On the other hand, logged-over forests were particularly affected by fire, especially those growing on drought-sensitive sites. There is a close correlation between the year of logging and fire intensity. Especially forests which had been logged shortly before the fire event were very seriously damaged. Finally, forests in the vicinity of settlements and along rivers and roads were particularly affected by the fire. The analysis of the inventory results for different tree species allowed the following classification according to their sensitivity to fire. The results reveal that light-demanding species are promoted by fire (e.g., *Euphorbiaceae*). Fire-resistant species were also identified, e.g. Bornean ironwood (*Eusideroxylon zwageri*) and many others. Species suppressed by fire belong to the *Dipterocarpaceae* and other genera suppressed by fire are *Anarcardiaceae, Annonaceae, Burseracea, Fagaceae, Melastomaceae, Meeliaceae, Myristicaceae, Myrtaceae, Sapindinaceae* and *Sapotaceae*. It is concluded that biodiversity of fire-affected forests is considerably reduced with increasing fire intensity.

Damage of the Fire Episodes After 1982-83

During and after the ENSO and fire episodes of 1987, 1991, and 1994 only limited research has been accomplished on the extent and damage caused by fire and atmospheric pollution. The Indonesian Ministry of Forestry released some figures on the extent of burning during the 1994 drought. For the first time the government included burning activities other than uncontrolled wildfires into the statistics. According to the Ministry a total land area of ca. $5.1x10^6$ ha had been affected by fire, thereof

Traditional dryland farming	$2.8x10^6$ ha
Shifting cultivation	$1.5x10^6$ ha
Transmigrant farming	260,000 ha
Plantations	221,000 ha
Transmigrant settlements	39,500 ha
Reforestation areas	20,500 ha
Timber estates	17,000 ha
Natural forests	8,000 ha

The figures of the 1997-98 fire episode are currently being consolidated. Several approaches were undertaken to determine the extent of the 1997/98 forest fires in Indonesia using optical and microwave sensors. Some studies were based on the visual interpretation of multi-temporal SPOT quicklook mosaics, the evaluation of NOAA-AVHRR (National Oceanic and Atmospheric Administration - Advanced Very high Resolution Radiometer) and the combined use of ERS-2 SAR (European Radar Satellite-2, Synthetic Aperture Radar) coherence data and ATSR data. Liew *et al.* (1998) estimated with SPOT quicklook mosaics the total area affected by fire (burn scars) in Sumatra $1.5x10^6$ ha and $3.06x10^6$ ha in Kalimantan for the period January-December 1997. Fuller and Fulk (1998) estimated the area affected by fire $2.3x10^6$ ha on the base of NOAA-AVHRR data within IFFM GTZ NOAA\AVHRR processing window which did not completely cover Sabah and West Kalimantan. Moreover with the combined use of ERS-SAR and ATSR Antikidis et al. (1998) produced a first estimation of the forest surfaces burned in Central Kalimantan in 1997. Out of an area of $21.76x10^6$ ha analyzed a total of 588,000 ha forest were burned at that time. This number was corrected later to $1.8x10^6$ ha (Antikidis et al., pers. comm.).

The land area affected by fire in East Kalimantan has been assessed by the Integrated Forest Fire Management (IFFM) project (Hoffmann et al. 1999). The study used ERS-2 SAR (European Radar Satellite 2, Synthetic Aperture Radar sensor) radar images to disclose the size of the fire affected area for the entire province according to all land uses. The results of the inventory show that the 1997/98 fires affected a total of $5.2x10^6$ ha - corresponding to ca. 25% of the total land area of the province. Almost $2.3x10^6$ ha are located in natural forest concession areas, $0.4x10^6$ ha in protected forests, and 0.9 million ha 30 forest plantation enterprises and $0.7x10^6$ ha industrial crop plantations were affected. Almost 75% of the plantation areas (forest, oil palm, etc.), that were located within the 1997/98 fire zone, have been fire affected, a large number of them severely.

It should be stressed that many of the forests which had burned in 1982-83 or during one of the following ENSO droughts have been burned a second time in 1998. The consequences of repeated burns are detrimental because they are a key factor of the impoverishment of biodiversity in rain forest ecosystems (see also Nepstad *et al.* 1999, Cochrane *et al.* 1999, Goldammer 1999). The photographic documentation of rain forest degradation by two subsequent fires in the Bukit Soeharto forest, East Kalimantan, provide visual evidence.

Fire in Seasonal Forests

The occurrence of seasonal dry periods in the tropics of South Asia increases with distance from the perhumid equatorial zone. The forests gradually develop to more open, semi-deciduous and deciduous formations (e.g., moist and dry deciduous forests, monsoon forests). The main fire-related characteristics of these formations are seasonally available flammable fuels (grass-herb layer, shed leaves) which allow the spread of surface fires. Grass species, understorey plants (shrub layer) and the overstorey (tree layer) are adapted to regular fire influence. The most important adaptive traits are thick bark, ability to heal fire scars, resprouting capability (coppicing, epicormic sprouts, dormant buds, lignotubers, etc.) and seed characteristics (dispersal, serotiny, fire cracking, soil seed bank and other germination requirements). These features are characteristic elements of a fire ecosystem.

During the dry season the deciduous trees shed their leaves and provide annually available surface fuel. In addition the desiccated and dried grass layer, together with the shrub layer, add to the available fuel which overall generally ranges between 5-10 tha^{-1}. The fires are mainly set by forest users (graziers, collectors of non-wood-forest products). The forests are underburned in order to remove dead plant material, to stimulate grass growth, and to facilitate or improve the harvest of other forest products. The fires usually develop as surface fires of moderate intensity (usually less than 400 kWm^{-1}; cf. Stott *et al.* 1990), and tend to spread over large areas of forested lands. The tree layer is generally not affected by the flames, although crowning may occur earlier in the dry season when the leaves are not yet shed. In some cases fires may affect the same area two or three times per year, e.g., one early dry season fire consuming the grass layer and one subsequent fire burning in the shed leaf litter layer (Goldammer 1993a,b).

Dry deciduous forests and moist deciduous forests occur on ca. $250x10^6$ ha and $530x10^6$ ha respectively. No reliable information exists on the extent of recurring fires in these areas. It was estimated that in Myanmar between 3-$6.5x10^6$ ha of forests are annually affected by fire. A report from Thailand in the late 80s estimated an annually burned area of ca. $3.1x10^6$ ha, predominantly in dipterocarp monsoon forests. The affected area has diminished considerably since then: measures of fire protection have reduced the average area burned to ca. $1.5x10^6$ ha (unpubl. fire survey from Thailand, 1994). Analysis of historic information from British India reveals that during the last century and early this century almost all Indian deciduous forests were burned every year (Goldammer 1993b). Regional vegetation fire patterns in South and South East Asia recently have been described on the basis of satellite-derived information (Malingreau et al. 1998).

The ecological impact of the yearly fires on the deciduous and semi-deciduous forest formations is significant. Fire strongly promotes fire tolerant trees, which replace the species potentially growing in an undisturbed environment. Many of the monsoon forests of continental Southeast Asia would be reconverted to evergreen rain forest biomes if the human-made fires were eliminated. Such phenomena have also been observed in Australia where the aboriginal fire practices and fire regimes were controlled and rain forest vegetation started to replace the fire-prone tree-grass savannas. The fire adaptations and the possible fire dependence of economically important trees such as Sal (*Shorea robusta*) and Teak (*Tectona grandis*) have long been the focus of controversy regarding the traditional fire control policy in British Indian Forestry.

The fire climax deciduous forests are not necessarily in an ecologically stable condition. Long-term impacts of frequent fires lead to considerable erosion because of removal of the protective litter layer just before the onset of the monsoon rains.

Fire Climax Pine Forests in South Asia's Tropical Mountain Regions

In mainland South Asia and Insular SE Asia the pines (genus *Pinus*) are largely confined to the zone of lower montane rain forest. They are usually found on dry sites and prefer a slight to distinct seasonal climate. Most tropical pines are pioneers and tend to occupy disturbed sites, such as landslides, abandoned cultivation lands and burned sites. Besides the pioneer characteristics, most tropical pines show distinct adaptations to a fire environment (bark thickness, rooting depth, occasionally sprouting, high flammability of litter) (Goldammer and Peñafiel 1990). The tropical pure pine forests of South Asia, e.g., *Pinus khesyia, P. merkusii, P. roxburghii, P. massoniana*, most often are the result of a long history of regular burning. As in the tropical deciduous forests, fires are mainly set by graziers, but also spread from shifting cultivation fires and the general careless use of fire in rural lands. Fire return intervals have become shorter during the last decades, often not exceeding one to five years. These regularly occurring fires favour the fire-adapted pines which replace fire-sensitive broadleaved species. The increased frequency of human-caused fires has led to an overall increase of pines and pure pine stands outside the potential natural area of occurrence in a non-fire environment. In the mountainous zones of the tropics, fire also leads to an increase of the altitudinal distribution of pines, e.g., by expanding the mid-elevation pine forest belt downslope into the lowland Dipterocarp forest biome and upslope into the montane broadleaved forest associations, e.g., the mixed oak-chestnut forests. These tropical fire climax pine forests occur throughout submontane elevations in Burma, Thailand, Laos, Kampuchea, Viet Nam, the Philippines (Luzón) and Indonesia (Sumatra).

All over South East Asia fire climax pine forests potentially provide a high degree of habitability and carrying capacity for humans. If used properly in time and space, fire creates a highly productive coniferous forest, which grants landscape stability and sustained supply of timber, fuelwood, resin, and grazing land. However, together with the effects of overgrazing (including trampling effects) and extensive illegal (fuel)wood cutting, the increasing occurrence of wildfires tend to destabilize the submontane pine forests and result in forest depletion, erosion and subsequent flooding of lowlands.

Burning for Control of Weeds and Succession, and Disposal of Crop Residues and Waste

The burning of vegetation residues and the use of fire for weed control and other regular burning takes place all over SE Asia's lands which have been permanently converted into agricultural and pastoral land-use systems. Most striking is the burning of rice straw which contributes to seasonal haze in the region.

The total extent of agricultural residue burning is not known at present. However, some first estimates made for rice straw burning in Viet Nam show that ca. 20 x 10^6 tons of rice straw are annually burned in this country alone which contribute significantly to regional air pollution budgets (Nguyen *et al.* 1995).

Burning of household waste finally adds to the manifold open fires in the region. In these fires vegetation residues are increasingly mixed with other waste types, e.g. plastic materials, etc. Together with fossil fuel burning these emissions may also contribute significantly to regional smoke haze. These emission need to be included in regional assessments and mitigation strategies at national and regional scale. Priority must be given to exploring the specific emission characteristics of fires in primary and secondary rain forests, peatlands and peat-swamp forests, *Imperata cylindrica* grasslands, and rice straw burning.

Research Initiatives

Fire Ecology

Fire research in Indonesia and the mainland in the 1990s largely concentrated on fire effects on ecosystem properties and ecosystem stability. Much of this research has been analyzed by the author the late 1980s (Goldammer 1990). More recent research has been focusing on slash-and-burn agriculture and vegetation succession (Kiyono and Hastaniah 1997) and fire ecology research in South Sumatra (Saharjo 1997). The 1999 fire workshop in East Kalimantan (Suhartoyo and Toma 1999) and a recently published monograph on East Kalimantan's rain forests (Guhardja et al. 2000) provide the most recent update of fire research in the region.

The Underlying Causes of Fire Application

While many of the publications cited above contain information on fire causes, only few in-depth studies are available on the socio-economic and cultural aspects of managing the fire problem. The forest fire management system in Thailand has its strong base on a fire prevention approach which is being realized by a close cooperation with the local population. The same refers to the IFFM approach in Indonesia (Abberger 1996; see also the work of Otsuka [1991] on forest management and farmers in East Kalimantan). A basic study on the socio-economic and cultural background of forest fires in the pine forests of the Philippines was conducted in the late 1980s and reveals the usefulness of such surveys for further management planning (Noble 1990).

Despite of the initial efforts it must be stated that there is a tremendous gap of expertise and available methodologies of socio-economic and cultural approaches in integrating people into operational fire management systems.

Interdisciplinary Research: Coupling of Ecological, Atmospheric and Climate Research in the IGBP/IGAC SEAFIRE Programme

Estimates of the magnitude of tropical plant biomass burned in shifting agriculture, permanent deforestation, other forest fires and savanna fires revealed that the prompt (gross) annual release of carbon into the atmosphere from these fires may range between 1 and 4 billion tons. Though the amount of carbon remaining in the atmosphere (net release) is not known exactly, it is generally accepted that the annual net release of carbon into the atmosphere from plant biomass burned for permanent conversion of tropical forest into other land uses ("net deforestation") amounts to ca. 1 billion tons per year.

Although emissions from tropical vegetation fires are dominated by carbon dioxide (CO_2), many products of incomplete combustion that play important roles in atmospheric chemistry and climate are emitted as well. Much of the burning is regionally concentrated, occurring mainly during the dry season, and resulting in levels of atmospheric pollution that rival those in the industrialized regions of the developed world. Photochemical reactions, for instance, in the plumes of vegetation fires may be responsible for as much as one third of the global input of ozone into the troposphere. Recent observations of seasonally elevated levels of tropospheric ozone in some tropical regions, particularly over the southern tropical Atlantic Ocean between South America and Africa, have been explained by emissions from tropical wildland fires and subsequent photochemical processes which may play an important role in atmospheric chemistry over that large region of the Earth. The investigation of this phenomenon through an international fire research campaign has verified this hypothesis (JGR 1996).

Vegetation fires in South East Asia have additional implications which are not yet entirely understood. The global climate is determined critically by tropical convective air movements, leading to the injection of air masses into high altitudes of the atmosphere and their long-range transport and re-distribution. These global circulation patterns originate at the continental and oceanic surfaces with elevated temperatures. This "warm pool" of the globe is in the maritime continent of the equatorial region of Asia.

In the midst of the warmest region of the world, the Indonesian archipelago, extensive burning of vegetation (shifting cultivation, forest conversion burning, and other agricultural burning) takes place. Although the impacts of these fires on atmospheric chemistry have not yet been explored, it is assumed that two major patterns of emission distribution from vegetation fires exist:

i. During the "High Phase" (normal years) of the Walker Circulation low pressure is centred over the hot spots. Air masses with products from biomass burning (aerosols, trace gases) are carried to the high troposphere and exported globally.

ii. During the "Low Phase" the warm waters of the "warm pool" are transported to the eastern Pacific, and high pressure builds up over the Indonesian archipelago. A typical ENSO situation develops during which emissions from forest burning are trapped in the lower troposphere.

The last years with extraordinary fire activities in Indonesia were years characterized by the Low Phase of the Walker Circulation. The fire season of 1982-83 was characterized by escaped land-use fires which caused large-size wildfires on several million hectares. In the following years the situation was different. The smoke emitted from the Indonesian archipelago in 1987, 1991, 1994 and 1997 was not primarily caused by wildfires. The main sources were shifting cultivation, a traditional practice, but one that is rapidly expanding, and the systematic application of fire for converting primary and selectively exploited rain forests into plantation forests.

A systematic, quantitative and qualitative regional research approach is still missing. The first program which had been proposed in 1994 was the South East Asian Fire Experiment (SEAFIRE). SEAFIRE had been planned as a research activity under the scheme of the International Geosphere-Biosphere Programme (IGBP). The International Global Atmospheric Chemistry (IGAC) Project is a core project of

IGBP. One of the activities of IGAC Focus 2 (Natural Variability and Anthropogenic Perturbations of the Tropical Atmospheric Chemistry) investigates the impact of biomass burning on the atmosphere and biosphere (Biomass Burning Experiment [BIBEX]). However, the issues to be addressed by SEAFIRE did not receive sufficient attention before the 1997-98 fire episode. After 1997 numerous individual short-living research projects were implemented, all of which missed a concerted multi-institutional and interdsicplinary research opportunity.

A Program to Address ASEAN Regional Transboundary Smoke (PARTS) was initiated in response to the needs and assistance requested by the ASEAN Committee on Science and Technology, Sub-Committee on Meteorology and Geophysics (ASCMG). At ASCMG's 18th meeting (Bangkok, 1995) it was agreed to create a project on transboundary air pollution. The World Meteorological Organization (WMO), in conjunction with the goals of its Global Atmospheric Watch (GAW) program, in 1996 reviewed and evaluated National Meteorological and Hydrometeorological Services (NMHS) capabilities in detecting, monitoring and predicting the long-range transport of atmospheric pollution. Subsequently, WMO designed PARTS to improve the regional capabilities in satellite usage, modelling long-range transport of smoke, haze, and other pollutants, and to design and implement a monitoring strategy for the region.

Conclusions

The smoke-haze episode in Southeast Asia during the 1997-98 ENSO for the first time received high public and scientific interest at regional and global levels. However, the state of fire research in the 1990s reveals that causes and impacts of vegetation burning are well explored. The unchanged and dramatic situation of forest conversion burning and escaped wildfires calls for management-oriented research and appropriate response.

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Forest Fires in Tropical America: Challenges for Research

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Abstract

Natural forests covers 47% of the total land area of Central and South America, almost all (95%) being tropical. Forest cover continues to decrease due to clearance for cropland, cattle raising, and the construction of roads, dams and other infrastructure. More recently, fire has become a major threat to natural forests throughout the region. In 1997-1998 fires raged through the forests of Brazil, Colombia, Mexico and many countries in Central America. Tropical forests are burning due to a number of interdependent natural and human-related factors that are often obscured by lack of information. Undisturbed rain forest is highly resistant to burning, but will burn during severe droughts, principally after it has been logged or otherwise disturbed. In the Brazilian Amazon a combination of logging and drought are increasing the flammability of large tracts of forests. Fire research in the Amazonia is in its infancy, and has eluded the priority-setting processes of the region's government research institutions. Economic and policy studies are urgently needed to document the costs of fire to landholders and society at large, to identify how land users can be encouraged to control and prevent fire damages, and to propose mechanisms by which the disparate public policies that influence deforestation could be integrated to favor a more sustainable and less fire-prone development pathway. Research is needed to determine which kinds of production systems are most likely to use fire, and which ones invest most in fire control and prevention both for fire risk assessment and for targeting governmental initiatives to reduce fire. Field studies of the causes of forest flammability could provide the basis for a regional early warning system of forest fire risk. One of the most serious impediments to fire risk assessment in tropical forests is the insufficiency of rainfall data collection. In the short term, an *El Niño Early Warning System* indicating impending drought episodes, could act as an effective substitute for a comprehensive fire risk warning system, giving landholders time to incorporate the prospect of severe drought into their land management planning. In the long term, research on fire behavior and its impacts on ecosystem processes, biodiversity, biogeochemical cycles, atmospheric quality, and local and global climate, as well as evaluation of damages and losses, are needed to establish management practices for the forests of tropical America. The probability of future forest fire disasters can only be reduced if the causes of hazard and risk are well understood and comprehensive strategies devised to address these causes.

Keywords: Forest fire, Rain forest, Brazil, Amazonia

Introduction

Natural forests cover 47% of the total land area of Central and South America, almost all (95%) being tropical. Forest cover continues to decrease due to clearance for cropland, cattle raising, and the construction of roads, dams and other infrastructure. More recently, fire has become a major threat to natural forests throughout the region. In 1997-1998 fires raged through the forests of Brazil, Colombia, Mexico and many countries in Central America. Tropical forests are burning due to a number of interdependent natural and human-related factors that are often obscured by lack of information. Undisturbed rain forest is highly resistant to burning, but will burn during severe droughts, principally after it has been logged or otherwise disturbed.

In the Brazilian Amazon a combination of logging and drought are increasing the flammability of large tracts of forests. Fire research in the Amazon is in its infancy, and has eluded the priority-setting processes of the region's government research institutions. Economic and policy studies are urgently needed to document the costs of fire to landholders and society at large, to identify how land users can be encouraged to control and prevent fire damages, and to propose mechanisms by which the disparate public policies that influence deforestation could be integrated to favor a more sustainable and less fire-prone development pathway. Research is needed to determine which kinds of production systems are most likely to use fire, and which ones invest most in fire control and prevention—both for fire risk assessment and for targeting governmental initiatives to reduce fire.

Fires in the Humid Neotropics

Fire is a fast and cheap way of clearing land, providing nutrient-rich ash to the soil and of reducing populations of weeds and pests. The use of fire makes economic sense when land and forests are abundant and inexpensive resources. Burning in the Amazon region today is primarily associated with the clearing of forests for agriculture, pastures, logging, and other purposes. By 1988 approximately 400,000 square kilometers (8% of the Amazon region) had been cleared, and it was increasing at a rate close to 35,000 square kilometers per year (Fearnside 1993). More recently it has been estimated that around 517,000 square kilometers of the Brazilian Amazon forests had been clear-cut and burned by 1996 (Nepstad et al.1998). Most of the deforested areas in the Amazon are maintained as cattle pasture. Large ranches account for 75% of the clearing for pastures and small farmers account for the remaining clearing. Usually pasture burns are done every 2-3 years (Fearnside 1993) and fire spreads from cattle pastures into surrounding forests where selective logging has occurred (Uhl and Buschbacher 1985). Fire is the quintessentially extensive land management tool of the tropics. However, fire is wasteful of nutrients and forests and it threatens investments made in agricultural and forestry production systems.

Three major types of fires have been recognized in the Amazon (Nepstad *et al.* 1999): i) Deforestation fires, associated with the clear-cutting and burning of standing forests for agriculture purposes (pasture formation, plantations, crops, etc.); ii) Forest surface fires, associated with standing forests, either primary or logged, where the fires burn through the fuel layer on the forest floor, and iii) Fires on deforested land, occurring in pastures, secondary forests, croplands, plantations and other vegetation on lands that had once been forested. Generally, deforestation fires and fires on deforested land are ignited intentionally as the main tool for land management, while forest surface fires may occur accidentally.

Deforestation monitoring by satellite is an important tool to study the length of human effects on the Amazon forests because it documents extreme forms of land-use, over large areas, and at relatively low cost (Nepstad et al. 1999). Clear-cut deforested land is easily distinguished from forest in Landsat TM images even years after the deforestation took place. However the scars left by fires in standing forests are harder to detect and much degraded forested areas in the Amazon are counted as closed forests on deforestation inventories (Nepstad, Moreira and Alencar 1999). According to Nepstad et al. (1999) estimated that selective logging severely damage 10,000 to 15,000 km^2 of forests per year and that this is not represented on the annual estimates of deforestation for the Brazilian Amazonia that is impoverished by logging and fire each year, and even less during years of severe drought. Despite an early report of the synergism between logging and forest fire (Uhl and Buschbacher 1985), little information is available on the areal extent of this very important alteration of Amazonian forests. We have estimated that approximately 200,000 km^2 of forest were at very high risk of burning by the end of the 1998 dry season, that is, forest that had depleted all of the plant-available water in the upper five meters of soil (Nepstad *et al.* 1999). This estimate is 10 to 15 times the total area deforested each year in the Amazon.

The largest ecological impact of fires on the Amazonian forest could be the replacement of vast areas of closed-canopy evergreen forest with savanna-like, fire-prone scrub vegetation through the synergistic effects of increasing drought and human land-use activities. According to Cochrane et al. (1999) the average rate and intensity of forest burning and deforestation in the Brazilian Amazon can be expected to increase as previously burned forest area expands. A positive feedback exists between forest fires, future fire susceptibility, fuel loading, and fire severity. First-time burns can be controlled and put out manually with minimal equipment, but fires in previously burned forest generally have fire line intensities that are beyond the limits of manual control. These fire-induced changes will take several years to occur but are likely to be irreversible under current climatic conditions. Effects on the regional climate, biodiversity, and economy are likely to be extreme.

Challenges to Research and Policy

Fire is a challenge to both research and policy because it is a very appealing land management tool in most of tropical America. It is an inseparable feature of the agriculture frontier in Amazonia, where land is abundant, but labor and capital are usually in short supply. Millions of farmers and ranchers ignite tracts of forest to release crop-fertilizing ash onto the soil, or to get rid of pasture weeds to favor grass production. The problem is that many of these fires escape their intended boundaries with large costs to land-holders and society at large. Solutions to this problem must therefore acknowledge that fire is currently a chronic, annual feature of rural Amazonia (Moreira 1999).

Solutions to the fire problem must harness the public concern that arises during "emergency" years, when severe drought and/or accelerated fire-dependent land-use activities greatly increase the occurrence of accidental fires during a particular period of time. The solution is to direct public concern into political processes that leads to a long-term approach that gradually decrease the use of fire by rural producers and increase landholder investments in prevention of accidental fire. Here we briefly discuss techniques and community-level approaches that are currently employed by Amazonian farmers and ranchers to combat accidental fire on their properties, and the research and education needs associated with the testing and dissemination of these approaches. Since many of the benefits of landholders' investments in fire prevention accrue to society at large, or to neighbors, strategies to reduce fire losses cannot rely on the enlightened self-interest of the landholder alone, particularly in the absence of effective mechanisms to enforce existing legislation. Instead, such strategies must place restrictions on the ways in which rural landholders use their land, and must provide economic incentives.

Fire Prevention and Suppression Techniques by Landholders

Effective techniques for preventing and controlling accidental fires in rural Amazonia are available and widely used, but the knowledge of these techniques resides among the farmers, ranchers and loggers who are faced with economic losses to fire every dry season. This "indigenous" knowledge of fire management techniques has received little attention by researchers, and remains to be tapped by government institutions responsible for defending public interests in Amazonian natural resources. This knowledge should be rigorously tested, documented and incorporated into training programs for extension agents, agronomists, foresters and other natural resource professionals (Nepstad, Moreira and Alencar 1999).

The first rule of fire prevention and control is that it is much easier and cheaper to prevent accidental fires from occurring than to put them out once they escape the limits of the intended burn area. Small, strategic investments made in fire prevention can thus avoid the need—and the expense—of assembling large groups of people and equipment to combat fires under emergency conditions. Cattle pastures are the most flammable ecosystems in Amazonia because forage grasses exposed to the full drying action of the sun are highly flammable (Uhl and Kauffman 1990), and the winds that sweep across large pasture clearings provide ample oxygen. Techniques for preventing and controlling accidental fire must remove at least one of these essential fire ingredients in order to be effective. The options for removing these ingredients are many, with varying requirements for labor, capital, and equipment.

Vegetation can be protected from fire by strips of land from which fuels have been removed. These "fire breaks" are the single most important technique for defending vegetation against accidental fire, but they are also the most expensive to implement. Small-scale rancher would spend half of his anticipated profits from cattle production in the manual preparation of fire breaks around a 100-ha pasture. Hence, education programs that encourage farmers and ranchers to invest in the preparation of firebreaks run the risk of encouraging practices that are not economically viable thus discouraging landholder investment in fire prevention (Nepstad *et al.* 1999).

Fire education campaigns should encourage those fire prevention and control practices that are relatively cheap to implement. One of the most underutilized, inexpensive techniques for containing fire is the back-burn, in which a fire line is ignited along the downwind border of an area that is being intentionally burned. This back-burn has the effect of widening the downwind fire break at a very low cost. Back-burning can therefore reduce the expense of preparing the downwind fire break.

The "cool burn", in which intentional burns are set when vegetation moisture content is high, or late in the day, as the relative humidity of the air begins to climb, may appear to be an inexpensive technique for reducing the risk of accidental fire. However, there is a large cost associated with it, in that less of the vegetation being burned is converted to ash. Farmers can suffer reduced crop harvests, for example, if large portions of their slash and burn plots fail to burn effectively.

Perhaps the most effective technique for controlling the spread of forest fires is the forest fire break line. Subsistence farmers across Amazonia control the low, slow-burning fires that spread into their forests by sweeping the forest floor free of organic debris along narrow trails that circumscribe the forest fire. These forest fire breaks impede the spread of forest fires at a much lower cost than military troops and water-bearing helicopters.

Local Governance among Neighbors and Farm Communities

The greatest challenge of fire prevention and control techniques is to reduce the amount of money, labor, and/or time needed to implement them. One of the most promising ways of reducing the costs of these techniques is through cooperation between neighboring landholders, or among members of farm communities. The types of cooperative agreements that can be made range from an agreement between two neighbors to notifying one another when an accidental fire is spotted, to a full-fledged community fire ordinance that defines the ways in which fire can be used by community members, and with penalty imposed for non-compliance. The easiest fire agreement to make is between two neighboring landholders with a common interest in reducing the occurrence of accidental fire (Moreira 1999). Such agreements take place informally between landholders across Amazonia, but their effectiveness in reducing accidental fire remains to be studied. Our findings indicate that this is virtually the only type of agreement that is made by large scale landholders, since they are rarely organized into close-knit communities as small-scale farmers frequently are. More sophisticated agreements between neighboring landholders can include the spatial planning of different agricultural systems to reduce fire risk (Nepstad, *et al*. 1999).

How to Encourage Investments in Fire Prevention?

Even the most remote farm communities in Amazonia have access to AM radio, and can be reached through educational radio spots. Educational handbooks are another tool by which successful approaches to the prevention of accidental fire can be disseminated. These dissemination efforts represent important research opportunities to measure the changes in farmer and rancher behavior that occur in response to information on fire. Of greatest interest is the long-term sustainability of any behavioral change. Educational campaigns may cause a temporary pulse in farmer investments in firebreaks, for example, which diminishes in subsequent years because of its considerable cost.

An additional constraint on the potential of education programs to reduce the occurrence of accidental fire is our lack of knowledge of the most cost-effective techniques and institutional arrangements for preventing and controlling accidental fire. The fire prevention and suppression techniques described above are being used in rural Amazonia, but their relative effectiveness has not been studied, nor have their costs and benefits been analyzed.

We do not know the circumstances under which it is economically advantageous for landholders to invest in fire breaks, fire surveillance, and emergency fire suppression plans. Such information is essential to enable public authorities to allocate scarce budgetary resources for fire prevention where they will be most effective.

There are no easy short-cuts around the formidable organizational and economic barriers that prevent groups of Amazonian farmers or ranchers from joining forces to reduce the occurrence of accidental fire on their land. Sometimes, a lack of leadership, low levels of community participation, and community instability may present the greatest barriers to the implementation of community fire regulations in communities across Amazonia. A single recalcitrant farmer who refuses to pay his neighbor for damages caused by an escaped fire can undermine a fire regulation that required repeated community meetings over several months to establish (Nepstad, *et al.* 1999).

The development of the capacity for local governance within a farm community is a long-term process, which can be accelerated through sustained inputs from dedicated, well-trained professionals, willing to spend much of their time working directly with communities under harsh field conditions. There is a severe dearth of such professionals in Amazonia. Many of the technical schools and university programs that are training agronomists and foresters have curricula aimed at industrial production systems, with virtually no training in the management of fire within agricultural or forestry production systems given. A new generation of extension agents and researchers is needed; one that is capable of integrating a variety of disciplines.

Community-based approaches to the reduction of accidental fire require more than just a new generation of multi-disciplinary, field-oriented extension agents and researchers. In addition, the economic and legislative context in which rural development proceeds also must change. Economic and legislative tools implemented by government can create an environment in which rural producers shift to agricultural systems that are less dependent upon fire, or are encouraged to invest in fire prevention techniques, and organize themselves to reduce the occurrence of accidental fire. We analyze here some of economic and legislative approaches to the reduction of accidental fire.

Economic and Legislative Tools.

It makes economic sense to use fire when land and forest is abundant and inexpensive. Fire is an intrinsic component of the current model of occupying rural Amazonia, in which natural resources such as land and forest are viewed as virtually unlimited commodities that can and should be mined. The long-term solution to the fire problem of Amazonia will depend upon the emergence of an alternative model for regional development that favors greater investments of labor and capital in smaller areas of land (Moreira 1999).

Public policies are important part of any strategy to address tropical forest fires. In the Amazon fire is not just another environmental issue, rather, it influences—and is influenced by—a broad spectrum of the region's rural development policies. As one of the essential tools of extensive land use, fire is at once both the cause and the result of a development pathway based on natural resource mining. Efforts to change the model of natural resource use from its current mining approach to a "sustainable" basis will require integrating Amazonian policies aimed at promoting economic development and settlement with those designed for conserving natural resources. In this sense, the cross-cutting nature of the fire problem represents an opportunity to reconcile interests in the region's economic development with interests in natural resource conservation. Policies are needed that provide incentives for increased agricultural productivity on deforested lands while at the same time reducing the availability of forested land. The key elements of this policy integration include land tenure, infrastructural planning, protected areas, and credit programs (Nepstad *et al.*1999).

Land tenure policies should be aimed at granting legal titles to land in the very early stages of frontier evolution. Land title given to settlers helps them acquire access to credit that they need to make investments in their land that create disincentives for fire use and incentives for fire prevention. Legal ownership of land also favors more intensive forms of land-use because it can decrease the risk of government appropriation and increase the confidence that benefits of investments in the land will accrue to the landholder. We interpret all government decisions to establish infrastructure in unsettled forest regions of rural Amazonia as *de facto* policy decisions to expand the agricultural frontier, indirectly exacerbating the Amazon fire problem. The construction of all-weather roads, electric power grids, waterways, railways, gas pipelines, hydroelectric dams and the concession of industrial mining permits brings people into remote forest regions, and brings new lands into the frontier and onto the land market. This frontier expansion drives down the value of land that is already accessible, and favors extensive forms of agriculture that give high yields on labor (or on the capital that is invested), but that require new cheap land to be economically viable (Schneider 1993). Infrastructure investments should focus on existing frontiers, where they can favor land use intensification.

Increases in the area of forest effectively protected from development also impedes frontier expansion. The Brazilian government's recent commitment to set aside 10% of the Amazon forest in strict protected areas could represent a substantial contribution to fire control efforts in the region. The requirement that 50% of private properties must be kept in forest reserves could also act to slow the rate of frontier expansion, if it were implemented. However, the current structure of this law results in severe fragmentation of forest reserves on individual properties; it would have much greater forest conservation value if each landholder's forest reserve were part of a large, consolidated forest reserve. Finally, agricultural credit programs should include technical assistance and other measures designed to promote the intensification of land-use systems by improving marketing facilities and by building the capacity of local institutions to engage in commercial enterprises.

Credit, subsidies, and tax breaks may represent the most direct way by which society can compensate private landholders for the added investments in fire prevention needed to defend forested areas. Economic policies are well known and frequently utilized instruments for influencing decisions by landowners, and they often have more far-reaching effects than legislation. The Amazonian fire problem is a particularly appropriate target for the application of such policies, since the brunt of economic damages associated with accidental fires falls on private landholders. Currently, none of the economic programs available to Amazonian farmers and ranchers are explicitly designed to reduce accidental fire Amazon (Nepstad, Moreira and Alencar 1999).

Rural credit policies should include support for investments in fire prevent and control techniques and equipment in their programs that finance agricultural and forestry activities. Such changes would be easy to make because these policies are legally autonomous. In the case of financial support programs directed specifically towards rural communities, could be designed to encourage the adoption of fire use regulations by funding community-level infrastructure and equipment needed to manage fire, and by covering the expenses of establishing and maintaining local organizations for fire prevention and control. For instance, in the Brazilian Amazon small changes could be incorporated into the fiscal and taxation policies that already exist for the region: Fire utilization should be prohibited in agricultural projects approved through the Amazonian Investment Fund. Businesses throughout Brazil that draw on this fund and enjoy income tax exemptions of up to 75% over a ten year period, could be threatened with removal of this tax holiday if they fail to exclude the use of fire from their enterprises. Tax exemptions on the purchase of equipment could also be used to encourage communities to adopt fire regulations, and to create volunteer fire-fighting brigades at the community or municipal level.

Fire insurance for farmers and ranchers who adopt fire prevention practices could also reduce accidental fire. Producers who invest in fire breaks, for example, could be compensated for damages associated with accidental fire through such an insurance program. Such a program would run the risk of encouraging accidental fires, and would have to be closely monitored.

These economic approaches to the fire problem could be used over the long term to encourage the substitution of fire-dependent forms of land-use with more intensive production systems on land that is already deforested. In the context of an overall policy reform that improves transport systems, energy supplies, health services and education systems in old frontier regions instead of encouraging the expansion of new frontier regions, these economic tools could be used to make agricultural intensification through agroforestry systems, cattle production intensification (Mattos and Uhl 1994), and forest management for timber (Uhl et al. 1997).

Fire Risk Warning Systems

The vast ecological and economic damages caused by accidental fires may decline if the region's land holders use fire less—and invest in fire prevention more—when the risk of accidental fire is high. Currently in the Amazon, every landholder is on his/her own in deciding what this risk might be, even though the interest in fire risk is very high. The ability to predict fire risk could also provide a powerful tool to reduce the occurrence of accidental fire. The personnel, vehicles and other resources that are necessary to implement legislation designed to prevent accidental fire are tiny given the magnitude of the Amazonian agricultural frontier, and predictions of the severity of fire risk in different parts of Amazonia could help government agencies decide where to invest their scarce enforcement resources, and when additional resources are needed.

In the case of Brazil it will take a major investment in fire research to develop fire warning system for Amazonia, similar to that already in operation in both the US and Canada, for instance. Fire warning systems in these countries are the fruit of decades of fire research and dozens of scientific careers that have yielded numerical models for the major fire-prone ecosystems that incorporate information on fire spread, fire energy release, ecosystem flammability, and human factors under a wide variety of climatic conditions.

In contrast, fire prediction is in its infancy in Amazonia. The first map that we are aware of that integrates data on rainfall, soils, and field measurements in Amazonian forests to identify areas of fire-vulnerable forests is the "RisQue" (described below). Its predictions are based on data from a mere 60 weather stations, compared to more than 1000 in the US! Many of the assumptions and algorithms used in the construction of RisQue must be verified in the field, and modified as new data arrive. Until a national fire research program is established within Brazil, fire prediction in Amazonia will depend upon models such as this (Nepstad *et al.*1999).

One promising approach to fire risk prediction in Amazonia would directly involve rural landholders. Farm communities and ranchers could calculate forest fire risk themselves once fire researchers have developed equations that describe the relationships between rainfall, soil water availability, and forest flammability for Amazonia's major forest and soil types. Fire risk prediction kits could be disseminated to rural landholders through rural extension programs, and would include rain gauges, rain data collection sheets, calculators and tools for sampling soil. Based on soil textural analysis, regional research centers could provide the appropriate equation for calculating forest fire risk, and extension agents would teach the landholders how to calculate fire risk with this equation using rainfall data input. This approach to fire risk would address one of the most serious impediments to fire risk assessment in Amazonia, the insufficiency of rainfall data collection.

In the short term, an "El Niño early warning system" could act as an effective substitute for a fire risk warning system. During most El Niño episodes, the surface temperatures of the southern Pacific Ocean begin to warm approximately six months prior to the onset of El Niño-related climate disruptions (such as Amazonian drought). Rapid dissemination of early El Niño signals would give Amazonian landholders time to incorporate the prospect of severe drought into their land management planning.

Predicting Future Burnings

Accidental fires in Amazonia may become worse in the future. El Niño events are associated with severe droughts across much of Amazonia, and have been more frequent in the last 15 years. The increase in El Niño events may be associated with the accumulation of carbon dioxide in the atmosphere (Trenberth and Hoar 1997), and could therefore represent the beginning of a long-term trend. Rainfall reductions in Amazonia are also a predicted outcome of Amazonian deforestation itself (Nobre et al. 1991, Shukla et al. 1990). Either of these trends would exacerbate the problem of Amazonian fires by increasing the susceptibility of forests, pastures and plantations to conflagrations.

Accidental fires may also increase in the coming years because of the expanding agricultural and timber frontier. As roads such as the Santarem-Cuiabá, the Manaus-Boa Vista, and the Acre-Pacific are paved, logging, colonization by landless poor, and large-scale forest conversion to cattle pasture by large scale landholders, will both increase the flammability of vast stretches of new forest, and introduce fire sources through traditional agricultural and pasture management practices. The prediction of future fire scenarios for Amazonia—and the influence of public policy change on them—is a crucial task for science.

One illustration of the potential application of science to environmental policymaking was the work of The Woods Hole Research Center (WHRC) and the Amazon Institute for Environmental Research (IPAM). In 1997/98, when forest fires became an important issue in the Brazilian Amazon, WHRC/IPAM scientists used accumulated knowledge on the dynamics of Amazonian fires to create a fire-risk prediction model (called "RisQue", from the Portuguese "Risco de Queimadas e Incêncios") that incorporates data on climate, soils, forest flammability, logging, and agricultural fires to predict future Amazonian fire regimes (Nepstad et al. 1998). The model played a pivotal role in raising worldwide awareness about the problem. The model was subsequently presented to Brazilian policymakers and general public and led to an overhaul of the legislation and policy approach to forest fires. This case presents evidence that both natural and social sciences can influence environmental politics/policy in positive ways. Further development of this model could provide a powerful tool for illustrating the impacts of current rural development trends in Amazonia.

Conclusion

Fire is deeply inter-woven into the cultural fabric of tropical America. It is the basic tool by which subsistence farmers survive in remote forest regions, and it is the means by which larger landholders claim and defend their property, and fend the regrowth forest from their sickly cattle pastures. Given the difficulty to implement fire-related legislation in the region, strategies to reduce forest burning must address the central role played by fire in the lives of forest residents and therefore there is no quick mechanisms for solving fire problems. The challenge is to find more effective means to support rural land-holders in their struggle to prevent and control unwanted fires. The solution will depend upon fundamental changes: reduction of the rate of agricultural frontier expansion and intensification of agricultural and forestry production systems where the frontier is already settled. It is through a dramatic reduction in the availability of new forested land that producers will use fire less, and invest more heavily in fire prevention. Extending new roads, waterways, and electric grids into remote forestlands will perpetuate the presence of fire in agricultural landscapes.

Farmers and ranchers throughout the region suffer substantial economic losses through fires that escape their desired boundaries, thus farmers, small and large, more than anyone else, want a solution to the fire problem. If the "supply" of virgin forest land ripe for colonization dwindles, farmers and ranchers must turn to their existing land for sustenance and wealth, investing in fire-sensitive fences, fruit trees, and forage grasses that create a powerful incentive to use fire less. This common interest in less fire, less smoke, and lower risks to investments made in the land, is the seed of solutions for the fire problem.

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Forest Fire Research in North America and Russia: Building on Past Accomplishments to Address Current and Future Needs

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Abstract

National forest fire research programs have enjoyed a long and productive history in Canada, the United States, and Russia. These programs have traditionally addressed major and topical fire management issues, so have evolved in concert with, and in support of, changing fire management practices. Although fire research activities are carried out at academic and regional institutions in these three countries, research at the federal government level has been dominant, providing the much-needed stability and continuity required to build relevant and adaptable research programs. The recent collapse of the Soviet Union presented the first opportunity for Russian and western fire research scientists to interact openly and productively. Since 1992 organizational structures have been put in place to facilitate this cooperation, joint meetings and experiments have been undertaken, and a great deal of progress has been made on many fronts. With the growing trend toward international, cross-disciplinary approaches to global fire problems, it is anticipated that this cooperative approach to fire research between Russia and North America will continue to flourish.

Keywords: Forest fire research, Research institutions, Research history, Mandates, International collaboration.

Introduction

By the beginning of the 20^{th} century, forestry education and forest practices in Canada, Russia, and the United States were strongly influenced by European views of proper forest management. Fire was viewed as an enemy, something to be controlled and even eliminated where possible, replaced by intensive, structured forest management. Accomplishing this in Europe, however, proved much easier than in the vast boreal and temperate forests of both North America and Russia. Fire is both natural and essential to forest ecosystem composition, structure and function in these biomes, and suppression of all fires has proven neither physically possible nor ecologically desirable. Settlement and exploitation of these boreal and temperate forests led to the development of sophisticated fire management programs that have had great success in reducing the areas burned by unwanted fires in protected zones, even as the numbers of ignitions from human causes was often increasing. However, at least in North America, it is becoming apparent that in many ecosystems, economically feasible levels of protection may delay, rather than prevent, eventual fire impacts. This is evidenced, for example, by the buildup of fuels and, therefore, resistance to fire control, in many of the short fire return interval systems (such as ponderosa pine). While the suppression of fires that threaten public and industrial interests is a goal over much of North America and Russia, there are also large areas in northern Canada, Russia, and Alaska where values-at-risk are low and little or no forest protection takes place and fire is allowed to perform its natural role. For these reasons, forest fires continue to exert a significant influence on boreal and temperate forests in North America and Russia. Furthermore, the large magnitude of annual burning in temperate and boreal forests, and the predictions of global change models that boreal forests will see above average increases in temperature, suggest that it is critical to develop data and models for better prediction of the impacts of boreal forest fires on the global environment.

Coincident with the implementation and expansion of fire suppression capabilities there was a realization that effective fire control required an intrinsic understanding of the factors governing the incidence and behavior of forest fires, and forest fire research programs were undertaken to provide this information. Canadian and American fire research began in earnest in the 1930s, with similar research priorities and approaches. Just as operational fire management agencies in Canada and the U.S. have cooperated in sharing ideas and resources, the fire research programs in these countries developed through extensive exchange and collaboration. Contact with fire managers and researchers in the former Soviet Union was, until recently, sporadic and incomplete at best. Despite this situation, the Russian approaches to operational fire management and fire research have gone down some similar paths to those in North America. Expanding collaboration over the past decade has provided the realization that Russia and western countries, while poles apart ideologically during the Cold War and earlier, have much to offer each other in exchange of information and technology for fire management and in collaboration and information exchange in fire research. Differences in political history and in the development of fire management and fire research have also led to unique strengths in each country's research program that can be built on by collaboration.

This paper outlines the development of fire research programs in each country and shows how research has evolved to meet developing fire protection needs. It concludes with a summary of current collaborative research activities involving Russian and western fire scientists.

Recent Historical Forest Fire Research Directions

Russia

Early fire research activities in Russia were closely tied to operational fire problems, and have developed in conjunction with the evolution of fire protection methods and capabilities. In the early 1920s it was recognized that effective protection of the vast Russian taiga required aircraft, and research was focused in this area. Experimental aerial reconnaissance flights were undertaken sporadically, with the beginnings of a formal aerial protection program initiated in the early 1930s when organized, operational flights for fire detection and monitoring began in the central Urals, Siberia, and the Far East regions of Russia, under the All-Union Scientific Research Institute of Agriculture and Forestry Aviation, and later the All-Union Trust for Forest Aviation. This formalization of aerial fire protection led quickly to rudimentary attempts at dropping chemicals and water from aircraft and, in 1934 a smokejumping program was initiated. New bases were established across Siberia, and the program expanded dramatically after World War II using surplus military aircraft and demobilized paratroopers. Avialesookhrana - the aerial forest protection service - began using helicopters to transport firefighters and equipment (some mechanized) in the mid-1970s, and began to exert a major influence on the area burned throughout Russia, especially as regards suppression of human-started fires near settlements. By the 1990s the Soviet Union had amassed the largest firefighting system in the world. However, when the Soviet political system collapsed in 1991, budgets for fire control were greatly reduced. With these recent political and economic changes in Russia, the past gains in fire suppression have become difficult to sustain as the area receiving fire protection, the frequency of reconnaissance flights, and the numbers of fire fighters that can be hired and deployed have all decreased.

The development of forest fire research in the Soviet Union closely paralleled the expansion of fire control across the country. Within various forestry institutes, fire science developed through the 1930s, with emphasis on fire behavior, ecology, control and use. Although disrupted by World War II, fire research programs continued to expand, with sophisticated textbooks being produced, and a national system of fire danger rating (the Nesterov Index) being developed. Postwar reconstruction led to the development of three major institutions, under the auspices of the Russian Academy of Sciences and the State Committee on Forests, that have dominated Soviet/Russian forest fire research activities to the present - the Leningrad Forest Institute, the

Far Eastern Scientific Forestry Research Institute in Khabarovsk, and the V.N. Sukachev Institute for Forest Science in Krasnoyarsk. The Leningrad institute focused on forest pyrology in European Russia, specializing in aerial operations, including fire detection and weather modification (cloud seeding), fire retardants, and pumps. The Khabarovsk institute carried out research in the development of forest fire spread models, fire danger rating, and fire ecology of the forests in the Far East, while the Krasnoyarsk laboratory pioneered research in fire fundamentals and the fire ecology of Siberia. Major fires in 1972 brought a renewed commitment to fire research, with expanded facilities and financial support. In addition to continuing ongoing research, emphasis was placed on the development of fire-fighting equipment, particularly the conversion of agricultural and military machinery for this purpose. An emphasis was placed on theoretical modeling, including the development of a comprehensive mathematical model of fire behavior. Fire ecology research was also expanded across Siberia. Other centers of forest fire research have included Tomsk University (physical fire behavior modeling) and Novosibirsk (wildfire smoke chemistry and aerosols). The International Forestry Institute in Moscow has taken a leadership role in analysis of national fire statistics and development of a national system for satellite fire detection and other satellite applications. A number of technology institutes have been established and maintained by the Russian Forest Service, with a primary goal of developing new firefighting equipment and technology. The number of fire research publications increased dramatically, and fire research symposia were held frequently during the 1960s and 1970s. At this time the Canadian fire research community, although lacking direct contact with their Soviet colleagues, was acquiring and translating many Soviet fire research publications.

With the economic stagnation and eventual collapse of the Soviet Union in the late 1980s and early 1990s, funding for fire research dropped dramatically at the same time as fire suppression capabilities diminished. Research programs were cut, institutions stagnated, and those researchers who persevered worked for little or no salary. This was the situation when western fire scientists, following the "opening" of Russia to the west, began to interact and collaborate directly with their Russian counterparts in 1992.

Canada

In the early 1900s Canadian forestry practices were strongly influenced by European approaches to forest management. As a result fire was seen as an enemy and something to be eliminated from the forest whenever possible. Recognition of the folly of this approach was long in coming, but a series of catastrophic wildfires across Canada in the first three decades of the 20th century galvanized public opinion, and resulted in the birth of modern forest fire management. Although fire exclusion was still the policy of the day, there was a recognition that much more knowledge was required on the occurrence and behavior of forest fires if fire protection efforts were to be successful. The Canadian federal forestry service was responsible for fire protection nationally in the early 1900s, turning this responsibility over to provincial agencies by the early 1930s, and beginning to focus on the development of fire protection techniques. Beginning in 1925, a modest program of forest fire research was initiated by the Canadian government, and this program has developed and expanded to the present day. Although various provincial/territorial fire management agencies, and some universities, currently conduct some fire research, the Canadian federal government program has been by far the strongest, broadest, and most continuous commitment to forest fire research across Canada.

Early Canadian fire researchers began investigations into the relationship between weather and forest flammability, working primarily in Ottawa and the Petawawa Forest Experiment Station in Ontario, but expanding a network of field experiment stations into western and Atlantic Canada in the 1930s. Fire danger studies, including the conducting of numerous small-scale test fires in the field, resulted in the development of a national system of fire hazard rating which was implemented at that time, and which has survived many metamorphoses to form a part of the current Canadian fire danger rating system. While fire hazard research was a primary research thrust at that time, fire suppression research was also carried out, with the development of fire retardant chemicals and specifications and performance-testing procedures for portable fire pumps and accessories. The number of professional fire researchers in Canada increased gradually during this period, reaching a modest total of 8 by 1958. During this period, although visits were few, there was substantial correspondence and sharing of ideas with fire scientists in the United States, particularly in the area of fire danger rating.

A major expansion in Canadian fire research capabilities occurred in the 1960s, when fire research programs were established at federal regional laboratories across Canada (in British Columbia, Alberta, Ontario, Quebec, New Brunswick, and Newfoundland) to supplement the continuing fire research activities at the Petawawa Forest Experiment Station. The regional establishments provided continuous, rather than sporadic, contact with operational fire management agencies, and the development of broader research programs aimed at addressing fire agency requirements directly. During the 1960s the Forest Fire Research Institute was established in Ottawa to act as a focus for the federal fire research program, which was at its zenith during the 1960s and 1970s with 29 professional researchers working (with support staff) across the country. This period saw the increasing use of physics and laboratory studies to support a field program aimed at the development of a continuously improved fire danger rating system which included the prediction of quantitative fire behavior through empirical models based on an extensive national experimental burning program. The result is the Canadian Forest Fire Danger Rating System, completed in 1989, which is currently in use throughout Canada and in many other countries. During this period the evolution of computer technology, along with modern management science and remote sensing led to the development by Canadian fire researchers of sophisticated computerized fire management systems that revolutionized operational fire management in Canada. Integrating remote sensing for fuel type identification, the prediction of daily lightning and human-caused fires, fire detection planning techniques, resource inventories and fire growth models, these fire management systems were tested and implemented across Canada in partnership with fire management agencies, and have been exported internationally. Fire ecology research became a major research focus in the 1970s, particularly with respect to Canada's national parks where perpetuating natural forest ecosystems that include fire as an environmental factor is a priority, but a gradual decline in research resources prevented fire ecology research from becoming a sustained major research focus. Fire economics, as a component of a larger field of forest management economics, received some attention from the Canadian fire research community during this period, focusing on the impact of fire on timber supply and the determination of optimum expenditure levels in fire protection. At the same time, some fire suppression research, from equipment development and assessment, to formal studies of aircraft water/retardant bombing effectiveness was carried out over a number of years.

From this peak period, the resource level of Canadian fire research has seen a steady decline, consistent with a lack of funding support from the federal government to federal scientific research in general. In 1979 the Forest Fire Research Institute was disbanded, with much of its program, with staff reductions, being transferred to the newly reorganized Petawawa National Forestry Institute. In the mid-1990s, amid a general federal government downsizing, the Petawawa National Forestry Institute was closed, along with the regional laboratory in Newfoundland. Since that time, the Canadian Forest Service (CFS - the current federal forest research entity), scrambling to maintain a national scientific program in the face of diminished support, has developed a series of Science and Technology Networks designed to address cross-disciplinary forestry research priorities in an integrated fashion, making the most of continually dwindling resources. The Fire Research Network, one of 10 CFS S&T Networks established in 1995, has a research complement of 25 (16 professionals), located primarily at the Northern Forestry Centre in Alberta and the Great Lakes Forestry Centre in Ontario, with smaller components at Pacific Forestry Centre in British Columbia and the Laurentian Forestry Centre in Quebec. The current research objectives of the Fire Research Network are:

- produce the scientific understanding and decision support tools required to manage wildland fire within the context of sustainable development;
- form a foundation of knowledge to model fire behavior and fire effects at ecosystem and landscape scales, and establish a national decision support system t implement these models;
- construct tactical, strategic, ecological, and economic decision support tools and systems for use in fire and forest management;
- determine and assess the role of fire in relation to global change; and
- monitor fire weather, fire behavior, and fire activity on a national scale.

Research activities in support of these objectives are organized into five program areas within the Fire Research Network: Fire Environment, Fire Ecology, Fire Management Systems, Fire and Global Change, and the Role of Wildland Fire in Canadian Forests.

A significant but lesser volume of fire research has come from Canadian universities in recent decades, often in collaboration with federal and provincial colleagues, particularly in the areas of fire management systems, fire ecology, fire occurrence prediction, fire danger rating, and physical fire modeling. Most notable have been the University of Toronto and Lakehead University in Ontario, Laval University and the University of Quebec at Montreal in Quebec, Brandon University in Manitoba, and the Universities of New Brunswick, Alberta and British Columbia.

Over the past seven decades the fire research program of Canada's federal forest service, through many organizational changes and fluctuations in resource strength, has produced a continuous series of innovative products of practical value to fire and forest management in Canada and abroad. Fire research in Canada has largely followed the empirical method, primarily through extensive field observation and measurement programs, although theory has been linked with field results where possible. Successive research generations have expanded, and built upon, the progress of their predecessors as new information and technologies became available, but a strong sense of continuity has remained. There has always been a large amount of cohesion and collaboration within the Canadian fire research community, despite varying disciplines and locations, and this approach, combined with a close working relationship with operational fire managers across Canada, has been fundamental to the success of the program.

The United States

While early European settlers in the US often used fire to help clear land for homes, agriculture, and other purposes, by the end of the 1800s the effects of devastating fires on forests and on communities were converging with the opinions of some ecologists to embrace the idea that fire was bad both ecologically and socially. Fire destroyed valuable timber, interrupted natural succession processes, and caused tremendous loss of property and life in the early wildland-urban interface fires such as the 1871 Peshtigo and Humboldt fires in Wisconsin, where perhaps 2,250 people died. Although arguments about the usefulness and role of "light fire" and prescribed fire as management tools were to continue even to the present day, fire protection and suppression became the primary focus of fire management. This focus changed gradually as prescribed burning was increasingly advocated and used, beginning with policy changes allowing burning for specific purposes in the 1940s. In many cases, the National Park Service led the charge on implementing prescribed burning programs in the West (e.g. Sequoia-Kings Canyon National Park). However, outside of the South, the areas covered by these programs were often small. It has only been in the 1990s that a series of large and costly fires, the weight of scientific evidence on negative effects of fire exclusion on both ecosystems and fire hazard, and increasing concerns over management of fire in wilderness and wildland-urban intermix areas led the federal agencies to make major changes in fire management policies. As a result, there has been a dramatic upturn in the extent of fuel management and prescribed fire programs in agencies such as the USDA Forest Service and the Department of the Interiors

Bureau of Land Management (BLM) as well as a shift toward better integration of fire management into overall land management planning. Strategies and tools for addressing risks of increased vegetation buildup to forest health and to fire hazard and for monitoring changes and impacts of treatments will need to continue to evolve if land managers are to deal effectively with the large areas currently believed to be at risk of catastrophic fires. Throughout the changes in fire policy over the course of the 20th century, fire research programs provided support for improving operational capabilities of fire suppression, as well as the scientific foundation for changes in attitudes and policies toward wildland fire.

The beginnings of fire research as an independent area of investigation in the US might be traced back to 1898, when the first chief of what is now the USDA Forest Service requested a study of the effects of wildfires in southern California. The Transfer Act of 1905 provided the initial authorities for managing and studying fire, but interest in the study of fire accelerated after the devastating fires of 1910. This early research was carried out primarily in California by researchers and administrators in the Forest Service (FS). It consisted largely of case studies and retrospective analyses of fire statistics. In 1915, the Forest Service established a new Division of Fire Control, as well as a separate Branch of Research. In 1926 a national program of forest fire research was developed, and the California Experiment Station was established, with fire research as one of its areas of emphasis. And in 1928, the McSweeney-McNary Act gave the responsibility for all federal research on forest fire to the Forest Service. Early work focused on analysis of fire statistics, fire control, fire danger, and fire behavior, with the emphasis on developing better methods of fire suppression. This work laid the foundation for the 10 a.m. policy, established in 1935 (which called for fires burning the previous day to be extinguished by 10 a.m.). While this policy received strong political and popular support, some researchers and historical users of fire (e.g. in the southeastern US) questioned its wisdom as a blanket policy. Both Forest Service and university researchers continued studies on the effects of frequent “light burning”, although results from FS research were sometimes suppressed for several years before publication. University researchers at Washington, California, and Yale, along with the Tall Timbers Research Station in Florida were among the pioneers of fire ecology and the advocacy of a natural role for fire. Despite official policy, prescribed fire continued to be used in local areas, particularly in the short-fire return interval pine systems of the southeast and the west. The 1940s and 50s began to see increased use of prescribed fire as a management tool in some areas of the South and the West. During and after World War II, many of the federal fire research programs were focused on projects supported by the military, which addressed topics such as mass conflagrations from nuclear attacks; many of the results of these studies are still classified. But by the early 1950s emphasis in the Forest Service programs was returning to the problems of wildland fire prediction, behavior, and control with a great deal of emphasis on equipment and techniques for fire suppression, such as aircraft and fuelbreaks, and a lesser emphasis on the effects of fire on ecosystems. It was during this period that a large research program on delivery and testing of aerial fire retardants was begun; this program continues today as a development and application program supported by the Fire and Aviation operations branch of the Forest Service. Meanwhile, at universities and research institutes such as Tall Timbers, studies on the ecology of fire and its natural role were increasing.

In the late 1950s , after severe fire seasons in 1953 and 1955, federal support for fire research grew, and the FS ultimately received funding to build three major fire research laboratories in Missoula, Montana, Macon, Georgia, and Riverside, California. These laboratories initially focused strongly on developing models and tools to support fire operations (including fire behavior and fire danger rating systems), but programs increasingly focused also on the ecological and environmental impacts of fire, fire exclusion, and fire use. A major research program also was built in Arizona during the 1970s to address problems of fire ecology and management, and effects of fire on erosion and watersheds. A large research program was developed in the Pacific Northwest, focusing on slash burning, smoke, and forest fuels; and programs at the North-Central Forest and Range Experiment Station addressed social aspects of wildland fire management and atmospheric processes. Federal fire research programs, and fire research at universities, have seen great variability in funding support and capacity over the past 30 years. Decreases in funding for fire research in the 1980s led to closure of the Macon laboratory, numerous personnel transfers, and severe reductions in staffing or closure of programs at other locations. The trends in reduced staffing of FS programs have continued into the 1990s, with approximately a 50% reduction in permanent staffing for FS fire research programs between about 1985 and 1999. Currently over 50% of the fire research in the USFS is conducted outside the two main fire labs, often as part of interdisciplinary projects on silviculture or ecosystem processes. The smaller fire research programs in the Department of Interior, formerly located primarily in the National Park Service, have also been disrupted by major restructuring, and now reside in the newly-consolidated Department of Interior (DOI) research program under the US Geologic Survey (USGS). A number of universities, including the University of Washington, University of California, Northern Arizona University, Arizona State University, University of Montana, University of Idaho, Duke University, and University of Colorado have built strong research programs in various aspects of fire research over the last 20 years, with particular strengths in fire ecology, fire history, and remote sensing. Major accomplishments during the 1980s and 1990s have included development of the BEHAVE fire modeling system, the National Fire Danger Rating System, fuel models, the Incident Command System, models and data on fire emissions, systems for improved prediction of seasonal fire hazard, better understanding of fire meteorology, ecology, and the effects of fires on erosion, vegetation structure and dynamics, and nutrient cycling. Through the use of satellite data, coarse-scale maps of fire danger and other parameters are now available on the internet. A number of the systems developed by US fire scientists (such as the BEHAVE system, the landscape fire modeling system FARSITE, and the Incident Command System) are used widely outside the US. Fire research has a long tradition of close cooperation with users in research development and application. Much of the current fire research in the US is carried out in interdisciplinary teams that often include cooperators from federal, state, and local land management agencies, non-governmental organizations, universities, USFS, USGS, National Aeronautics and Space Administration (NASA), and Department of Energy scientists, and regulatory agencies such as the Environmental Protection Agency (EPA) and state air quality boards, and funding often comes from multiple sources. Establishment of the interagency Joint Fire Science Program in 1998 to provide scientific support for fuel management activities on federal lands, has provided a new source of competitive funding for applied fire science in a wide range of disciplines. Other aspects of research programs are being supported by NASA, EPA, and other agencies.

Several trends will strongly influence fire research in the US over the next five years. These include: increasing emphasis on integrating fire management into land management planning; recognition of fire's role in forest health and sustainability; the need to quantify the impacts of changing fire regimes on regional, national, and global carbon budgets; the need to understand and predict interactions of fire with other key disturbances such as global change, climate extremes, insect and disease, and harvesting and silvicultural systems; and the need to understand the social context of fire management. Addressing these issues will require integration of fire planning and economics, physical science, fire effects, ecosystem process, and social sciences research. Specific needs include:

- better quantification of the extent and severity of fire on the landscape, and its impact on ecosystem dynamics and carbon budgets;
- improved models and data on emissions and smoke dispersal for better air quality management and understanding of regional and global impacts of fire emissions;
- improved fire meteorology models and fire hazard prediction and mapping systems;
- tools for monitoring and modeling of the effects of vegetation/fuel management treatments on a landscape to national scale;

- modeling systems that integrate improved and validated fire behavior and fire effects models;
- integrated and consistent approaches to mapping and monitoring fuels and for modeling succession and fuel development over time;
- tools to evaluate the cost-effectiveness and environmental impacts of alternate management strategies;
- improved understanding and models of interactions between fire and other disturbances.

While planning and management tools for fire suppression activities will continue to be improved, the future of fire research lies in a shift of emphasis and expansion into research that will help managers and policymakers address key issues in landscape management, strategic planning, and influence of fire and fire management strategies on global and regional environments and on the sustainability of ecosystems to meet future needs for fiber, clean water, recreation, and other resources.

Current and Future Trends

As previously mentioned, early attitudes toward fire management in the US and Canada were shaped by management concepts from European forestry. International collaboration has played a key role in fire research and fire management for many years. Fire researchers and managers have long been involved in international activities, often in the form of technology transfer or training. These activities have certainly proved mutually beneficial, and will undoubtedly continue (e.g. US involvement in response to the recent fires in Indonesia; training programs on fire behavior modeling or use of the Incident Command System), but the most fruitful international work in fire research will continue to be that which involves true collaboration and mutual information exchange.

Over the past 20-30 years North American fire research has benefitted greatly from long-standing collaborations with researchers in countries such as Spain, Portugal, Australia, Germany, China, Japan, South Africa, Zimbabwe, Brazil, Honduras and Guatemala, Mexico, and France, to name a few. These collaborations have been critical in helping to develop a better understanding of fire behavior modeling, the role of fire, vegetation dynamics, fire management strategies, the influence of social and economic factors on fire use and suppression, and the interaction between fire and global change. Interest in remote sensing of fire has led to recent collaborations with scientists in the European Union.

Despite this history of broad international collaboration in fire research, for many years the extensive literature and experience of fire researchers in the former Soviet Union was largely inaccessible due to restrictions on travel and communication and to the strong language barrier. Direct collaboration between western and Russian fire scientists began in 1991 when, after the collapse of the Soviet Union and the relaxing of political tensions, the International Boreal Forest Research Association (IBFRA) was formed at a meeting of Russian, Canadian and American representatives in Arkangelsk, Russia. The Fire Working Group of IBFRA met for the first time in Krasnoyarsk in central Siberia in May 1992. The goal of this meeting was the development of a set of protocols and hypotheses that would guide future cooperative fire research initiatives between western and Russian scientists. In all, a series of 8 hypotheses were developed, dealing with fire behavior, fire ecology, ecosystem processes and response to fire, climate change and fire, and determining the spatial and temporal distribution of large fires. These specific long-range hypotheses envisioned international, multi-disciplinary research teams conducting a coordinated and sequenced series of experiments addressing these issues.

During the summer of 1993, the first international fire conference involving western and Russian fire scientists was held in Krasnoyarsk. This conference ("Fire in Ecosystems of Boreal Eurasia") attracted over 40 papers (presented by fire researchers from 9 countries) dealing with many aspects of fire ecology, fire behavior, fuels classification, fire meteorology, modeling, and global change - with emphasis on boreal Eurasia. The proceedings from this highly successful, groundbreaking conference were published as a monograph (see References). Following the

Krasnoyarsk conference, a field experiment, Fire Research Campaign - Asia North (FIRESCAN) was carried out under the joint sponsorship of IBFRA, the International Geosphere-Biosphere Program (IGBP), and the United Nations Team Of Specialists on Forest Fires. The aim was to conduct a high-intensity experimental fire under controlled conditions that would permit Russian and western fire scientists to compare research methodologies. This fire was thoroughly documented (e.g. fire behavior, fire effects, and smoke chemistry measurements) by Russian and western fire scientists, and the results published jointly. Followup measurements were made annually for 5 years by a joint team of North American, European, and Russian scientists.

A major focus of collaborative research between Russian and western scientists has been quantifying the extent and impact of Russian boreal fires. In 1993, NASA cooperated with Russian scientists in to establish ground receiving stations for obtaining NOAA/AVHRR data across Russia. Data on fire activity from the Krasnoyarsk station and from NOAA archives is being jointly analyzed by US, Canadian, and Russian scientists. With the diminished capacity of Russian fire protection, satellite monitoring of fires, particularly in the more remote regions of Russia, provides an essential capability. Recent emphasis on global change issues, including carbon budgets, have focused attention on the large carbon pool in Russian boreal forests, and the need project climate change impacts on this resource. IGBP high-latitude transects have been established in Siberia, Scandinavia, Canada and Alaska to investigate and determine how the terrestrial carbon cycle will be affected by the rapidly changing environment in these regions. As fire is the major disturbance regime in boreal forests, controlling ecosystem dynamics including carbon cycling, Russian and western fire scientists are planning interdisciplinary experiments along these transects, along with colleagues investigating many additional aspects of the terrestrial carbon cycle.

Another outgrowth of the 1993 activities has been the development of strong collaboration between Russian scientists, Avialesookhrana, the Russian Forest Service, the USFS, NASA, and the Canadian Forest Service in the Krasnoyarsk Region in a program of fire effects research that will combine experimental and remote sensing data to obtain better estimates of the extent of fires of differing severities in central Siberia, and of the impact of fire severity on ecosystem processes. The goal of this program is to better quantify the effects of fire on carbon cycling and sustainable management of pine forests in Siberia. The USFS is also collaborating with researchers, fire managers, and forest managers in Krasnoyarsk on a pilot demonstration program on the use of prescribed fire. Development of these programs has involved repeat exchange visits between the US, Canada, and Russia over the past several years.

The IBFRA Fire Working Group has also initiated studies into the suitability of the Canadian Forest Fire Danger Rating System for use in Siberia, and are jointly analyzing historical weather data for Siberia. In addition, support has been extended to the physical fire modeling group in at Tomsk University, including the translation of a Russian book on high-intensity fire modeling, and participation in a fire modeling conference in Tomsk in 1995. Russian fire scientists have also been sponsored to attend the ongoing (1997-2000) International Crown Fire Modeling Experiment in Canada's Northwest Territories.

In the summer of 1996 a major United Nations seminar, “Forests, Fire and Global Change”, sponsored jointly by the Russian Federation and the UN Team of Specialists on Forest Fire, took place in Shushenskoye in south-central Siberia. The goals of this seminar included assessments of the extent and impact of wildfires globally, the development of methodologies for collecting and archiving fire data at a global scale, and the development of mechanisms for expanded international cooperation in fire and disaster management. Holding this meeting in Russia demonstrated the important role of Russia in global fire management and further accelerated their involvement internationally.

Declining budgets, government downsizing, and a growing awareness that fire is a global force with multi-dimensional social and environmental impacts, have resulted in an unprecedented trend toward more cooperative fire research activities. International, cross-disciplinary collaborative investigations into common problems are becoming the means by which fire research programs are now being delivered. The International Geosphere-Biosphere Program has many Core Projects with fire research components operating studies and field campaigns in many regions of the world, including North America and Russia. The International Boreal Forest Research Association has a Fire Working Group conducting collaborative fire research programs in northern Canada, Alaska and Russia. The United Nations Team of Fire Specialists, and the International Union of Forest research Organizations (IUFRO) Fire Research Group are also actively involved in this modern, and growing approach to forest fire research.

International meetings, translations of Russian literature, and increasing exchange visits and research cooperation have opened up vast new opportunities for collaboration and information exchange between Russian fire research and the rest of the world since 1991. Collaboration in the international fire research community has grown tremendously in recent years. Some of the key areas of current cooperative research include active fire monitoring; remote sensing of burned areas; development and testing of fire behavior models, emissions, carbon cycle, and ecosystem process models; and use and effects of prescribed fire. While fire researchers and managers have long been involved in international activities, in the past these were often in the form of technology transfer or training. These activities have certainly proved mutually beneficial, and will undoubtedly continue (e.g. international involvement in response to the recent fires in Indonesia), but the most fruitful international work in fire research will be that which involves true collaboration and mutual information exchange.

Although fire management and fire research programs in Russia developed largely in isolation from similar programs in Canada and the United States, there have been many similarities in these highly-effective approaches. Now that isolation is no longer an issue, joint research programs have been accelerated and are proving quite fruitful. In a world where individual countries can no longer solve problems alone, and where a rapidly expanding capability to communicate and collaborate in addressing environmental problems that transcend borders already exists, this collective approach to fire research challenges can only continue to grow.

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Fire in the Mediterranean Basin: Towards an Interdisciplinary Science Program

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Abstract

This paper discusses and presents the underlying factors and the need for a coherent research campaign concerning forest fires in the Mediterranean Basin. With a very long history of human settlements and land use coupled with the climatic and topographical conditions, Mediterranean Basin has very distinct landscape patterns shaped by biotic and abiotic factors. Of the factors involved, forest fires human made or natural are among the most important ones. Fire in the region is of social, cultural, economical, historical and psychological origin. Yet, fire research has mainly concentrated on the prediction of fire behaviour and ecology, i.e., the immediate effects of fires on fauna, flora and soil. No genuine effort has been made to relate resulting landscape patterns with typical fire regimes to historical land use practices, and socio-economic, cultural, historical and political backgrounds of fires, nor is it clear how the changing land-use pattern would affect the vegetation types and fire regime, overall land management planning and the contribution of wildland fires to regional atmospheric chemistry.

To overcome the problems in such a complex region the Mediterranean Basin, a multi-national, interdisciplinary research effort dealing with a broad range of interlinked aspects of the fire problem is vital. Here, the concept and tentative framework of a such research exercise is presented.

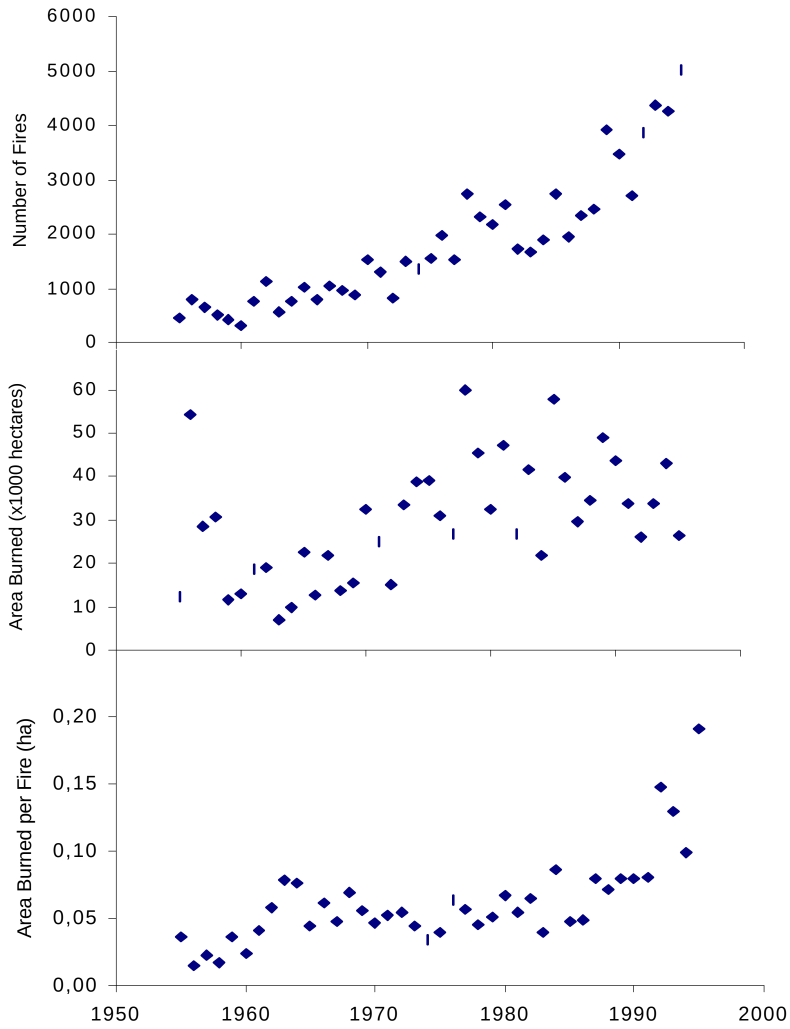
Keywords: Forest fire, Mediterranean Basin, Research

Introduction

Fire has been, still is and certainly will continue to be one of the great forces of nature in the Mediterranean Basin, and has a pervasive influence on its forests and their management, consuming hundreds of thousands of hectares of forest land annually resulting in billions of dollars in suppression costs and causing great damages in lost timber, real estate and recreational values, and even loss of life. Recent statistics indicate that the region is experiencing an ever increasing wildland fire problem. Supporting this statement is the fact that there are now an average of 50,000 forest fires per year in the region, consuming an area of 600,000 hectares, twice that of 1970s (Fig.1). While natural fires play an important role in many of the Mediterranean forest types, the increasing frequency of recent fires has transformed the fire from nature’s tool to nature’s threat, resulting in a dramatic decline in the quality of forests with the average fire cycle, in some localities, having been reduced to as little as 25 years (Alexandrian and Esnault 1999).

Fire in the region is of a very complex and multifaceted phenomenon involving social, cultural, economical, historical and psychological aspects, and marked by a prevalence of fires of human origin, with reliable estimates being up to 99%. However, fire protection agencies have evolved around an effective fire protection policy with a strong emphasis on fire control with little or no regard given to underlying causes of fires, and fire research concentrated mainly on the prediction and the immediate effects of fires on flora, fauna and soil.

Figure 1. Pan-Mediterranean fire statistics for the period 1955-1997. Source: Alexandrian and Esnault (1999).



Investigation of fire behaviour and fire impacts on ecosystems is undoubtedly very important. But knowledge about the human impact on fire and fire regimes, about the correlation of land use and fire regimes, about arson in relation to political and economic situations, about cultural, ethnological and psychological factors of ignition, about the history, the present and the future trends of those anthropogenic factors that determine fire regimes is essential. For effective and long-term prevention against wildfires, research must fill this gap in present fire ecology studies. It has to be made clear what the main determinating human factors are in producing high fire risk and uncontrollable fires.

"To address the complex and far-reaching issues related to anthropogenic impacts on fire regimes and ecosystem properties, formulation of a truly interdisciplinary approach is critically needed" (Kauffman *et al*. 1993). This calls for a genuine support and cooperation of nations and operational organizations to take it part in a multi-national, interdisciplinary research effort dealing with a broad range of interlinked aspects of fire problem.

The objective of this paper is to identify and present the underlying factors concerning forest fire problems in the Mediterranean Basin. To deal with the problem, the concept and tentative framework of a research exercise is presented.

A Retrospective Synthesis of Fires in the Mediterranean Basin

The Mediterranean Basin distinguishes itself from the rest of the world by its very long history of human settlements and land use with distinct climatic and topographical conditions. From the first hints of hunters (300,000 years ago) to our days many different cultures and civilizations (Persian, Egyptian, Hellenic, Roman, Byzantine, Islamic, capitalism, and international tourism) have established their typical land-use systems and therefore changed natural ecosystems completely. Fire was, in many cases, the only management tool by which the change in natural ecosystems was realized, and the evidence of anthropogenic ecosystem modification can be found up to the most peripheral sites of the region. "Europeans burned woods as well as heath and moor to improve pasture and range. ... They burned agricultural fields and gardens. Until very recently agriculture, after all, was rotational, either because it moved the farm through the landscape or because, in effect, it moved the landscape through the farm; both forms demanded fire. Europeans adapted slash-and-burn farming into slash-and-burn forestry. And so it goes" (Pyne 1994).

Fire has been identified as a natural process in dry and semi-dry landscapes which keeps vegetation forms in a dynamic equilibrium, guaranteeing the maintenance of biodiversity, the release of nutrients, and elimination of dead or otherwise not usable plant material. Since mankind learned how to handle fire, they have used it in many different ways: "Humans purposefully set fires to increase food choice, to facilitate the gathering of edible plants, and to attract and hunt games" (Perles 1977, cited after Trabaud *et al.* 1993). The domestication of animals and agricultural expansion promoted ignition in order to clear and fertilize wide areas. At the same time, biomass fuel was collected for heating and cooking. "The development of all human cultures was dependent on the free burning of vegetation and on the use of plant biomass to provide energy" (Goldammer 1993).

The introduction of exotic plant species and plantations, excessive wood cutting (deforestation) and increasing grazing pressure changed the natural fire regimes entirely. "Humans are a principal force that shape the size, frequency, and severity of fire on Earth. They directly impact the biota by accelerating, modifying, or excluding fire from ecosystems" (Kauffman *et al.* 1993). The cultivated and densely populated landscape ecosystems of the Mediterranean Basin have been in an equilibrium which was based on human activities. Two recent tendencies, which have started at almost the same time, have changed the existing "Total Human Ecosystem" (Naveh and Lieberman 1994) deeply and modified the artificial but well-balanced fire regime - the shift from burning wood to fossil fuel combustion, and urbanization.

As has been stated by Kauffman *et al.* (1993) "the shift from burning wood to fossil-fuel combustion has dramatically changed human society, the biota on Earth, and the chemical composition of the atmosphere". With the onset of the modern industrial age, the region has experienced an ever increasing influx of peripheral populations into larger cities resulting in the abandonment of traditional farming practices and the use of fires therein. This has led to an increase in the buildup of fuels and an expansion of fire-prone areas. The accumulation of fuel material in Mediterranean shrub and forest lands that was previously used for heating and cooking has increased the fire risk and the intensity of wildland fires. Coupled with the total fire control policy of the governments, this has also, in many parts of the region, resulted in a change in the vegetation types and, thus, fire regime. Moreover, afforestations with highly flammable pine and eucalyptus forests on former agricultural and pasture lands have increased fire hazard. Recently recreation activities, the development of urban sites in woodlands (tourism and residential housing), and the misuse of fire-setting as a political device have raised the probability of ignition. It is, however, not clear how the changing land-use pattern will affect the vegetation types and fire regime, overall land management planning, and the contribution of wildland fires to regional atmospheric chemistry.

The contemporary fire regimes of the Mediterranean Basin are entirely human-made. This is why "the protection against forest fires needs to recognize two facts:

(i) Fire is an integral factor of the Mediterranean ecosystems, because of the climatic and demographic conditions of this region.

(ii) The worsening of the situation has a socio-economic origin" (Vélez 1993).

Therefore, it is mostly astonishing that the eco-subsystem "society" is still treated marginally in both fire prevention policy and fire ecology research.

Fire Causes

The majority of forest fires in the region are caused by humans. Human-caused fires account for 95 to 99% of all fires, while natural agents are responsible for the remaining 1 to 5%. Human-caused fires can be examined under three broad categories – voluntary, involuntary, and unknown fires. The shares of each category differs from country to country and from region to region. When examined in detail, it is very obvious that fire causes are closely related with land management activities, standards of living and population dynamics (Bilgili *et al*., 1999). Thus, to better understand the underlying causes of fires, the subject should be examined in relation to these factors.

Land Use and Vegetation

Land use is the general term for human activities on earth surface. It includes agriculture, silviculture, pasture, settlements, networks of communication, recreation areas, and so on. Through using the landscape - extensively or intensively - mankind changes the land´s natural potential and with it also the natural fire regimes. The manner of land use is usually a combination of tradition and history, economic constraints, technical and financial possibilities, natural delimitations, cultural and psychological motivations, the means of land possession, and politics. Three main land use types prevail in the Mediterranean Basin, namely forestry, pastoralism and agriculture.

Of course the changing of natural fire regimes is very obvious in **forestry**. By planting or cutting woods, by collecting fuel biomass, by fighting wildfires, and by setting woodland on fire both purposely and accidentally, the natural equilibrium of the forest ecosystems has been disturbed and has been replaced by entirely human-made ones.

In the Mediterranean Basin **pastoralism** still plays an important role. Through setting fire to natural forest and brush humans gain pastorages, while repetitious grazing selects plant species and prevents maturation of vegetation. Overgrazing has been recognized as one of the most destructive processes to the Mediterranean environment. However, "animal grazing of the understorey vegetation, carried out in a rational way, constitutes a very efficient tool for eliminating fuel accumulation on the ground surface..." (Liacos 1988).

The third area-wide land use in the Mediterranean is **agriculture**. By clearing surface cover in order to receive arable lands, farmers stopped natural burnings and replaced them for occasional prescribed burns. The migration of the rural population from peripheral regions into cities and the abandonment of traditional agriculture have made possible the reinstallation of brush and forest lands - and with them the return of fire risk.

Forestry, livestock-farming, and agriculture - as area-wide activities - influence to a highest degree the actual fire regimes. These activities are dependent on social and economic factors. Determination and analysis of these factors should be a major task for the research community.

In order to approach economic and political factors of land use and fire regimes, the following questions should be answered:

- What are the future tendencies?
- What kind of socially acceptable land-use practices would keep the biomass fuel at acceptable levels of low fire hazard (e.g., prescribed burning, prescribed grazing)?
- What is the social and economical interest in existing vegetation (structure and species)?
- What is the fire adaptation of socially and economically desirable plant species?
- How did history and land use influence vegetation composition?

- What are the ethnic, cultural, and psychological motives behind the human creation of different vegetation formations?
- What could be socio-economically compatible alternatives of less flammable vegetation to the existing one?
- What kind of natural firebreaks are socially acceptable?
- What other interests besides the reduction of fire hazard could society have in vegetation pattern diversity (e.g., biodiversity, recreation activities, hunting)?

Only answering these questions will we be able to determine the human impact on plant composition and to give sound recommendations for a socially adapted but less fire-prone vegetation. The analysis of vegetation is also closely connected with the land use. As a result of investigation in the impact of land use on fire regimes, suggestions for less fire-favouring and more socially acceptable patterns of land use should be made. This could happen through both general and specific terms (e.g., national agriculture policy, land-use maps of a region), by consulting responsible institutions (e.g., the fire risk of different plantations), and by advising politicians (e.g., laws).

Population

Population and land use are correlated systems. Not only the quantity of human beings, but also their distribution and the quality of their action and interaction determine land use. Settlements and communication networks cover more and more of the earth's surface. Metropolitan areas expand while at the same time rural homes are mostly constructed within woodlands. The wildland/residential interface shows an increasing disaster risk. Investigations have shown "a significant conformity" of burnt areas "with the areas where an important, demographic unbalance has penetrated and become accentuated" (Delgado 1990).

The expansion of recreational uses in the forest - mostly in times of high fire risk - leads to an increase of potential ignition sources. This new tendency of residential urbanization and tourism in "natural" woodlands has risen the peril of careless ignition. Additionally, criminals have discovered in arson a means of reaching their aims (vengeance, delinquency, speculation). There is substantial evidence that social and political unrest leads to an increase of arson fires. Examples from Greece, Cyprus, and - recently - Algeria show that domestic political problems are well reflected by forest fires.

In order to effectively prevent wildland fires, the reasons why they exist and spread have to be clarified. Demographic and political analyses, inquiries in behaviour of individuals and societies, inventories of urbanization, and plans of development need to be carried out. This requires a broad cooperation of various social scientists and geographers. Moreover, the results of such a research should be prepared in forms not only suitable for integration into research models but also for teaching and raising public awareness.

Culture and History

"Wholesale anthropogenic modification of the biosphere did not begin with the industrial revolution or with the neolithic revolution but with the hominid revolution announced with promethean splendor by the capture of fire" (Pyne 1994, 1997). Being conscious of the importance of human impact on fire regimes, it is hard to understand why Mediterranean fire ecology research has neglected the cultural and historical aspect of the topic for such a long time. "An understanding of fire history is necessary to ascertain future effects of anthropogenic fire on the environment and atmosphere. ... Such studies should include the cumulative influences of past burning practices and current fire regimes, and they should seek to establish trends that can be projected into future scenarios for societies and the ecosystems they inhabit" (Kauffman *et al.* 1993).

The comparison of different eras and/or different cultures would help illuminate the human impact on fire. Questions should be asked and answered such as following:

- How did fire regimes change within key epochs (Roman Empire, Islamic expansion, end of pre-Columbian period, industrial period)?

What is the cultural impact on wildfires?

How do differing land-use systems affect fire regimes in naturally similar but culturally different landscapes? (e.g., Southern Spain and Northern Africa).

Research that seeks answers to such questions has to deal with a broad spectrum of scientific methods and strategies. Every data set - charcoal, fire scars, ethnographic accounts, forest stand structures, paintings, census statistics, literature, government reports, etc. - has to be taken into account (cf. Clark *et al.* 1997). Sophisticated technologies and traditional concepts as well as the natural and social sciences should be complementary. One of the biggest problems of such an investigation may be the exchange and accession of dispersed data.

Socio-Economics and Policy

"Forest fires are not an autonomous phenomenon, but a symptom of socio-economic problems" (Vélez 1993). Depopulation of rural areas, the relinquishing of traditional agriculture, pasture, and silviculture, recreational activities, urbanization, arson, and so forth are the results of the socio-economic situation that confronts the Mediterranean population, and these considerations must frame any policy of fire management. The governmental support of fossil energy, for example, has displaced traditional fuels which now remain in the forests. The subsidy of intensive mass production gives way to the abandonment of peripheral and multifarious agriculture.

A political decision might influence fire regimes in a way that can scarcely be foreseen when released. Goldammer (1988) lists some legislation and regulations related to forest fires. It is amazing how multiple are the direct impacts of policy on fire regimes. How much more involved must be the indirect impact, usually through the device of economic regulations. There should be analyses pointing out the effect of political decisions on fire regimes. Moreover, the causes of incendiarism have to be clarified and the motives eliminated. Social, political, and psychological analyses are needed and such scientists should work together with the fire ecological research community toward common solutions.

Research Needs: Rationale

In the last decades many efforts have been made in the Mediterranean to collect data regarding ecosystem response to wildfires as well as fire behaviour. Danger-rating systems have been installed; models for simulating fire behaviour and for detecting fire-prone areas (e.g., BEHAVE, CARDIN) have been elaborated. At the same time fire fighting techniques have improved, the amount of well trained personnel has increased, detection and monitoring networks have expanded, and aircraft, helicopters, and modern fire patrol vehicles have been made available. But "in spite of the efforts and expenditures on fire suppression, wildfires in the Mediterranean are becoming more frequent and devastating" (Naveh 1990).

Fire ecology research still concentrates on the natural causes of wild fires (climate and weather conditions, vegetation composition and fuel development, topography), on fire behaviour (simulation), and on fire impact on the ecosystem (monitoring of vegetation succession and soil characteristics, atmospheric deposition), whereas the social impact on the fire regime is treated marginally by researchers. This is an irony given the fact that fire conditions in the Mediterranean Basin are primarily anthropogenic.

In order to be able to predict fire regime tendencies, to detect fire-prone areas, to launch sound fire prevention measures, and to understand fire behaviour, complex models are required. A lot of investigation has been executed within this scope, and many different models are available. Most of them concentrate on those subsystems of the ecosystem that include biological and geographical data. Meteorological values, vegetation and fuel factors, and the georelief deliver the main input parameters for the common models (e.g., BEHAVE). But remembering statements made, for example by Vélez (1994) - "The forest fire problem has an essentially human origin component which has to be dealt by sociological approaches" - one can ask why so few models contain anthropogenic system parameters.

One problem is the incompatibility of the type of data required by mathematical models and the type of data delivered by sociologists, historians, and ethnologists. Another problem is the reluctance for interdisciplinary cooperation within the research community. Researchers nowadays tend to restrict themselves to details within their scientific scope and to consider every possible aspect of each detail. But the more perfect the subsystem models are, the greater the risk that they cannot be integrated into a general/complete system. More-over, the complete model has to reduce its level of quantitative characterization to the level of the least figured one (Leser 1991). One of the least figured systems in fire ecology is the human subsystem. Making other subsystems more perfect will not improve the complete model as long as anthropogenic factors remain neglected.

"A sizeable body of work on fire has concentrated on individual events and on the characteristics of the burning process itself; there is now a recognized need for assessments of the characteristics and effects of fire at hitherto unexplored scales. This calls for a better understanding of burning on regional and global scales, a better appreciation of historical changes that have affected the use of fire during various periods of human history, and, if possible, improved predictable capabilities to chart future trends and possible impacts" (Malingreau *et al.* 1993). "...Research is needed to develop fire models that link spatial scales. These models must be developed with the capacity to account for the evolution of changing cultural, economic, atmospheric, and biological conditions. ...Trade-offs of ecological effects, altered fire regimes, and ecosystem properties between the use of fossil fuels and the traditional role of biomass burning must be described. These include costs and benefits of land-use practices on the atmosphere, biota and humans at local, regional, and global scales " (Kauffman *et al.* 1993).

Politicians and managers ask for research that clarifies the reasons for the increase of wildfires and that is applicable and politically acceptable. They request background analyses and practical suggestions. Research results should lead to recommendations for application: Realistic recommendations for land-use systems have to be made. The way has to be shown by what political devices (e.g., laws, subsidies, education) the stated objective can be achieved. Key questions have to be asked and answered. By understanding the anthropogenic background of fires we will be able to think about solutions to the problem. This will enable managers and politicians to enact an effective prevention policy.

Moreover, international exchange and cooperation of fire research groups seem to be very unsatisfactory. Thus, efforts have to be made to promote international cooperation and exchange of knowledge and to compare different fire regimes created within the same ecosystems but with different land-use systems, and to analyze future tendencies. The concept presented in this paper shall be one step into this direction.

All these problems should not produce a hopeless feeling, but should be an encouragement to tackle the task. Anyway, before thinking of how to integrate anthropogenic data into a coherent and realistic operational system we should think of what parameters are needed in order to understand the human impact on fire regimes. The input data are derived from research results (i.e., model development), and there is still an immense scientific backlog of demand. "The body of knowledge currently available to address the human role in the use of fire has been driven by a variety of land-use, scientific, and cultural objectives. As such, there has been no overall strategy for data collection.... identification and investigation of the critical gaps in our knowledge concerning the human role in shaping fire regimes, ecosystem properties and climate are particularly important" (Kauffman *et al.* 1993).

Fire ecological research will have to include economical, social, cultural, historical, ethnological, and psychological factors of the "Total Human Ecosystem" (Naveh and Lieberman 1994). All the parameters that influence and interfere with fire regimes have to be investigated and analyzed. Efforts have to be made to investigate the impact of society on wildfires, to promote international cooperation and exchange of knowledge, to compare different fire regimes created within the same ecosystems but with different land-use systems, and to analyze future tendencies. High levels of interdisciplinary and international cooperation will be demanded - a challenge to the research community.

The System and the Model

At the Second International Conference on Forest Fire Research, Coimbra University, Portugal 1994, the first pan-Mediterranean fire research program was proposed (Goldammer 1995). Its interdisciplinary nature was expressed by its designation "**F**ire **I**nformation Systems **RE**search in the **S**ocio-**C**ulture, **H**istory, and **E**cology of the **M**editerranean **E**nvironment" (FIRESCHEME). FIRESCHEME was proposed to be a large research endeavor in the concert of a series of other programmes which address the role of vegetation fires in regional, subcontinental, continental, and inter-continental to global scales. FIRESCHEME was proposed as an international multi- and interdisciplinary project, which aims to illuminate the human impact on fire regimes in the Mediterranean Basin, in particular:

- History and prehistory of land use and fire
- Development and treatment of Mediterranean vegetation and potential natural vegetation
- Socio-economical, cultural, historical, and political background of fires
- Present state of vegetation as related to e.g., wildfire hazard, consequences of fire
- Contribution of Mediterranean wildland fires to regional atmospheric chemistry during the fire season
- Management practices.

The FIRESCHEME concept shall not only show the complexity and diversity of natural and anthropogenic fire regimes and fire impacts, but also contribute to the

- Development of a new valuation of Mediterranean fire
- Delivery of data to a Global Cultural and Historical Fire Model
- Contribution to a Global Vegetation Fire Information System (GVFIS) at the Global Fire Monitoring Center (GFMC)
- Delivery of data to regional and global atmosphere and climate models
- Improvement of operational fire management decision support systems.

The research must be supported and integrated by advanced methods and technologies used by the scientific disciplines involved, such as remote sensing and Geographic Information Systems (GIS). "We still need to develop more sophisticated answers to meet the needs in the coming decades. This may require rethinking some of our approaches, redesigning some of our methods, and reconstructing our research. Answers must become more realistic and non-deterministic; approaches more integrative and holistic" (Martin 1990).

FIRESCHEME will be a research activity coordinated with ongoing and planned regional fire research programmes under the umbrella of the International Geosphere-Biosphere Programme (IGBP) Core Project "International Global Atmospheric Chemistry (IGAC) with its Biomass Burning Experiment (BIBEX), IGBP-GCTE (Global Change and Terrestrial Ecosystems), IUFRO, and the International Boreal Forest Research Organization (IBFRA).

Operational Steps: Definition of Objectives, Planning and Implementation

The objectives of FIRESCHEME are not yet defined in detail. The definition will depend on the inputs and implementation capabilities of the research groups interested in becoming involved. The IUFRO Forest Fire Group (8.05) meeting at this World Congress is offering an opportunity to determine the first steps to be taken.

The finance component is still open. FIRESCHEME could potentially be financed following the example of STARE/TRACE-A/SAFARI (Van Wilgen *et al.* 1997, JGR 1996). That research campaign involved more than 150 scientists from numerous institutions of 14 participating nations. Each of the groups brought their own budget into the exercise and shared resources.

The organizational umbrella of the International Geosphere-Biosphere Programme

(IGBP) with its core projects, e.g., IGAC (International Global Atmospheric Chemistry Programme), GCTE (Global Change and Terrestrial Ecosystems), and PAGES (Past Global Changes), is offering structures and access for national funding.

In the case of FIRESCHEME, however, it is proposed to conduct the programme under the auspices of the European Forest Institute (EFI). An independent and non-governmental research body, EFI conducts problem-oriented and multidisciplinary forest research at the European level in order to serve the needs of policy-making and decision-making bodies in Europe. FIRESCHEME would include the North African and Near East regions because of their strong historic, cultural, and environmental links to the European part of the Mediterranean Basin. This should not discourage the fire research community to apply for sponsors through a Europe-oriented research facility. A relevant proposal needs to be drafted and submitted to EFI. A feasibility study would provide appropriate answers to the many open questions which remain after the founding of FIRESCHEME.

Call for Participation

Objectives and final achievements of FIRESCHEME depend highly on inputs and active participation of interested groups. In order to explain Mediterranean fire, FIRESCHEME requires a large variety of datasets, e.g., analyses of sea and lake sediments, alpine ice cores, pollen, charcoal, fire scars; anthropologic, ethnographic, socio-economic, and cultural accounts; historic and modern literature, paintings, and other artwork; reports from explorers; government reports, census statistics; historic and modern composition and distribution of vegetation; historic and contemporary land-use systems; regional climatology and atmospheric chemistry; etc.

With the use of modern technologies for describing the Mediterranean fire environment, such as remote sensing techniques, and advanced methods of processing large amounts of data and integrating information into systems like Geographical Information Systems (GIS), the research community will be able to create a highly interdisciplinary working platform.

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Sub-Plenary Session: A2 – Posters

Sustainable Management of Natural Resources:
Fire and Forest

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Fire Occurrence in Relation to Weather Conditions

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Abstract

This paper presents and evaluates the effects of fine fuel moisture content of forest floor fuels on fire occurrence in mediterranean ecosystems of Turkey. Fine fuel moisture contents were measured in an even-aged, fully stocked red pine (Pinus brutia) stand near Izmir. Three fuel samples were taken daily in the early fire season in June and once or twice a week thereafter. Fuel samples were weighed and oven-dried at 100^{o}C for 12 hours or until no change in weight was attained. Moisture contents were determined based on the weight difference between before and after oven-drying. Weather measurements were taken daily at noon local standard time from a nearby weather station located at Menderes Interantional airport. Measurements included temperature, relative humidity, wind speed and direction, and precipitation. Fire occurrence data during the study period were obtained from the Regional Forest Directorate in Izmir. Analyses showed that a close relationship exists between weather conditions and fire occurrence. Indexes generated from this study should be invaluable for fire managers in the region and other places having similar conditions.

Keywords: Fine fuel moisture content; Weather; Fire occurrence; Turkey

Performance of the Monte Alegre Formula on Fire Danger Evaluation in Different Regions of Brazil

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Abstract

The occurrence of forest fires is highly influenced by weather conditions. For that reason, fire danger rating indices based on meteorological variables are important tools to aid in planning and supervising fire control activities in fire protection units. Besides presenting a good performance, an index must be adapted to the local conditions, mainly to the available data for its calculation. That is why sophisticated indices that require data that is not easy to obtain cannot be used in developing countries, where meteorological and other necessary information are seldom available. The "Monte Alegre" formula (MAF) was developed in 1972 using meteorological and fire occurrence data of the central part of the State of Paraná , and has since been used by most forest institutions and companies in Brazil and other South American countries to predict fire danger. It uses only three variables: relative humidity (directly), number of days without rain and amount of precipitation (both indirectly), and can be easily calculated every day through the following equation:

MAF = 100 SUM FROM { n=1 } TO { n } 1 OVER H

where n is the number of days without rain and H is the relative humidity measured at 1:00 PM.

The performance of the MAF was evaluated in three deferent forest districts in the southeastern and southern regions of Brazil. Firstly, using a data set from the region where the index was developed (Cfa climate, according to Koppen's classification), its performance was checked. Results showed that 52.5% of the fires registered in that period occurred when the index indicated a very high danger; 31.7% when the danger was high; 13.8% when the danger was medium; 2.0% when the danger was low; and no fire was recorded when the index indicated no danger. Secondly, using data from a forest district in the southern State of Santa Catarina (Cfb climate), the MAF was compared to the locally used index, developed by the South Carolina State Department of Forestry, USA, (SCI) in the 1960s. By the MAF, 13.0% and 87.0% of the recorded fires occurred when the index indicated high and very high danger, respectively. When the SCI was used, 43.5% of the fires occurred when the danger was low, 26.1% when the danger was medium, and 30.4% when the danger was high; and no fire was recorded when the index was very high. Thirdly, using data from a forest district in the central region of the southeastern State of S o Paulo (Cwa climate) the performance of the MAF was compared to three other indices: Nesterov, Tellysin, and the Canadian Fire Weather Index (FWI). Three methodologies were used to test the efficiency of the indices: Mahalanobis distance, Friedman's test, and distribution of the occurrences through the danger scale of the indices. According to the Mahalanobis distance and Friedman's test, the FWI was more efficient but when the distribution of the occurrences through the danger scales was used, the MAF was more efficient in estimating the fire danger of the region.

Keywords: Fire occurrence; Fire causes; Brazilian tropical forest/savannas

Wildfire Occurrence in a Forest District and Other Brazilian Protected Areas

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Abstract

Wildfire is a permanent threat to native and planted forests in most part of the Brazilian territory. Periodical dry seasons and abnormal weather conditions have induced to large and destructive fires from time to time. In 1998, for instance, an extremely large fire burned about 13,000 km2 of tropical forest and savanna vegetation in the State of Roraima, located in the Amazonian region. Despite the preoccupation with the tropical forests, data on fire occurrence in that ecosystem are not sufficient to make a good description of fire occurrence in Brazil. This paper presents the history of fire occurrence in the Agudos region, State of Sao Paulo, southeastern Brazil, from 1984 to 1995 and other protected areas throughout the country. The center of the forest district area is located approximately at 22 28'S, 48 59'W and 526m above sea level. The fire season in the region goes from June to November. There was statistical difference among the months of the year for both, number of fires and burned area. August, with 21.60%, presented the higher number of occurrences, and 76.36% of the fires occurred from June to November. September presented the largest burned area (28.49%), and 80.41% of the total area affected by wildfires burned from August to November. There was no statistical difference in the number of fires or burned areas among the days of the months and the weekdays, although Sunday, with 17.36% of the occurrences and Monday, with 24.86% of the total burned areas had presented the highest numerical values. However, significant difference was observed both, in the number of fires and burned areas, among the hour of the day. About 85.17% of the fires and 91.97% of the burned areas were recorded between 10:00 AM and 06:00 PM. The hour that presented the highest occurrence was 02:00 PM, with 17.20% of the recorded fires. Precipitation was the weather variable that presented the best correlation with fire occurrence. About 42.1% of the annual precipitation and 82.41% of the recorded fires occurred between April and October. August was the month with lower precipitation and higher number of fires. Data collected from protected areas in the Brazilian territory in 1994 and 1995 presents similar results showing that the history of forest fire occurrence is similar all over the country. September, with almost 30% of the recorded fires, was the leading month in fire occurrence, and 84.61% of the fires and 97.85% of the burned area were observed between July and October. Arson (41.40% of the fires and 11.81% of the burned area), Debris burning (32.26% of the fires and 79.55% of the burned areas), and Smoking (10.21% of the fires and 1.13% of the burned area) were the leading causes of forest fires.

Keywords: Fire danger rating; Fire occurrence prediction; Brazil fires

An Analysis of Forest Fire Behavior Based on Estimation of Wind Direction and Wind Velocity at the Time of the Fire

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Abstract

Wind direction and wind velocity data are necessary to analyze the behavior of forest fire and its propagation. It is possible to obtain prevailing wind data from weather stations but not the characteristics of fire whirlwind at the site of the forest fire unless we measure it at the time of the fire.

This paper presents a procedure of estimation of wind direction and wind velocity from the stem-bark char remained at the forest fire damaged area. In this investigation, in order to clarify the relation among the factors affecting fire-scar of stem, wind tunnel experiments were carried out. And in order to establish how to predict the forest fire behavior, field experiments were carried out using opportunities of prescribed fire.

In the wind tunnel experiments, it was observed that the height of stem-bark char registered at the windward face of a stem is smaller than that of the opposite face of a stem under all the experimental conditions. Therefore, an estimate of wind direction from the remaining stems in a burned field can easily be done.

Further it was found that, the height of stem-bark char of windward face of a stem decreased as the wind velocity increased. The height of stem-bark char of a stem opposite the windward direction increased as the diameter of the stem increased. It was derived from these results that the magnitude of the difference in height of stem-bark char of windward face and opposite face of a stem was an important factor for estimation of wind velocity. From a viewpoint of field application, stem-bark char ratio of both faces of a stem tends to be significant as well as the difference in height of stem-bark char of both faces, because of the dissimilarity of scale in wind tunnel experiment and actual phenomena in the field. Dimensional analysis was carried out for the factors affecting the stem-bark char using the observations mentioned above. Based on the results of the study, the equations for estimation of wind velocity were proposed when the stem partially burned.

In the field experiments, first, the wind velocity calculated by experimental equations was compared with wind velocity observed in two prescribed fire sites. It was observed that the wind velocity could be expressed with a high accuracy by the above-proposed equations.

When the fire behavior was an upslope fire, the fire whirlwind directions estimated from the stem-bark char showed a fixed direction. Fire whirlwind direction agreed approximately with slope azimuth, in spite of a prevailing opposite wind direction. Further relationship between fire whirlwind velocity estimated by experimental equations and maximum slope gradient was investigated. However, it was not possible to recognize a relationship between them using individual data of slope angles and wind velocities estimated, which could be due to the differences in on-site condition of experimental logs. But, dividing the slope into ranges and taking mean values for gradient instead of individual values, it was observed that fire wind velocity increased as maximum slope gradient increased.

Keywords: Forest fire; Fire behavior; Wind direction; Wind velocity; Stem-bark char

Forest Plantation Fire: the SAFODA Experience (Sabah Forestry Development Authority)

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Abstract

The Sabah Forestry Development Authority (SAFODA) was enacted in December 1976, its objectives are to convert wasteland and marginal agricultural land to a highly productive forest plantation and to uplift the living standard of inhabitant through employment in reforestation and afforestation work related to forest plantation establishment. SAFODA has allotted 118,756 ha. of land throughout the state of Sabah for that purpose. By the end of July 1998, SAFODA has planted about 31,417 ha. of trees mainly *Acacia mangium* and 8,356 ha. of rattan. Other than pest and disease problems, fire is still the most dangerous phenomena due to its extensive negative impact toward certain ecosystems and has long been the major treat in forest plantation project. In 1983, it is recorded that about 5,565 ha. of the SAFODA forest plantation throughout the state of Sabah had been burnt and the latest occurrence was during El Nino 1998 period, which 3,818 ha. of plantation were totally burnt. The objectives of this paper are to highlight and share the experience of forest fire occurred in the Bengkoka Forest Plantation Project in Sabah, its also discuss the problems encountered, annual budget, fire fighting technique, material and equipment used as well as the future direction of research needs. Since 1983-1998 there were 124 fire cases in Bengkoka Forest Plantation Project caused by mainly farm burning, smokers, campfires and incendiary. Most of the fire occurred in March to October each year. It is also noted that one to five years old forest plantation is very severe to fire. Therefore, an effective forest fire management system is really needed to lessen these problems.

Keywords: SAFODA; Reforestation; Afforestation; Plantation fires

Natural Regeneration of Tectona Grandis and Gmelina Arborea After Fire in Ikrogon Forest Reserve, Cross River State, Nigeria

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Abstract

Ikrigon Forest Reserve is a dry lowland rainforest, surrounded by a Derived Savannah and located between latitude 6.17 degrees north and longitude 8.36 degrees east. The total forest reserve area is about 600 hectares. The soil is loam to loamy sand with rock composition of mainly granite, quartzo-feldspathic biotite and hornblends-bearing gneisses, schists and magmites (Wright et al 1985).

Since the forest reserve is within a derived savannah, there is yearly fire occurrence which affects the natural and artificial forest in the area. At the plantation forest edge, bordering the savannah where principally *Gemlina arborea* (Gmelina) and *Tectona grandis* (Teak) are the planted reserve boundary species, there is annual seed dropping on the forest floor and the adjoining savannah area. This annual seed dropping has led to the natural establishment of seedlings of these plantation species on the frontiers of the adjoining savannah woodland. Over the years, the seedlings have grown under the strong competition induced by annual fire, spatial distribution of seedlings, nutrients, soil, water and sunlight.

The result of this situation is natural selection in which some seedlings have grown to poles and trees while others remain stunted as perpetual understory species due to lack of adequate sunlight and persistent annual fire. The litter drop of *T. grandis* is heavier than that of *G. arborea* and the leaves of the former wider in area than the latter. The leaves of *G. arborea* decay faster than those of *T. grandis*. The result is that there are more *G. arborea* seedlings on the forest floor than those of T. grandis. The perpetual persistent litter of Teak does not support profuse seedling production in Teak.

Data collected in mini-quadrats of 10 m by 10 m show an average spread of about 8,900 seedlings per hectare in Teak and 8,547 in Gmelina. There are also 494 trees established in one hectare of Teak and 567 in Gmelina. This means that the trees naturally establish themselves at an average espacement of 4.5 m by 4.5 m for Teak and 4.2 m by 4.2 m for Gmelina. It is also deduced that in Teak area, over 8,406 seedlings lose the competition battle due to annual fire, heavy leaf litter, root competition, and canopy closure of dominant trees. The maturity survival percentage of the species under natural and untended conditions is 5.6%. Similarly, in the Gmelina area 7,980 seedlings lose the attainment of mechartable size due to fire, competition for nutrients, sunlight, and weeds. The maturity survival percentage of Gmelina in the area is 6.6%. The heavy litter and canopy in the Teak area neither permits weed growth nor speedy development of seedlings. In the Gmelina area however, canopy is almost open thereby allowing for more Gmelina seedlings and weed growth. This is proved by the tree survival in the two plots assessed. The Teak plot does not therefore allow for encroachment of many indigenous species while the Gmelina plot does - especially weeds (Cromolena odorata).

Recruitment and survival is therefore based on the annual severity and time of occurrence of fires, competition for nutrients, sunlight, weeds, and canopy effects. Natural espacements for Teak and Gmelina seedlings on the forest floor are 1.06 m by 1.06 m and 1.2 m by 1.2 m, respectively. Also natural espacement for mature teak and Gmelina are 4.5 m by 4.5 m and 4.2 m by 4.2 m, respectively. The espacements exhibited by these tree species can scientifically influence espacement decision in plantation silviculture.

Keywords: Nigeria; Plantation fires; Regeneration; Fire severity and timing

Impact of Fire on Forest Insect Species Diversity: A Study in the Silent Valley National Park, India

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Abstract

The Western Ghats of India, which is the most imposing, but extremely threatened topographical, floristic and faunistic feature of the Indian subcontinent is one of the 18 biodiversity 'hotspots' of the world. Spread over an area of 175,000 sq.km. in six States, this mountain range extends more or less parallel to the west coast of Indian Peninsula from Kerala to Gujarat traversing a length of 1600 km. The Silent Valley National Park is situated in the Palghat District of Kerala State, between latitudes 1103' and 11015'N and longitudes 76023' and76030'E. As per the world classification of Udvardy, the area falls under the Malabar Rainforest Realm.

The total area of this forest is 90 sq.km. and accessibility to this area is restricted due to the steep slopes on all sides. The region is characterised by heavy summer rains and the mean annual rainfall is 4400 mm. The major forest disturbance is fire which frequently occurs during the summer season in the grasslands and spreads to the adjacent natural forests. As a result, several patches of natural forests get degraded leading to disappearance of many evergreen species. The 'gaps' thus formed in the forest due to burning are subsequently colonised by various secondary species that are found in the adjacent moist deciduous forests and grasslands.

The impact of fire on insect species diversity was studied in representative plots. Altogether. eight plots were taken along a transect in such a way that four plots were in the fire affected zone and the remaining in the unaffected forest patch. Plot size was fixed as 625 m2 and the distance between plots was 25 m. Data on vegetation and insects were collected from all the plots and from this, the species composition as well as the indices of diversity, dominance, evenness, species richness etc., were computed separately for plots in the fire affected and unaffected zones.

There were 3951 plants belonging to 130 species in the study area, of which 1608 plants belonging to 81 species were found in the undisturbed area and 2343 plants belonging to 109 species in the disturbed area. The diversity index for the undisturbed area was 3.66 and the value for the disturbed area was 3.55.

The floral composition in the disturbed and undisturbed areas was also interesting. While the undisturbed areas had good representation of primary species like Palquium ellipticum, Aglaia sp., Myristica dactyloides, Mesua ferrea, Cullenia exarillata, Holigarna arnottiana, Casearia bourdiloni and Persea macrantha, the disturbed areas had only poor represention of these species. More over, there was an invasion of various secondary species like Olea dioica, Scolopia crenata, Macaranga peltata, Zizyphus rugosa, Walsura trifolia, Celtis sp., Albizia chinensis and weeds like Clerodendron viscosum, Mikania micrantha and Lantana sp.

Altogether. 10451 insects belonging to 578 species under 13 Orders and 67 families were collected from the study area. Of these, 5781 insects belonging to 449 species were from the undisturbed area and 4670 species belonging to 417 species from the disturbed area. Thirteen Orders and 61 families were represented in the undisturbed area and 12 Orders and 60 familiesin the disturbed area. The species diversity index was 4.76 in the former and 4.65 in the latter.

Consequent to the changes in plant composition following forest disturbance, there was a higher representation of arboreal feeding insect families (Geometridae, Saturnidae, Cossidae etc.) in the undisturbed area where as herbaceous feeding families like Pyralidae, Noctuidae, Chrysomelidae etc., were very abundantly found in the disturbed area. The Orders Diptera, Lepidoptera, Coleoptera and Hymenoptera were the most dominant groups in both the areas.

The implications of forest fire on insect species diversity in the tropical forests are evident from the reduction in species diversity. As a result, several rare and endemic species are seriously affected and many are likely to be phased out unless urgent corrective measures are undertaken. A critical examination of species collected from the study area has shown a steady loss of arboreal feeding forms and abundance of weed feeding forms. Conservation strategies based on the findings of this study will be discussed.

Keywords: Western Ghats; India; Biodiversity; Fire impacts; Succession

Growth and Development of A Maritime Pine Stand After Fire

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Abstract

Three permanent plots, each with 1000 m2 were laid out in 1989 in a State managed pine forest in the northwest of Portugal. The plots, installed in 1989, are located on a natural regenerated pure even-aged stand of Maritime Pine (Pinus pinaster Ait.), after a forest fire in 1975. To decide about the most appropriate degree of thinning for this kind of stands two degrees of intermediate thinning were performed in 1992. In August 1993 a forest fire attained the three plots but it was decided to keep it to evaluate the impact of the fire on tree vigour, tree mortality, tree growth and yield and the occurrence of natural regeneration of maritime pine and other forest tree species.

At the first measurement, in 1989, each plot contained six tree rows, approximately four meters apart. Diameter measurements, at 1,3 meters above ground level, were collected for all trees within each plot, by taking the average of two caliper measurements. Tree height measurements were performed for sample trees only, ca. 40 in each plot, using an extending measuring pole. At the second measurement in 1992 tree height and breast height diameter were measured in the same manner. The height of the beginning of the crown was measured for all sample trees using a pole. The crown was considered to begin at the point on the tree stem where the first two green branches were detected. Furthermore, for all trees within the central four rows of each plot, four crown radii measurements, considering the greatest extension of tree crown, were made at approximately 90 degrees to each other. The overall plot dimensions and the spatial arrangement of the trees within each plot were measured using a extending tape. The corrected distance measurements, for the slope, together with crown radii measurements were utilised to construct crown maps of each plot.

In 1994, 1996 and 1998 tree height, breast height diameter and the height of the beginning of the crown were measured in the same manner, all the trees were examined in relation with the occurrence of pests or diseases and classified according their vigour. In 1998 new crown maps were realised and the natural regeneration was identified and counted in ten square plots randomly located , each with 1m2, in each plot.

The effect of fire on all the above-described parameters and their evolution in the last five years are reported in the paper/poster.

Keywords: Portugal fires; Regeneration; Growth rates

Assessment of Forest Fire Impacts in East Kalimantan Using Satellite Remotely Sensed Data

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Abstract

It is difficult to assess and get general view of large scale forest fire with ground survey alone. Satellite remote sensing technique, which enable monitoring over a large area multi-temporally, were employed to map the extent and degree of the large scale forest fire occurred in East Kalimantan Province, Indonesia, between mid 1997 and early 1998. According to the report of Indonesian Government, this fire damaged more than 520,000ha of forest in this Province. Southern part of Samarinda, the capital city of East Kalimantan Province, was selected as a study site. The study site covers 24,1000ha, including Bukit Soeharto Education Forest (BSEF) and Sungai Wain Protection Forest (SWPF). Although BSEF and SWPF are both protection forests, they have different degree of protection level and different types of vegetation management.

Two change detection analysis methods, Normalized Difference Vegetation Index (NDVI) analysis method and Change Vector Analysis (CVA) method, were introduced to map vegetation cover changes caused by the forest fire, using 5 scenes of Landsat TM data (acquired on 1997/4/13, 1997/8/3, 1998/1/26, 1998/2/11, and 1998/3/31) and 3 scenes of JERS-1 OPS VNIR data (acquired on 1996/9/27, 1997/8/1, and 1998/6/5). Maps of detected change derived from NDVI analysis represented suitable results compared to CVA when using limited ground information, and were adopted as the maps of vegetation cover change in this study. From this satellite remote sensing data analyses, 26.8% of land area in the study area showed vegetation decrease from February to March 1998, which probably caused by the forest fire, and 11.8% showed vegetation increase from March to June 1998 by regeneration of vegetation after the forest fire.

A GIS database of this study area was newly constructed to find out the relationship between human activities and forest loss due to the fire. The database comprises spatial data such as 1) slope model, 2) basin/ridge model, 3) buffer zones representing human activity area, 4) boundary of the BSEF and SWPF, and 5) land cover map of the study area before the forest fire obtained from RS data classification. By overlaying vegetation cover change layers with other GIS layers, it was possible to assess the scale and degree of the forest fire in relation to human impact and vegetation management condition.

From February to March 1998, 54.8% of forest area in BSEF, where protection of vegetation by university had been not carried out sufficiently, showed vegetation decrease caused by the forest fire. While in SWPF, where sufficient vegetation protection by Indonesian Government had been carried out, 31.5% of forest area showed vegetation decrease in the same period. Furthermore, SWPF showed 6.1 times large vegetation regeneration area compared with BSEF after forest fire, from March to June 1998. By using 1 kilometer buffer zone of human activity area, where human impact to vegetation environment thought to be large, 65.1% in BSEF and 50.2% in SWPF showed vegetation decrease from February to March 1998. They suggest that the vegetation change of the study site caused by forest fire have strong relation to the conditions of vegetation management.

Keywords: Remote sensing; Indonesia fires; Fire impact assessment

Sustainable Management of Natural Resources: Fire and Forests

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Abstract

Forests are not merely an economic resource but constitute an essential life support system, especially for the people living in mountainous or rural areas, Recurring forests fires cause considerable damage and degradation to forests and environment every year and more so in a cycle of four to five years. Ministry of Environment and Forest, Govt. of India, appointed a committee to assess the damage from forest fires in Uttar Pradesh (U.P.) and Himanchal Pradesh (H.P.) in 1995. This committee assessed direct economic losses to the tune off 139.3 million rupees, in U.P. alone during the Fire season of 1995. It also recommended that studies to make a scientific and comprehensive assessment of damage resulting from forest fires should immediately be undertaken by the Indian Council of Forestry Research & Education (ICFRE) and then the result of those studies applied in all states in evaluating the loss from the fire damage. These recommendations clearly reveal that research on Forest fires has seriously been neglected.

It is paradoxical that fire protection was one of the first tools of scientific forest management in India, yet research in forest fires has been a neglected field in this country. Although research on two other injurious agencies off forest viz. Diseases and Insect pests started long time ago, limited studies have been made on forest fires so far.

To estimate the true extent of fires losses, quantitative value has to be assigned to various impacts of forest fires. Forest fires are known to bring down considerably the various values e.g. productive, wildlife, aesthetic-recreational grazing, socio-economic & others. It is also essential to have a reliable data base to generate the desired type of information. Expenditure on fire control can be justified only up to an amount representing the savings or loss reduction which results from that expenditure. The more valuable the forest, the greater is the amount that it is worth spending to control fires. Research has to encompass all aspects of forest fire from pre suppression, prevention, detection, control, reporting, quantification and monitoring of losses. In the Himalayan region specific research is required towards cost effective & environment friendly hazard reduction methods e.g. some economically viable use for chir pine needles or some process to hasten its rate off decomposition. A modest beginning towards forest fire research has been made during the past two decades by adopting fire danger rating system for different type of forests, evaluating direct fire losses, designing statistical format for fire reporting for subsequent use in fire damage analysis. In view of the importance of the forests in Himalayan ecosystem forest fire problems of this area need prioritisation in the Forestry research agenda.

Keywords: Indian forest fires; Economic impact; Sustainability; Fire research

Prognosis of Emergency Situations under Wildland Fires

by
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Abstract

It is proved that climate changes occur with extreme declination of seasonal weather variations and may cause large scale fire emergency situations (Stocks, 1993; Wein, Groot, 1996; Fosberg, Stocks, Linham, 1996). In the last years climate changes are vividly seen in the South of Siberia and the Far East and they are the cause of intensified spring and summer droughts. Due to these droughts such emergency situations often occur when forest and steppe fires become dangerous for inhabited localities and even inflict casualties. This work analyses the peculiarities of dangerous wildland fire development, the forecasting and possibilities of prevention emergency situations on the basis of vegetation fuel maps. Emergency situations take place when a strong fire threatens an inhabited locality or some valuable object.

The dangerous fire intensity depends on the mass of vegetation fuel burning down in flame regime in time unit per long meter (but not per square meter!) of fire edge. This mass depends on two factors: a) the stock of such vegetation fuel per unit of area and b) the speed of fire edge spread. If the speed of spread is large, the intensity of fire can be very high even under small stock of vegetation fuel. The presence of considerable stock of vegetation fuel burning down in the regime of smoldering (litter, peat, duff) decreases the intensity of flame burning. Fires become of high intensity and, therefore, of danger if they reach the so called phase of self development Firstly, it happens at the expense of their speed increase under potted spread with throwing about burning particles in front of the fire front. It is especially characteristic of explosive fires.

Ignitions in inhabited localities and industrial objects occur because of burning particles which are thrown about in front of a strong forest or steppe fire front. This usually happens in dry windy weather, therefore, ignition of separate dwelling houses and industrial buildings can spread over other buildings and objects. Burning particles can spread up to 500 meters distance and more. Due to this, strong vegetation fires can get over the rivers, unburned bogs and other obstacles.

The main way of protection objects against an approaching strong fire is preliminary backfiring. The history of very large forest fires (for example, fires in the Northern China in 1987) shows that such fires are able to spread freely over the area for a long time destroying inhabited localities and crossing the rives and roads which could be the best initial line for preliminary backfiring.

The list of problems on prevention of loss under the emergency situations, connected with wildland fires close to inhabited localities and others valuable objects, includes the following tasks: 1) showing up of inhabited localities which can be damaged under wildland fire (forest, steppe and so on); 2) elaboration of prophylactic measures on protection of such objects from wildland fires; 3) prognosis of possibility of wildland fire dangerous development, active near the inhabited locality or near the industrial object; 4) prompt, safe and reliable stoppage of dangerous fires with the least expense of strength and means.

The solution of enumerated tasks is possible on the basis of vegetation fuel maps usage and method on vegetation fires behavior prediction. Technology of vegetation fuel maps creation on the basis of forest inventory data and air-space information and method of fire behavior prediction are elaborated (Volokitina, Klimushin, Sofronov, 1995).

Keywords: Russian fires; Climate change; Vegetation mapping; fire behavior

Seedling Survival, Mortality and Regeneration After Fire in A Tropical High Forest in Ghana

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Abstract

Tropical high forests were previously thought to be immune to fire. However, studies and empirical evidence have suggested that fire might have played an important role in their evolution. Following the extensive bush fires throughout the tropics in 1982-3, fire has become a major issue impacting on the management of dry semi deciduous forest types of the tropical high forest of Ghana. Several hectares of intact forest have been degraded due to the combined effects of recurrent fires and logging.

Studies including prescribed burning have been conducted elsewhere with the aim of reducing the detrimental effects of fire on the forest, whilst promoting regrowth of woody vegetation. However, most of these studies have focused more on the savanna woodlands and transition zones and least on the tropical high forest itself. At present, data is not available for a systematic study of the influence of fire on seedling survival, regeneration and tree mortality following fire in the tropical high forest.

This study attempts to quantify the effects of early and late burning on the survival and mortality of seedlings and trees and regeneration after fire in a tropical high forest in Ghana. It has been observed that tree seedling survival and mortality and regeneration thereafter are greatly influenced by the time of burning,. Early or late burning is rather subjective and is determined by the prevailing weather conditions at the time of burning.

The implications for forest management in the dry zone of the tropical high forests are discussed.

Keywords: Ghana tropical forest; Regeneration; Early/late burning

About the Necessity of a New Approach to Estimating Forest Potential Pyrological Forests

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Abstract

Principles of forest protection from fires, the evaluation of their consequences and their elimination, as has been shown by the catastrophic fires 1998 in Khabarovsk Territory, Russia, are no longer the matter of any separate country or any of its regions alone. Catastrophic forest fires periodically appear in this or that region and not only in Russia. No atrocious forest exploitation can be compared with the pyrogenic consequences, because only due to fires in a very short period are possible irreversible disturbances and destructions of formed many centuries ecological connections and trophic chains on the vast territories. Besides, as a result of fires, the indirect consequences are possible which it is impossible to take into account immediately. For example, soils destruction on mountain slopes in the result of burned stand decomposition which could happen after 10 or more years after the fire. Experience shows that no country having large forest volumes located in insufficiently accessible areas (due to weakly developed road networks) is not indemnified from the development of fires up to catastrophic sizes with all ensuing global ecological consequences. The world community is not so much worried by the loss of raw potential of the forest lands as by those ecological consequences which follow mass deforestation of the territories. Among the most meaningful ecological consequences are soil erosion, low river water, the loss for a long period carbon sequestration functions and, as a consequence, contravention of climatic situation on the planet. Evidently, it is necessary to improve all facilities of forest protection from fires - from their forecast and inventory to elimination of their consequences.
One of the important aspects is the determination of fire cause needed both for current and retrospective analysis of succession dynamics. If earlier it had a specifically administrative meaning, then today the role of cause in determination of priorities in pyrologic territory organization, prophylactic work with the population, improvement of legislative and regulatory bases becomes more actual.It is evident, that both physically and economically there are no possibilities to fight all forest fires. In other words, it must be discriminatory relating territory and relating the value of forests. Such experience has been accumulated, particularly, by Canada. For Russia conditions, with its mammoth and hardly accessible territories, it is necessary to zone areas on a new basis - first of all according to forests ecological value, not only formally stated in the regulatory documents, but also actual, for example, according to carbon sequestration ability. The last could be estimated on green mass production and not only by the stand, but forest coenosis on the whole. According to these signs, the territory must be differentiated by zones according to prioritization of fire control active methods use under mass ignitions, similar to fires 1998, and according to the necessary expenditures for prophylactic measures. To prevent fires and decrease their destructive impact, especially in the forests of high ecological and social value, it is necessary to introduce a system of prescribed burnings with the elaborations of corresponding technologies and regimes relating to the concrete forest formations or even to economic groups of the forest types. Similar experience also has been accumulated by a number of countries.One of the most important moments of a pyrological situation estimation is forest fires registration system improvement. It must be not only forehanded and independent from any interests but accessible both for professional use and for informing of population. This will permit to exclude disinformation, and also will be a good foundation for arranging global monitoring of forest fires dynamics and their consequences. Realisation of this thesis is possible with the use of satellites. Besides all, it will permit to advance sufficiently the formed system of land and airplane protection of forests.

Keywords: Russian Far East; 1998 fires; Biodiversity; Protection strategies

Influence of Bush Fires on the Dynamics of Dry Forest: Case of Degraded Forests in North-Benin

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Abstract

The North-Benin is in the dry part of the country where dry season covers 6 to 7 months of the year with a rainy season of 5 to 6 months. The average temperature is about 27°C with the rainfall oscillating between 900 and 1200 mm annually. The vegetation is savannah type with low density of large trees. The main activities are agriculture, breeding and hunting. In this part of the country, bush fires are widely used by farmers, breeders and hunters for their activities. So, every year, many hectares of forests are burnt with consequence of gradual degradation of forestland. This attitude of populations has a sociological foundation, which is not easy to overcome. In order to appreciate the real impact of fires on natural regeneration of forest, an experiment was initiated in 1990 with objective to determinate the appropriate periods for fires use as a tool for forest management. For this purpose, five treatments have been applied on six different sites as following: a) use of "Early fires" (EF) on 11 November and 11 December; b) use of "Late fires" (LF) on 11 January and 11 February; c) no fire use (NF) as control. After some years of observation, the tests have been evaluated in 1996 and 1997 in order to appreciate the evolution of plots. The results appear that the LF is very damaging for young regeneration with about 95% seedling burnt causing in fact progressive genetic erosion and the destabilization of soil. On the other hand, the EF of 11 November stimulated more the natural regeneration with appearance of new species in the experimental plots. With this treatment, it has been observed a natural pruning of trees with best development of trunk. Concerning the protected plots, grass has grown with high concurrence to young regeneration and natural sowing and seedling. On these plots, it also appeared that the renewal of grass is low comparing to EF, the trees have developed large crown with big branches and the high accumulation of dead vegetation. The conclusion is that, fire is a real tool for forest management in dry regions when its use is well analyzed. For now, fire appears as the best tool to fight against the risks of uncontrolled bush fires in dry regions in regard to the context of socio-economic conditions of the populations concerned. The EF applied just at the beginning of dry season has a positive influence on natural regeneration and the reconstitution of dry forests for wood and fodder production as well for biodiversity conservation.

Keywords: Benin; Bushfires; Early fires; Late fires; Regeneration; Dry forests; Natural forests; Forest management.

Monitoring and Assessing Forest Fires Using NOAA AVHRR Data With Special Emphasis on Borneo

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Abstract

Forests are managed not only for the production of wood, but also as a safeguard for environment. One of the main factors effecting forest degradation is forest fires and uncontrolled burning. Asean countries especially Malaysia and Indonesia were most affected by forest fires during July-November, 1997. The worst haze occurred in Sarawak, Malaysia when the Air Pollution Index (API) reached 800, exceeded the 500 danger level. Consequently the state was declared emergency by the government. This paper will highlight the capabilities of satellite image (NOAA-AVHRR and SPOT image) in monitoring forest fires. Observation and studies showed that the haze was caused by fires and burning. This paper also assessed the burned forest areas and the relationship between the number of hot spots and the severity of haze occurrence i.e. affected areas. The causes of forest fires were highlighted and management plan of forest fire control was proposed.

Keywords: Indonesian fires; Remote sensing; Smoke/haze; Fire management

Effect of Fire on Soil Properties in Pine and Natural Forest in Sri Lanka

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Abstract

Forest fires have become regular events in Sri Lanka due to intentional burning by livestock owners and hunters and practice of slash and burn agriculture (shifting cultivation). The foresters as a tool to eliminate undesirable weeds or dominant species in forests also use burning. In Sri Lanka other than the natural forest, part of the hill country is reforested using exotic species as Pinus and Eucalyptus. Much information is available on the regeneration of forests and regarding the change of the composition of vegetation after forest fires, its effect on soil properties have not been studied in detail. By studying the effect of forest fires on soil properties will help in understanding forest regeneration patterns and help in efficient management of natural and plantation forests. Therefore the objective of this study was to study the effects of fires on soil physical and chemical properties in a natural and pinus forest in Sri Lanka. These were studied at three stages, namely before the occurrence of fire, one day after fire, one and three months after fire.

This study was conducted in adjoining pinus and natural forest in the mid country of Sri Lanka. The soil profiles of the two sites were described using the FAO guidelines and the major soil horizons were identified. Soil properties as soil texture, acidity, total nitrogen, available phosphorus, organic matter and aggregate stability were measured. The area were burnt as usually done at the end of the dry season before the rains and similar measurements were conducted for soil samples obtained one day and three months burning.

More emphasis in this study was given to the determining of dry and wet soil aggregate stability, as soil erosion is one of the major problems in these sloppy lands. The dry aggregate stability was determined using dry sieving with a nest of sieves. The mean weight diameter and log standard deviation was obtained as aggregate indexes reflecting resistant to erosion by wind. Wet aggregate stability was determined by wet sieving using a single sieve technique. The percentage of the initial sample remaining after 18 minutes of sieving was used as the index showing the resistance to erosion by water. The results showed that the soil pH increased just after burning and again decreased to the original value after about three months. The increase was higher in the pinus plantation than in the natural forest. The increase was from 4.6 to 5.1 and is mainly due the basic nature of ash remaining after burning. Afterwards these bases are easily leached due to rainfall and the soil becomes strongly acidic as before. The soil organic matter content nitrogen decreased with burning which the most damaging effect related to the loss of biomass to the atmosphere. The available phosphorus increased significantly in the surface layers of natural forest due to burning. The available P increase from 40 to 62ppm in just after burning and decreased to 50 ppm after three months. The change in available P in pinus plantation was not significant.

The dry aggregate stability and wet aggregate stability decreased in the pinus forest with burning. In the natural forest the decrease in soil aggregate stability were not significant. These aggregates developed to the original size after three months of burning. This shows the vulnerability to soil erosion by wind and water in the pinus plantations during the first three months of burning.This study shows how the soil property change after burning in natural and pinus forests in the mind country of Sri Lanka. In both forest types the chemical properties changed significantly after burning. In natural forest the properties attain the pre-burning values in three months after burning while in pinus forest it took longer times. In the pinus forest the susceptibility to soil erosion increased during the first three months after burning when compared with the natural forest.

Keywords: Sri Lanka fires; Fire severity; Soil properties

Forest Fires in Russia

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Abstract

The area of the forest stock in Russia, including forests transferred to the permanent use, according to the calculation made in January 1,1993 is 1180,9 million hectares. Burned-out forests, cuttings, swamps and hayfields are also included into this territory. Forests proper take the area of 705,8 million hectares; 507,7 million hectares are covered by coniferous species: larch (52%), pine (22,5%), spruce and fir (17,8%), and cedar(7,7%). Acerous leaves(needles) and timber of these species contain essential oils and colophony, that is why they are too flammable(susceptible to fire). Russian forests have a multiple-aged structure: undergrowth-22%, middle-aged-33%, maturing-11%, mature and overmature-34%. Formation of such forest structure was influenced by industrial cuttings; but the main factor of taiga forests formation is forest fires. According to the official statistics their number varies from 13,4 thousand (1987) to 31,3 thousand(1997); the area of forests, subjected to fires -from 569(1987) to 2450(1998) thousand hectares. Pine and larch forests of the North, Siberia and Far East, growing on the drained, rising grounds are mostly subjected to fires.

The average temporal interval, during which these forests may undergo low fires is 30 years. In the course of this period the critical amount of combustibles, able to catch fire in hot dry weather and keep burning, is accumulated under the forest canopy. Spruce young growth, which is a constant competitor to pine and larch, burns out in low forest fires. Dark-colored spruce-fir forests grow on the low areas with damp(moist) soils close to subsoil waters. That is why fires can hardly occur in these forests even in the short-term periods of drought. In case of fierce droughts, occurring every 70-90 years, when caught by fire spruce-fir forests burn out completely, without any young growth left. Due to this reason their further reforestation goes, as a rule, through the change of species, that is, at first, the process of regeneration of cutover stands by broad-leaved species (birch and aspen) takes place, and only then young spruce and fir sprouts start growing. In the light-colored coniferous 30 year-old forests low fires, which do not cause damage to them, prevail. These fires play the role of thinnings, by means of taking away weakened trees and those falling behind in growth, providing the rest of trees with optimum light condition and space for roots development. In the permafrost region of light-colored coniferous forests low fires destroy the mossy cover, warming overburden layers.

After fires the level of permafrost goes down, but the power of root layer increases, providing conditions for significant increment of trees. It is found out that successful reforestation of pine and larch can be possible only as a result of low fires, destroying thick mossy cover and debris layer. With the average interval between fires of 30 years and the mean age of mature and over-mature forest crops in the boreal forests of 150-200 years, every crop is subjected to low fire as many as 4-7 times during the period of its growth before it is completely replaced by young growth. Only top fires may happen on the areas covered by coniferous young growth, but they lead to the complete damage of the latter. By the way, pine undergrowth is mostly subjected to fires. Dead larch undergrowth cover burns out only in the periods of drought, accompanied by strong wind. Artificially planted even-aged coniferous crops seldom happen to grow till their natural decomposition.

On the contrary, wild multiple-aged forests, formed by fire during millions of years, not only survive in the temporal fire weedings, but even improve, becoming more fire-resistible. We have a powerful overland and aviation forest service, which protects forest stock territory on the area of more than 700 million hectares. With the help of aviation, tele-and infrared equipment, and data obtained from artificial Earth satellites, forest service detects and eliminates considerable number of forest fires in proper time. But we should admit, that these activities do not exert great influence upon the general amount of forest fires. On the

contrary, eliminating forest fires we favor the accumulation of combustibles under the forest canopy, which may cause destruction of the crop in case of fire. Every year in two or three regions of the country fire passes through the area of 1-2 million hectares. Coordinates of these regions, time of fires origin, their number and extent of the burned out territory are programmed by nature itself, but it is still beyond our capacity to make a prediction in advance. Specialists in the field of fire fighting assure, that fire behavior in the forest is unpredictable. It is necessary to carry out a thorough and detailed research of this natural phenomenon, to reconsider our hostile attitude to the fire and to start using it as an ally.

Keywords: Russian forest fires; Light forest; Dark forest; Succession

Sub-Plenary Session : A3

Sustainable Management of Natural Resources:

Management and Conservation of Forest Gene Resources

Coordinators:

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Management and Conservation of Forest Gene Resources: Social and Economic Considerations

by
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Abstract

This paper discusses social and economic aspects of management and conservation of forest gene resources. The goal is defined as sustainable use and development of forest gene resources toward sustainable improvement in the human condition through wise self management and wise environmental stewardship. A review of the kinds of human values that may be associated with or dependent on forest gene resources, including economic value, leads to identification of the boundaries of economic value as a necessary but not sufficient criterion. Social and ecological complexity, bounded human rationality, and institutional dysfunction stand as obstacles to achievement of the sustainability goal. The policy and management choices we make now will determine Homo sapiens' long-range alternative futures. Our choices include (1) guiding cultural and institutional evolution through a "new social contract for science," public education, and wise political leadership and (2) allowing the invisible hand of the macro processes of nature to take us where they will. The first is the recommended course, but governmental interventions must be evaluated carefully to ensure that the "cure" is not worse than the "disease." The paper closes with the proposition that while social dysfunction may be the proximate cause of our erosion of natural capital, it poses a more immediate threat to our well-being.

Keywords: Human values, Economic, Social, policy, Management

Introduction

This paper discusses social and economic aspects of management and conservation of forest gene resources. The first section defines "sustainability" and "forest gene resources." The second is a review of the kinds of human values that may be associated with or dependent on forest gene resources, including economic value. The third identifies the boundaries of economic value as a necessary but not sufficient criterion. The fourth reviews social and institutional obstacles to sustainable use and development. The fifth section reviews two long-range alternative futures that appear to be contingent on the policy and management choices that lie before us. The seventh section summarizes the arguments. The final section briefly recommends what this author believes we must do to enable sustained improvement of the human condition over time.

This paper assumes that the goal is sustainable use and development of forest gene resources toward sustainable improvement in the human condition through wise self management and wise environmental stewardship. "Sustainable use and development" means that use and development of forest gene resources can continue indefinitely into the future without foreclosing future options. "Sustainable improvement in the human condition" means that Homo sapiens moves continually toward a more benevolent future. The UNEP Global Biodiversity Assessment reviews the state of scientific knowledge about global biodiversity as of 1995 (Heywood and Watson 1995). The assumption that the criterion is human use and development requires examination of the question of "value" in some detail.

The Nature of Value and the Value of Nature

The Anthropocentric Premise

Prevailing sovereign authority defines the policy criteria. In a democratic society that policy is the collective will of the people, as expressed through their legal and political institutions, on those things to which they can agree. We thus accept human preference as the criterion by which to measure the value of nature. As stated by Santayana (1896):

> "We may therefore at once assert this axiom, important for all moral philosophy and fatal to certain stubborn incoherences of thought, that there is no value apart from some appreciation of it, and no good apart from some preference of it before its absence or opposite. . . . Or, as Spinoza clearly expresses it, we desire nothing because it is good, but it is good only because we desire it."

Human appreciation is multifaceted, however. In order to understand the meaning of forest gene resources to Homo sapiens, we must understand the various ways we humans appreciate those resources.

The Preferred versus the Preferable

Morris (1956) defines value at three levels: operative, conceived, and object. Operative value is the domain of the preferred as evidenced by what people choose (revealed preference). Conceived value is the domain of the preferable, i.e., what one believes one ought to choose. Object value is the domain of what is, in fact, preferable, given one's desired outcomes and the reality of cause and effect. People do not always choose what is good for them because of ignorance or irrationality. For example, in the years before medical science discovered our dependence on vitamin C, many people died of scurvy on long ocean voyages. They desired health and long life, but their ignorance of the need for vitamin C misled their preferences and choices.

Individual and Collective Preference

Institutions, laws, and governmental powers as expressed through whatever political and judicial processes of social choice exist in a given society define collective preference as the long-run value structure of society within which individual short run preferences express themselves. The two are not always in agreement (e.g., Hardin 1968; Sen 1977; Harsanyi 1955, Blamey 1995). The enablements, constraints, and incentives created by collective preference exert strong influence on individual behavior, however. If that institutional framework is dysfunctional, it will guide behavior away from sustainability.

Derived Value

Our preferences assign derived value indirectly to other things by functional dependence. Such derived value often is implicit and beyond awareness of the relationship that assigns the value, as illustrated by the vitamin C example. If human well-being depends indirectly on forest gene resources in addition to the obvious and direct linkages (e.g., forest product markets), ignorance will allow us to make foolish choices. Because of that problem, the precautionary principle (Taylor 1991, Haigh 1993) is finding application in policy around the world.

Normative Value

A conceived or held value advocated by one agent as a standard or norm by which to judge the desirability of something to a second agent is a "normative" value. Keeping and advocating that value account is the domain of scientific, educational, philosophical, and ecclesiastical institutions. When based on good science or cultural experience, it is an information system worth listening to by those whose rights and lives may be affected.

Held versus Assigned Value

Brown (1984) differentiates between held value and assigned value. A held value is an enduring conception of the preferable. Assigned values arise from preference relationships among things about which people make choices. Held values tend to guide behavior. Assigned values are the outcome of choice. The value classifications of Brown and Morris imply that sustainable use and development of forest gene resources requires people to desire sustainability, understand the impact of their choices, and choose to behave rationally.

Economic Value

Economic value is the amount of money (or other parameter of value in exchange) one is willing to trade for the thing in question, either as a buyer, seller, or loser and is a specialized member of the operative assigned value account. In a market economy, equilibrium between supply and demand assigns marginal market prices which individual producers and consumers then decide whether to accept, based on the economic value to them. Market prices are economically efficient only under perfect competition, the conditions of which are well known but rarely achieved. Economically efficient prices and the resulting allocation of resources are equitable only under the assumption that the existing distribution of income is fair.

Market prices fail to include the value of goods that are non-rival and/or non-excludable in consumption (e.g., public goods), are external to market transactions, or are non-priced for other reasons, such as government policy or cultural tradition (Friedman 1981, Randall 1983).[1] We therefore break the economic objectives of efficiency and equity into financial and total economic components. The financial component includes only direct revenues and expenditures and, in the case of equity, the financial impacts amplified through the economy. The total economic approach adds non-market values.

Forest gene resources generate economic value at several levels of concern: (1) the value assigned directly through commercially harvested and marketed forest products; (2) the latent commercial value assigned by undiscovered but potentially marketable products, the focus of bioprospecting (e.g., Sedjo 1992; Polasky and Solow 1995; Sedjo and Simpson 1995a,b; Simpson, Sedjo, and Reid 1996; Polasky et al. 1999; Sedjo 1999; Simpson and Sedjo 1999; Rausser and Small, In Press; Simpson, Sedjo, and Reid 1998; (3) the derived value assigned indirectly by the relationships by which things preferred by people depend on forest gene resources (Heywood and Watson 1995); (4) amenity use value realized through forest recreation and other forest-dependent activities (e.g., Rosenberger and Loomis 2000); and (5) passive use value, including existence and bequest value, people assign to specific species, places, or the wholeness of complex systems of diverse species (e.g., Krutilla 1967; Ciracy-Wantrup 1968; Krutilla and Fisher 1975; Bishop 1978; Randall and Stoll 1983; Walsh et al. 1984; Brookshire et al. 1986; Walsh et al. 1990; Cicchetti and Wilde 1992; Freeman 1993; Mazzotta and Kline 1995; Loomis and White 1996; Crowards 1997; Farmer and Randall 1998; Carson et al. 1999; Morton 1999). Perrings et al. (1995) provide a good overview of the economic value of biodiversity, including theory and method of measurement. Polasky et al. (1999) at http://arec.orst.edu/biodiv/ is a comprehensive bibliography on the conservation of biological diversity, including a section on economics.

Some of the values find expression as prices through commercial markets. Others are measurable in theory (but often elusive in practice) by non-market methods such as contingent valuation. Still others, such as derived values, may require derivation through processes by which they contribute to direct values.

Dejure and Defacto Value

Preferences based on legally defined rights justify dejure value. People may have preferences that are not based on sovereign rights or effective powers, however. Such preferences yield defacto values that are important to people, but policy, litigation, and markets generally ignore them until they find expression by effective legal, political, persuasive, or coercive means. If end states such as sustainability and biodiversity that some of us may hold as preferred states are not protected effectively as property rights, economic, political, and judicial processes will not defend them in the short term.

Intrinsic Value

Biologists and ethical philosophers sometimes refer to intrinsic value as independent of human appreciation. They may mean thereby conceived values they believe people ought to hold. Or, they may have posited a

[1]A good is non-rival when consumption by one person does not reduce the amount available for consumption by others. E.g., viewing a sunset. A good is non-excludable when the owner is unable to prevent others from consuming it, e.g., appreciation of the existence of a wilderness area. A good (or bad) is external when, as part of a market transaction, it impinges on parties other than those directly involved in the transaction, the affected parties are difficult to identify, and the affected property rights are difficult to defend.

philosophical criterion of value other than human preference, such as a philosophical maxim, or what they believe to be the preference of God, of nature, or of non-human species (Rolston III 1981, 1985, 1994). Intrinsic value thus defined is a normative concept.

The Boundaries of Economic Value

When measured and applied correctly, economic value answers important personal, policy, and management questions. Cost and revenue accounting helps private firms and government agencies evaluate financial efficiency and distribution. Economic efficiency analysis with non-market values included addresses the broader concept of aggregate social welfare. Economic impact analysis addresses the equity objective by showing how an action distributes priced and non-priced costs and benefits among people. There are, however, other important questions economic value does not answer (Peterson and Brown 1999). This section lists reasons why economic value seldom tells the whole value story.

Failure to Explain Why

Economic value does not explain the functions and services that cause a thing to have value. A simple nutritional metaphor illustrates the point. The economic value of a meal at a restaurant is a sum of money. The price thus defined does not explain "why" the consumer was willing to pay, and it does not tell the consumer what will happen to her if she eats the meal. To make an informed choice among alternative meals, the consumer needs the advice of a professional nutritionist. The nutritionist will decompose the meal into its nutritional components and explain what it will do to the person who eats it. Environmental policy choosers likewise need information about the specific consequences of alternative choices in addition to their economic values. As stated by Hicks (1956) ". . . We ought to think of the consumer as choosing, according to his preferences, between certain objectives; and then deciding, more or less as the entrepreneur decides, between alternative means of reaching those objectives." The demand that assigns economic value to goods derives from the objectives people want those goods to serve. Two different goods can serve very different objectives while having the same economic value.

Poorly Defined Goods

In order to make good choices between goods and money as required for economic valuation, people need clear and correct perception of the goods in question. "Forest gene resources" are not well defined goods that people can understand in terms of monetary exchange.

Inability to Measure Some Values in Economic Terms

Economic valuation of forest gene resources generally is not achievable when: (1) the question is loss (WTA); (2) there are no substitutes for the good in question that money can buy; (3) the state of the art is inadequate; and (4) application of available methods to meet reasonable standards of quality is too expensive. Monetary valuation of public goods and passive use values remains controversial (Mitchell and Carson 1989; Arrow et al. 1993; Cambridge Economics 1992; Portney 1994).

The Distribution of Income

Economic value carries an implicit assumption that the distribution of income is fair. Fairness is a political question that each person, nation, and society must answer in the way it finds acceptable. When applied blindly across significant income differences, for example, across rich and poor nations at the global scale, the assumptions that underlie economic value (such as "one-dollar-one-vote") beg political questions with which the affected parties may not agree.

Ignorance and Consumer Sovereignty

Economic value as defined under the market system is justified by consumer sovereignty, but consumer sovereignty fails when the consumers are not fully informed. We do not fully understand the processes by which human welfare depends on forest gene resources, and we do not experience the costs and benefits of our impacts on those resources directly and in understandable ways, especially when the feedback occurs far in the future. Thus, the boundaries of human knowledge and rationality distort economic value (Simon 1985).

Intergenerational Failure

Economic valuation represents the interests of future generations through application of a discount rate to predicted future outcome. Discounting presents at least four perplexing problems. (1) Uncertainty about the preferences of future generations. (2) Uncertainty about future consequences of present decisions. (3) Uncertain about what discount rate to use. (4) Violation of the logical basis for discounting. The discount rate is, among other things, a rent to cover the opportunity cost of capital. Capital is capable of growth through wise investment, and a given amount of capital is therefore worth more now than later. But consumption of natural capital by the present generation can produce one of at least three alternative futures: (1) It may be a growth producing investment that makes the future better off through increased natural or man-made capital. (2) It may cause the loss of unique resources and opportunities for which money and technology cannot compensate. (3) It may be hedonistic consumption of pleasure that returns nothing to the future but a historical memory of past pleasures enjoyed by others. Even the "precautionary principle" carries the dilemma that failure to invest natural resources now may deny capital growth that might have been created. For a rigorous review of discounting and intergenerational equity see Portney and Weyant (1999).

Cultural, Political, and Institutional Diversity

Not all nations and cultures agree that economic analysis is an important language by which to consider personal and public decisions. Even among industrialized nations, there is disagreement about the usefulness and appropriateness of economic quantification of human values, especially those values that are external to market transactions (Peterson and Hoekstra 1990, Shrader-Frechette 1985). Values must be expressed by the systems of logic and negotiation appropriate to each nation and society.

A related problem is that economic values imply political assumptions that may not agree with all cultural and institutional value systems. Economic value also depends on the institutional context (Bromley 1982). Different nations provide different institutional contexts, thus creating a perplexing noncomparability.

Failure to Represent the Full Public Interest

Available methods for measuring the economic value of non-priced goods and services generally focus on short run individual values and may not capture long run collective values that need to be expressed through legislative, judicial, or ethical channels as institutional guidelines and constraints (Hardin 1968, Harsanyi 1955, Sen 1977, Blamey 1995). If technical valuations are to be complete, we also need to include methods that place people in citizen roles, such as values juries (Brown et al. 1995) and citizen juries (Crosby 1995, Armour 1995), or a court of generations (Tonn 1991). Because of market friction, market prices may not measure efficient marginal values for the goods to which they apply.

Marginal versus Total Economic Value

A common problem in application of economic value is confusion of the value of a thing with the value of the function it performs. Economists are well aware of this question as the difference between marginal and total value. Popularized as the "diamonds and water paradox," it was the focus of considerable concern in the early evolution of economic theory (Silberberg 1978). We must not measure the value of global biodiversity as the economic value of a marginal change in the population of an abundant species. The value of such a marginal change is likely to be trivial, but the cumulative value of many marginal changes may be large. The total value of a nonmarginal change in something like forest gene resources that goes beyond the bounds within which the earth can sustain human life is the value of life itself. The ability of economic theory to clarify this question of marginal versus total value is a strength of the economic definition of value, not a weakness. We discuss it here only because confusion about the matter is common, and ignorance of the theory sometimes causes abuse of economic value in application.

The Need to Look Beyond Economic Value

In summary, economic value is a useful tool, but it cannot capture or adequately represent all the values affected by forest gene resources. Full understanding of the value requires that we understand and correctly apply economic value, including its limitations in application, and also look beyond this useful but narrow concept by explaining the ways human survival and quality of life depend on the condition of our forests. Rather than abandon economic valuation because of its imperfection, however, we need to improve the state of the art and the quality of public opinion by investing aggressively in research and public education so that technical information systems and political processes both can function more effectively.

Obstacles in the Path

The preceding sections on value discuss what we want to achieve, why we want to achieve it, and how we measure achievement. Under the assumption that sustainable use and development of forest gene resources is a desirable goal, the discussion now turns to obstacles that stand in the way. Those obstacles are complexity, bounded rationality, and institutional dysfunction.

Complexity

Nature is extremely complex and " Systems Ecology" is not yet a mature science. Unlike physics, chemistry, or mathematics, there is no refined foundation of systematic knowledge from which to build theories and models that can offer effective predictions of the long-term consequences of our personal and institutional choices.

Bounded Rationality

We humans are not perfectly rational and informed creatures. The conceived values we allege to worship in cultural and religious institutions too often fail to describe the operative values implied by our personal and collective choices. The causes include short-sightedness and irrationality, as well as imperfect information and limited cognitive capacity (Morris, 1956; Simon, 1985). The imperfection infects both collective and personal choice.

Institutional Dysfunction

Some of the most serious challenges confronting ecosystem stewardship are creatures of a dysfunctional institutional framework (Honadle, 1993; Hardin, 1968) at both national and global scales, including the price signals to which personal and collective choices respond. Successful ecosystem stewardship requires major institutional reforms (Honadle, 1993).

Present Choices and Alternative Futures

Present economic and demographic trends in the use and development of forest gene resources do not appear to be sustainable (Aplet et al. 1993). Ecological complexity, bounded rationality, and dysfunctional institutional incentives seem to be moving us toward bankruptcy of the natural capital those resources represent. Scarcity caused by depletion in the face of growing demand will drive up the cost and reduce availability of some species while reducing overall diversity. How and to what extent the future welfare of Homo sapiens at the global scale depends on the holistic diversity of forest gene resources and the role it plays in the ecological fabric of the earth's biosphere is largely unknown. Acceleration of global climate change through reduction in carbon sequestration is one potential outcome. Our future destiny may well depend on choices we make now. There are at least two plausible courses of action: (1) use reasoned choice to change personal behavior and the institutional structure of incentives through scientific research, public education, and normative persuasion and (2) let the "invisible hand" of natural "happening" determine the future toward which we move.

Self Direction through Reasoned Choice

If all nations were under dictatorship, changing personal behavior and the institutional structure of incentives would be simple in theory. The people in command could simply direct the needed changes, but it would not be in their short-term interest to do so because the incentives to which they would respond are all short-term and they probably would not know what the best course is. It would require very thoughtful and well informed statesmen to choose to serve the long-term welfare of global society, and they would have to believe that leaders of other nations would do likewise.

In a democratic society the problem is still more complex. Noble statesmen, if they could get elected, could make noble choices, but they would not remain in office long and the changes they make would soon revert. Politicians respond to their perception of the "will of the people" as read from polls and expressed through power politics. The masses and the power brokers respond to the existing institutional incentives. The outcome is a paradox to which there seems to be no easy resolution.

The answer, if there is one, would seem to be in a slow process of cultural evolution facilitated as suggested by Rivlin (1993) and Lubchenco (1998) by scientific exposure of the processes by which human welfare depends on forest gene resources and effective communication through public education of the knowledge thus obtained. Scientists also need to use that knowledge to identify available choices and predict the alternative futures contingent thereon. Raising the quality of public opinion through public education may allow the emergence of informed statesmen able to work effectively toward the needed institutional reforms. Tolstoy (1957) asks in *War and Peace* whether leaders cause revolutions or revolutions allow leaders to emerge. Truth probably lies in a middle ground where enlightenment produces potential leaders, allows enlightened leaders to emerge, and moves the masses to call for and accept the needed changes. Changing values, perceptions, beliefs, and behaviors through education and persuasion is not a quick or easy process. But, the institutional structure of incentives must change if we are to achieve sustainability, and there seems to be no feasible course other than slow cultural evolution through sustained education, normative persuasion, and effective political leadership.

Leave It to the Invisible Hand of Nature

Failure to orchestrate cultural evolution will leave human destiny in the apparently indifferent "invisible hand" of macro-system processes. The state and process of nature are the products of at least four forces: (1) the press of non-living nature toward more probable states as described by the second law of thermodynamics, (2) the synergistic force of non-sentient life that reduces entropy locally while increasing entropy globally by creating otherwise improbable states through blind variation and selective retention powered by energy imported from the sun or stored within the earth, (3) the force of reasoned choice by which Homo sapiens and other reasoning species (if any) attempt to organize nature (including self) into preferred configurations, and (4) the growth of human learned culture by accumulation of successful values and beliefs as captured in folklore, religion, language, social organization, political institutions, and written knowledge capital.

We humans have been so successful in our accumulation of culture and population that our impact on the planet we inhabit is no longer marginal. A recent paper in the National Geographic characterized Homo sapiens as the "Sixth Extinction" (Morell 1999). Apparently we are in a race between the self-regulating mechanisms in nature (Wynne-Edwards 1965) and the technology by which we construct and fortify artificial habitat. The critical question is whether we can, by reasoned action, gain control of the macro system effects of our increasingly disturbing presence. If we do not, then we will be at the mercy of complex spontaneous processes that eventually may impose Draconian impacts on us as the consequence of our accumulation of non-marginal disturbances. To allow ourselves to follow such an arbitrary course is reminiscent of the conversation Alice had with the Cheshire Cat in Wonderland (Carroll 1993):

> "'Would you tell me, please, which way I ought to go from here?'

> 'That depends a good deal on where you want to get to,' said the Cat.
> 'I don't care much where . . .' said Alice.
> 'Then it doesn't matter which way you go,' said the Cat
> '. . . so long as I get SOMEWHERE,' Alice added as an explanation.
> 'Oh, you're sure to do that,' said the Cat, 'if you only walk long enough.'

And, we might add, we must also LIVE long enough.

If we are lucky, the combined effects of technological innovation and automated cultural and biological self-regulating mechanisms will keep us on a safe course. But, relying on "luck" sounds dangerously close to turning our fate over to the second law of thermodynamics which erodes improbable states. Nature's indifferent "choice" of a course for us may not be quite as benevolent as what we might want. Is our capacity for reasoned choice a force toward our salvation, or is it the cause of the problem? Perhaps the outcome of the race will be determined simply by which force is stronger, the press of non living nature toward more probable states or the synergistic power of the unconscious life force on which our arrogant consciousness rides. Despite such troublesome questions, we have no choice but to continue to investigate our relationship with the earth and strive toward sustainability.

Summary

Social and economic considerations in the management and conservation of forest gene resources include (1) the human preferences and behaviors that determine how we use and impact those resources and how that impact returns to affect us, (2) the role of economic value as a necessary but not sufficient consideration, (3) social and economic factors that push us away from sustainability and toward environmental bankruptcy, and (4) the alternative futures that depend on the choices we make now.

Notwithstanding alternative views, this paper adopts the premise that the principal reason for concern about management and conservation of forest gene resources is the welfare of Homo sapiens. We are severely modifying our habitat and we need to learn how to sustain it so it can sustain us. In order to understand and change the choices that hurt us by hurting our habitat, we need to understand the values, beliefs, and incentives that motivate those choices. Areas of concern include the difference between the preferred and the preferable, held and assigned values, collective and individual preference, values the law recognizes as property rights and those it does not, direct versus derived values on which we depend in ignorance of the processes that tie us to them, normative and intrinsic values, and economic value.

Economic value is a particularly important, useful, and potentially dangerous way to define and measure value. It is a necessary but not sufficient criterion because the economic paradigm is not appropriate for some factors; where economic valuation is appropriate, the state of the art is often inadequate; and application of available methods to meet reasonable standards of quality is often too expensive. Furthermore, before they can decide the economic value of something to them, individual citizens and policy makers both need to know the outcomes of the alternative choices they face. If abused or misrepresented, economic value and the analyses by which it finds expression can mislead.

Whether the values and beliefs that motivate our personal and collective choices are right or wrong, three major problems not only obstruct achievement of sustainability, they tend to move us in the opposite direction. They are (1) inadequate understanding of the overwhelming complexity of the physical, biological, economic, and social ecological systems of which we are a part; (2) the bounded rationality by which we make short-sighted personal and collective choices; and (3) dysfunctional institutional incentives that motivate us away from where we need to go.

Forest gene resources serve human welfare through commercial harvest and marketing of forest products, but such activity too often is

not sustainable. There also may be potential but unknown products, such as medicines and other useful marketable chemicals, hidden behind our ignorance. Such things are the focus of the growing activity of bioprospecting. Through the processes of adaptation and evolution, successful forest species have had to solve many problems to survive. The solutions to those problems, such as resistence to disease and predators, may have useful human applications.

Forest gene resources also serve us by creating forested environments where we can find scenic beauty, recreation opportunity, or simply appreciation of their existence. But, their most important service, a service that we least understand, may be their holistic role in the fabric of global biodiversity, a role by which they help control global climate change, for example, through carbon sequestration. The value of species, if any, that are keystones in the ecological structure, may be infinite.
Present trends in the use and development of forest gene resources appear to be leading us away from sustainability. Two courses of action are available. One is remedial. The other, which is to continue on the present course, may be catastrophic. The remedial course includes two major components: (1) A more aggressive research attack on complex natural, social, and economic processes by which our choices disturb the environment and return to disturb us, together with more effective injection of scientific knowledge into the personal and public decision-making processes that affect sustainability. (2) Constructive modification through public education and political and judicial leadership of the institutional framework of dysfunctional constraints, enablements, and incentives that guide individual and organizational choices away from sustainability.

The laissez faire option, which is simply to let things continue to go the way they are headed, places us at the mercy of purposeless and indifferent macro-system resolution of four major forces: The entropy maximizing force of non-living nature, the synergistic force of non-sentient living nature, the cognitive force of micro-level sentient reasoned action, and the quasi-sentient force of macro-level cultural evolution. The unguided resolution of those forces may or may not promote sustained improvement in the human condition over time. Being indifferent, the resolution doesn't "care" what impact it has on us. It simply carries us along or discards us in the process of macro system evolution.

Is the "invisible hand" of nature leading us with blind wisdom toward sustainable improvement in the human condition or toward catastrophe? Will reasoned efforts to control ourselves and our habitat help or hinder our quest for sustainability? Those questions have plagued humanity without resolution throughout history and perhaps even before.

Specific Recommendations

The recommended course of action is, of course, the first one, the process of cultural evolution toward institutional reforms, facilitated by "a new social contract for research" (Lubchenco 1998), including public education and effective political leadership. The problem is complex, and I do not pretend to have definitive answers. Specific institutional reforms, such as taxation and regulation policies, use of macro-economic indices that more effectively reflect the cost of natural capital depletion, political campaign finance reform, international transfer payments to buy forest gene conservation, creation of institutions that help people cope more effectively with change, increased investment in public environmental education, etc. have been advocated by various authors, but government intervention in private affairs often has unintended consequences that can make the cure worse than the disease. We need to be sure that any reforms we adopt solve more problems than they create.

Depletion of natural capital is not the only serious problem we face, however. Without apology, I submit a trite but unpopular proposition: Social dysfunction is at least as serious a threat. In the opinion of this author, unequal distribution of power and wealth, institutionalized intercultural discrimination, neglect and alienation of children, and intercultural and interpersonal violence, among other things, constitute immediate global crises that threaten to destroy human civilization. They are also are among the factors that contribute to unwise environmental stewardship. Nature has recovered sufficiently from cataclysmic events in the pre-human past to allow Homo sapiens to emerge and worry about the ecological condition of the earth. Nature will recover and move on from whatever disturbances our temporary presence imposes. Perhaps we should spend a bit more time worrying about the socio-cultural condition of ourselves. Our first and foremost concern ought to be the sustainability of human life and quality of human life. Concern for the long term welfare of Homo sapiens surely must be the cause and justification for our concern for sustainability of the ecological systems in which we participate, and social dysfunction is at the root of the disturbances we impose on nature. . . But I am preaching a sermon we all know to be true and apparently can't (or won't) do anything about.

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International Action in the Management of Forest Genetic Resources: Status and Challenges

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http://www.fao.org/forestry/FOR/FORM/FOGENRES/homepage/fogene-e.stm

Abstract

The paper describes some work carried out at international level in the field of forest genetic resources. It points to the urgency to translate general principles and international agreements into operational national programmes aimed at the wise management of these valuable resources, the need to review national forest genetic resources programmes within the framework of regional plans and activities, and the desirability to develop an action oriented, country driven framework to ensure complementarity of action at global level.. Special reference is made to recent efforts by FAO and international and national partners to support and facilitate the elaboration and implementation of regional and sub-regional action plans for the conservation and sustainable use of forest genetic resources.

Keywords: Biological diversity, Forests, Forest genetic resources, Genetic conservation

Introduction

Forest trees play a vital role in many national economies and in the daily life of rural communities, as sources of timber, fuelwood, food, fodder, essential oils, gum, resins, latex, medicines and pharmaceutical products, shade, shelter, as contributors to soil and water conservation, and as repositories of ethical, aesthetic, cultural and religious values. Such goods and services are provided by a large number of genera and species of trees and shrubs and, to a large extent, different species are used in different countries and regions to satisfy similar needs.

Forests are arguably the single most important repositories of terrestrial biological diversity. As major constituents of forest ecosystems, trees and woody plants support the life of a wide range of other organisms both directly and indirectly. As long-lived, outbreeding, and generally highly heterozygous organisms, occurring in often variable environments in time and space, they have developed at times complex mechanisms to maintain high intraspecific diversity. Genetic variation is needed to ensure present-day and future adaptability of species to dynamically evolving environmental conditions and their continued evolution. It is also needed to maintain options and potential for improvement to meet changing end use requirements. The well being and continued ability of forest trees to provide goods and services are thus dependent on the maintenance and management of their genetic foundation. The actual and potential value of this genetic foundation is embodied in the concept of *forest genetic resources*.

Unlike most agricultural crops, in which genetic diversity can be sampled, collected, and relatively easily stored and conserved in seed banks, the long-term storage, maintenance and regeneration of collections of forest tree seeds present a number of specific problems. Forest genetic resources are most commonly stored, in the long term, in living trees. Land use practices and variations in forest cover, quality and composition thus have direct and decisive impact on the extent and patterns of genetic variation in forest trees. In most regions of the world, threats to the integrity of forest genetic resources have increased in the past decades, in the form of deforestation due to changes in land use, forest habitat destruction and alteration, inappropriate forest harvesting practices, atmospheric pollution, and climate fluctuations and change. A further threat to genetically diversified, local populations, which may possess special or valuable attributes, is posed by introduction of non-local forest germplasm for plantation establishment, which may lead to hybridization of local and introduced genepools and to various degrees of loss of local adaptation in subsequent tree generations.

Management of Forest Genetic Resources

The aims of genetic management are to safeguard the evolutionary potential of dynamically evolving ecosystems and species, and to ensure the enhancement and sustainable utilization of the genetic variation available to meet present-day and future human needs. The specific objectives of genetic management will change over time, as environmental, economic and social conditions and requirements continually shift. Attention should therefore not only be given to those tree species, populations and genetic traits which are considered useful today, but also to those of potential future economic, social and environmental value. Priorities for action will depend on value-judgements, and are usually to a large extent determined by the primary beneficiaries of the conservation effort. To ensure a holistic view, it is clear that dialogue and involvement of all stakeholders is of utmost importance in the planning and implementation of conservation programmes. Such dialogue should include government institutions, private owners, industry and national non-governmental organizations, academic and research institutions, and others, as relevant. Mechanisms must also be in place to ensure that needs and aspirations of local communities or other present-day primary beneficiaries of forest goods and services are duly considered.

As a first step in action towards genetic management, the level or levels targeted must be clearly specified. This is of utmost importance since it is possible to conserve an ecosystem and still lose specific species, and to conserve a species and lose genetically distinct populations, genes or gene complexes that may be of future value. Decisions regarding strategies and methodologies will depend not only on the biological characteristics, genetic variation and variation patterns of a given species, but also on the degree of knowledge available on its silviculture and management; its present use, importance and uniqueness in this regard; perceived threats; and, quite decisively, the institutional capacities in countries directly concerned, including infrastructure and availability of funding over time.

Conservation of genetic resources is used in this paper in the commonly agreed-upon meaning, *the management of human use of genetic resources so that they may yield the greatest sustainable benefit to present generations, while maintaining their potential to meet the needs and aspirations of future generations*. The two main strategies for the conservation of genetic resources, *in situ* and *ex situ* conservation, complement one another. *In situ* conservation implies the continuing maintenance of a population in its natural or original habitat, within the community of which it forms a part. *In situ* conservation of forest genetic resources is, in practice, carried out in forests experiencing varying degrees of human intervention, from strict protection to intensive management for specified goods and services. *Ex situ* conservation includes conservation as seed, pollen or tissue, and conservation of genetic materials in live collections such as plantations, arboreta and clone banks, or in especially established *ex situ* conservation stands.

National Programmes

Growing concern over long-term maintenance of health and overall productivity of forests and forest ecosystems, species and genetic resources, and over alterations in forests at the landscape level, have led in many countries to the elaboration of national policies or special programmes for the conservation of biological diversity, including forest biological diversity and forest genetic resources. In this respect, the preamble of the Convention on Biological Diversity, adopted in 1992, reaffirms that States have sovereign rights over their own biological resources, and that they are responsible for conserving their biological diversity and for using their biological resources in a sustainable manner.

National policies and programmes relating to forest genetic resources cover a wide range of activities, from conservation measures taken to protect rare and endangered species and populations and regulations governing seed collection and transfer in socio-economically important tree species, to comprehensive approaches to the management of ecosystems and forest genetic resources. Implementation of conservation programmes has been accompanied by increasing recognition of their cross-sectoral nature, and by recognition that institutional strengthening, awareness raising and technical considerations in the management of forest genetic resources are intimately related and mutually dependant. Integrated strategic approaches to conservation are therefore necessary at national level. As an example, field repositories of genetic resources include nature reserves and other protected areas; private and publicly owned, managed and unmanaged, natural forests and plantations; trees outside forests in agroforestry systems, along rivers, canals, roads and in homesteads; arboreta and botanic gardens; and field tests and trials established within the framework of selection and tree improvement programmes. The maintenance and management of an appropriate combination of these *in* and *ex situ* "genetic repositories", in a range of locations under diverse environmental, institutional and silvicultural conditions, constitute the most efficient way to conserve various levels of genetic variation, while providing a buffer against actual and potential risks. However, it also constitutes a major organizational, institutional and technical challenge.

With the above complexities in mind, considerations related to forest genetic resources have been integrated in a number of countries within wider frameworks, such as national forest programmes and biodiversity status and action plans developed within the framework of the Convention of Biological Diversity.

The national programmes provide the basic framework for action, however, programmes confined within the national bounderies have a number of limitations, as the natural distribution of many forest tree species spans across political borders. Furthermore, at times, tree species or given populations or provenances have become socially or economically important outside of their natural ranges, while they may be of minor, present-day importance in their countries of origin; such situations raise questions regarding responsibilities in conservation, especially when *in situ* conservation is seen as an imperative. A number of introductions, frequently of undocumented origin, have also evolved into land races, which are well adapted to environmental conditions outside of the species' natural range, and these land races are often of importance in genetic conservation activities; also this situation calls for collaboration between two or more countries.

It is widely acknowledged that the greatest number of plant species occurs in tropical areas. These areas frequently coincide with territories of developing countries with limited financial, institutional and manpower resources. In the field of genetic resources, funding for research and development is available primarily in developed countries, while needs are global; there is an increasing urgency to acknowledge the need to share responsibilities in genetic conservation. In this regard, access and transfer of genetic resources and property rights issues are increasingly debated at national and international levels, *i.a.* within the framework of the Convention on Biological Diversity, with the aim to promote both the conservation and sustainable use of these resources and the equitable sharing of benefits derived from them.

The above considerations have strengthened the international element in genetic resource conservation and use. It is increasingly recognized that, while the national programmes form the building blocks in the genetic conservation and while implementation of such programmes is the responsibility of the national governments, collaboration and support at international level is also necessary. International mechanisms can usefully help ensure that action taken by individual countries is complementary, compatible and mutually supportive. Through such mechanisms attention can also be drawn to conservation issues of global concern, and gaps in coverage can be identified, pinpointed and agreement reached on remedial action, while at the same time respecting national souvereignity and priorities.

Initiatives at International Level

The International Forestry Dialogue

Heightened political and policy level recognition of the importance of conserving forest biological diversity culminated in the discussions in the United Nations Conference on Environment and Development, UNCED, held in Rio de Janeiro in June 1992. A number of agreements were reached at UNCED and a number of action frameworks were adopted and subsequently ratified by countries present. Some of these agreements and mechanisms directly addressed the forestry sector, notably Chapter 11 of Agenda 21 of UNCED, "*Combating Deforestation*"; and the "*Forest Principles*"[1]. The adoption and subsequent ratification of the legally binding Convention on Biological Diversity (CBD) was also of major relevance to forestry, in particular as regards protected areas, *in situ* conservation of biological diversity and genetic resources, and access to genetic resources, their sustainable use and equitable sharing of benefits derived from them[2]. A work programme for forest biological diversity was adopted by the CBD in 1998, and is under further development. The work programme makes reference to forest genetic resources and integration of related concerns into sustainable forest management.

The intergovernmental policy dialogue on forests following UNCED has been largely focused on the discussions in the Intergovernmental Panel on Forests (IPF) and, subsequently, the Intergovernmental Forum on Forests (IFF), established under the United Nations Commission on Sustainable Development. Neither IPF nor IFF, which held its final session in February 2000, focused specifically on forest genetic resources in their programmes of work, however, related issues on the conservation, management and sustainable development of all types of forests, which were discussed in more general terms, were of major relevance to the subject matter.

Coordination of inputs and support by the international organizations to the international forest policy dialogue has been ensured over the years by the high level, informal Interagency Task Force on Forests (ITFF), established in April 1995[3].

In addition to the active collaboration with its partners in the ITFF also an all issues related to forestry and in issues in forest biological diversity and forest genetic resources, FAO collaborates closely in these latter fields *i.a.* with the United Nations Educational, Scientific and Cultural Organization (UNESCO), the International Plant Genetic Resources Institute (IPGRI), the International Centre for Research in Agroforestry (ICRAF), the World Conservation Union (IUCN), and the International Union of Forestry Research Organizations (IUFRO). This latter organization recently established a Task Force on the management and conservation of forest genetic resources, which bridges the work of all relevant IUFRO Divisions.

Crop and Forest Genetic Resources

Concerns related to crop and forest genetic resources have received public and political attention in differing ways. The Fourth International Technical Conference on Plant Genetic Resources, convened by FAO in Leipzig, Germany, in June 1996, endorsed a State of the World's Plant Genetic Resources report and adopted a Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture. The present version of the Global Plan of Action, as endorsed in Leipzig, covers genetic resources of agricultural crops. While making reference to wild relatives of cultivated plants, often found in forest ecosystems, and to domesticated tree crops (fruit trees, rubber *etc.*), the Global Plan of Action explicitly excludes forest genetic resources.

In forestry, growing awareness of deforestation in the tropics and of forest and environmental degradation in both developed and developing

[1] The Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests.

[2] Other legally binding conventions of relevance include the Framework Convention on Climate Change, and the UN Convention to Combat Desertification.

[3] Partners in ITFF include: The Food and Agriculture Organization of the UN (FAO), the International Tropical Timber Organization (ITTO), the Secretariat of the Convention on Biological Diversity (CBD), the United Nations Department of Economic and Social Affairs (UN-DESA), the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), the World Bank, and the Centre for International Forestry Research (CIFOR).

countries, has contributed to the development of a number of international initiatives aimed at the conservation of forest biological diversity (including wildlife) on the one hand, and the sustainable management of forests and woodlands and the biological diversity housed in them, on the other. Although the need for specific focus on the management of the forest genetic resources has received increasing attention over the past thirty years, there is to date no international equivalent in forestry to the Global Plan of Action, mentioned above.

At technical level, a Panel of Experts on Forest Gene Resources was established by FAO in 1968. The Panel regularly provides advice to FAO and, indirectly, to the world community, on programmes and priorities in the field of forest genetic resources. The work of the Panel complements that of the subsequently established FAO Commission on Genetic Resources for Food and Agriculture (CGRFA), which oversees the International Undertaking on Plant Genetic Resources and the Global Plan of Action. The mandate of the predecessor to the CGRFA, the Commission on Plant Genetic Resources, established in 1983, was expanded in 1995 to cover "*all components of biodiversity of relevance to food and agriculture*", including the fields of agriculture in the strict sense, domestic animals, forestry and fisheries. The work programme of the CGRFA will be correspondingly expanded in the future, in a step-wise manner.

In line with the recommendations of the Panel of Experts on Forest Gene Resources, FAO has developed a worldwide data base and information system on forest genetic resources (REFORGEN)[4]. The objective of REFORGEN is to make available reliable, up-to-date information on forest genetic resources for use in planning and decision making at the national, regional and international levels. The information system complements national work in this field, and information contained in the national databases and information systems, and other country-derived information, will be aggregated for use and easy retrieval through REFORGEN. As of March 2000, information from 146 countries and on more than 1600 tree species was stored in the system. REFORGEN is linked to the FAO global forest resources information database, which contains information on forest areas and trends. It complements databases on threatened and endangered plants (including trees) administered by the World Conservation Union (IUCN) and the World Conservation Monitoring Centre (WCMC), and the data base on protected areas held by the WCMC. A great number of other international, regional and national organizations and institutions have established data bases or developed Internet sites and search engines on forest and tree genetic resources. The challenge will be to ensure compatibility between the major data bases, and to establish links between them for easy retrieval and use of all available information.

Initiatives at Regional Level

Regional and Species-Specific Forest Genetic Resources Networks

Regional approaches to the conservation of the forest biological diversity and the forest genetic resources are especially useful in cases in which countries have comparable institutional conditions and similar ecological needs and requirements. The regional approaches have over the past years been complemented by the eco-regional approaches and, at times, by action focused on common priority species or groups of species.

A number of international and bilateral development agencies and NGOs working at regional level have incorporated activities related to the conservation of forest genetic resources with the wider forestry strategies coordinated or supported by them. The activities undertaken cover a wide range of forest genetic resources issues, from exploration, evaluation, genetic conservation and tree improvement, to the incorporation of genetic considerations with the sustainable management of forests and woodlands, and the development of common technical methodologies, specialized training and capacity building, and strengthening of national institutions.

[4] REFORGEN is available on-line at the FAO Internet Homepage on forest genetic resources, at: http://www.fao.org/forestry/FOR/FORM/FOGENRES/homepage/fogene-e.stm

In some regions, country-driven action has lead to joint development of collaborative programmes in the forestry and forest genetic resources, which has helped ensure coordination of work between neighbouring countries. At each of three Ministerial Conferences on the Protection of Forests in Europe (Strasbourg 1990, Helsinki 1993 and Lisbon 1996), a number of resolutions were adopted, including one resolution specifically focused on the conservation of forest genetic resources (Resolution S2, Strasbourg 1990). As a follow-up to this resolution, five species-specific networks were established within the framework of the European Forest Genetic Resources Programme (EUFORGEN), a mechanism which was established following the Strasbourg Ministerial Conference to support countries in the implementation of resolution S2, and which is coordinated by IPGRI with technical support from FAO. Thirty countries participated in the first phase of the EUFORGEN programme (1994–1999). Proposals for a second phase have been finalized, with continued attention to the development of methodologies and "best practice" in *in situ* and *ex situ* conservation of genetic variation in targeted pilot species or groups of species, to the exchange of reproductive materials for purposes of research and conservation, and to the exchange of information and know-how.

Other regional and sub-regional programmes and projects include, among others: (i) the South Pacific Regional Initiative on Forest Genetic Resources (SPRIG), which during its pilot phase (1997–1999) helped develop comprehensive strategies and coordinated action in five island countries; a second phase of the project presently in preparation; (ii) the Integrated Regional Strategy for Seed Procurement in Central America and the Dominican Republic, carried out by concerned countries with the support of the DANIDA Forest Seed Centre, with the aim to strengthen national forest seed programmes and to enhance sub-regional cooperation; (iii) the Tree Seed Centres' Network of the Southern African Development Community (SADC), which has been instrumental in supporting the establishment or the strengthening of existing national tree seed centres in twelve countries in Eastern and Southern Africa; (iv) the Central Asian and Transcaucasian Network on Plant Genetic Resources (CATCN-PGR), coordinated by IPGRI, which focuses on the conservation of genetic resources of crops and forest trees in eight countries of the sub-region, and which benefited during its establishment from the experience and assistance of the EUFORGEN programme; and (v) the newly established Sub-Saharan African Programme on Forest Genetic Resources (SAFORGEN), co-ordinated by IPGRI, aimed at strengthening national research institutes and regional forest research programmes in countries in sub-Saharan Africa.

Examples of species-specific networks include*:* (i) the FAO coordinated project on Genetic Resources of Arid and Semi-Arid Zone Arboreal Species for the Improvement of Rural Living, initiated in the early 1980s in collaboration with IBPGR/IPGRI, UNEP and, subsequently, the DANIDA Forest Seed Centre (DFSC). The project is aimed at the exploration, collection, exchange, evaluation and conservation of genetic resources of dryzone multipurpose species, with special reference to two genera identified at the outset by collaborating countries: *Acacia* and *Prosopis* spp. The DFSC and FAO, in close collaboration with cooperating countries, are presently reviewing experimental results and their implications based on in-country findings and overall results across countries and sites; (ii) the International Neem Network coordinated by FAO, aimed at characterizing the extent and patterns of genetic variation of *Azadirachta indica*, and to assist collaborating countries in Asia, Africa and Latin America to make appropriate use of the potential which this species offers in arid lands; (iii) the International Network for *Leucaena* Research and Development, LEUCNET, based at the University of Queensland, Australia; (iv) TEAKNET, focused on *Tectona grandis*, hosted by the Forest Department of Myanmar; (v) the International Network for Bamboo and Rattan (INBAR), and the recently established International Centre for Research and Training on Seabuckthorn (ICRTS), both headquartered in Beijing, China.

Cooperative tree improvement programmes are common in both industrialized and developing countries. While many of these have originally received inspiration and a "model" from North American forest industries tree improvement cooperatives, such as the one operating in South Eastern USA and based at the North Carolina State University in Raleigh, these programmes at times also involve several countries. In this, latter case, membership might be based on the geographical closeness or ecological similiarities in conditions of collaborators, or on common interest in given species or groups of species. Existing cooperatives have often been established with a broad perspective, including seed exchange and tree improvement as well as conservation of genetic resources. An example of such programmes is the Central America and Mexico Coniferous Resources Cooperative, CAMCORE, hosted by the North Carolina State University, USA, which deals with the exploration, collection and exchange, testing, improvement and conservation of conifers and some hardwood species originating in Mexico and Central America.

Regional Forest Genetic Resources Workshops and Action Plans

As evidenced above, a number of international organizations has involved, directly and indirectly, in programmes related to forest genetic resources, and a number of mechanisms is presently used to further action in this field. While this situation offers excellent opportunities to address the conservation and sustainable utilization of forest genetic resources drawing upon a range of expertise and interests, and focusing on a range of different perspectives and modes of action, the lack of a common, global framework makes it difficult to define overall priorities, to identify possible overlap, and to identify and address gaps in the coverage.

In 1997, the Thirteenth Session of the FAO Committee on Forestry, "agreed that there was an urgent need for concerted action to strengthen national, regional and international activities in the conservation and sustainable use of forest genetic resources, to help enhance country capacities and to support the exchange of information, experiences and know-how". The Committee, "recommended that efforts to explore, conserve, evaluate and better utilize forest genetic resources be continued and further strengthened in collaboration with national institutes and international governmental and non-governmental partners". Some delegations considered that FAO should, "pursue efforts to develop regional plans of action for the conservation and sustainable use of forest genetic resources as a first step to develop a global plan of action". The Committee, accordingly, advised FAO, "in conjunction with Regional Forestry Commissions, international partners and countries that requested it, to convene a series of regional and sub-regional forest genetic resources workshops". The overall aim of such workshops, in accordance with the Secretariat Note prepared to underpin discussions[5], was to support countries concerned to develop mutually compatible and complementary action plans which would contribute to ensuring that forest genetic resources were conserved and sustainably utilized as a basis for local and national development, including food security, poverty alleviation, environmental conservation, economic and social advancement and the maintenance of cultural and spiritual values.

The Committee acknowledged that national plans and programmes would vary according to local biological, social and economic environments and according to national needs and priorities. The purpose of recommended action was thus not the development of one, single model for conservation for all countries, but the elaboration of a framework for national action, valid at regional level and, to the degree possible, consistent among regions[6].

Following the recommendations of COFO, FAO in collaboration with the national and the international partners has, to date, helped facilitate the organization of two regional forest genetic resources workshops, which are mentioned below. In these country-driven and action-oriented workshops, countries concerned assessed the status of their forest genetic resources and relations between forest genetic resources programmes and other sectoral programmes and overall development plans; defined national priorities and requirements in the conservation, enhancement and sustainable utilization of the forest genetic

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[5] Conservation and Sustainable Utilization of Forest Genetic Resources. COFO-97/5. Thirteenth Session of the Committee on Forestry. FAO, Rome 10-13 March 1997. FAO, Rome.

[6] The full report of the 13th Session of the FAO Committee on Forestry is available at: http://www.fao.org/forestry/fo/statbod/cofo/cofo97e.htm

resources; identified target species and genetic resources activities of common interest; and determined priority areas for future collaboration among countries in the region.

The first of these workshops, "*Conservation, Management, Sustainable Utilization and Enhancement of Forest Genetic Resource",* was organized by FAO in collaboration with IPGRI and ICRAF, in Ouagadougou, Burkina Faso, in September 1998. Following in-country consultation among institutions and stakeholders, thirty-five participants from fifteen countries and six international, regional, bilateral and national agencies met to identify the main components of a sub-regional plan of action on forest genetic resources for the Sahelian and North-Sudanian zones of Africa. A synthesis document on the state of forest genetic resources in the sub-region, based on national reports prepared by 18 countries, provided the background for discussions and for the sub-regional action plan. When fully operational, IPGRI's SAFORGEN programme, mentioned above, will provide a useful platform to help implement a number of the research activities identified in the sub-regional forest genetic resources action plan.

As follow-up to recommendations made by Heads of Forestry of Pacific Island countries and territories, a sub-regional workshop on forest genetic resources was convened in April 1999 by the Australian funded South Pacific Regional Initiative on Forest Genetic Resources project (SPRIG), FAO, the Forestry Division of Samoa, the South Pacific Community/UNPD Pacific Islands Forests & Trees Support Programme, and the South Pacific Regional Environment Programme. The workshop, which was the first of its type in the region, was attended by fifteen Heads of Forestry or their representatives. A sub-regional action plan on forest genetic resources was prepared, complemented by a sub-regional synthesis on status and priorities in forest genetic resources, based on reports from countries and territories concerned.

A workshop on forest genetic resources, which will cover twelve countries of the Southern African Development Community (SADC), is scheduled to be held in June 2000 in Arusha, Tanzania, with support from FAO and international partners. The sub-regional forest genetic resources action plan which is expected to be developed, will complement and strengthen action presently coordinated by a joint coordination unit for the SADC countries, and will be underpinned by an existing, dynamic SADC network of national tree seed centres.

Similar worshops are planned to be held in other regions, pending identification of international, regional and bilateral partnerships, and the identification of necessary funding. Priority will be given to those regions in which institutional networking mechanisms already exist, as this will facilitate both the development and the implementation of action plans on forest genetic resources. It is hoped that, ultimately, work will stimulate joint efforts at the global level, in line with the UN Secretary-General's vision that the United Nations should increasingly serve as a catalyst for collective action, both among its Member States and between them and non-state actors, including the private sector and non-Governmental organizations[7].

The flexible, country-driven, step-by-step process towards coordinated action in forest genetic resources described above, was noted and welcomed by the XI World Forestry Congress in Antalya, Turkey (October 1997), and by the 4th International IUFRO/FAO Consultation on Forest Genetics and Tree Breeding in Beijing, China (August 1998). Action is in line with, and complements, that of other initiatives presently undertaken at national, regional and global levels, such as the elaboration of National Biodiversity Status and Action Plans under the Convention on Biological Diversity (CBD) and the exchange and sharing of technologies, know-how and information to be implemented through the Clearing-House Mechanism of the CBD.

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[7] See document: *We the peoples: the role of the United Nations in the twent-first century*. Report of the Secretary-General. United Nations General Assembly, Fifty-fourth session: the Millenium Assembly of the United Nations. Agenda Item 49(b). Document A/54/2000. United Nations New York 2000.

Concluding Remarks

While some natural and human-induced losses in biological diversity over time are inevitable, the diversity between and within forest tree species can be maintained at an acceptable levels and managed by a wide range of human activities. The intensively managed commercial plantations for timber production and wilderness conservation areas represent some of the extreme alternatives in a wide range of forest genetic resources management options. All options provide benefits to the human populations and societies, while helping to maintain and develop genetic resources of proven or potential value to the present and future generations.

Long-term political commitment at national and local levels is a prerequisite for the implementation of sustainable genetic management programmes. The need for cooperation between a range of national agencies and local communities within a country stems from the multidisciplinary nature of genetic resource conservation, its close links and inter-dependency with other fields of forestry and development programmes in general, and the scope, vastness and urgency of the problem. Forest genetic resources considerations should increasingly be integrated with silvicultural and forest management practices, and they should also form part of national and local strategies for the maintenance of biological diversity in and outside protected areas. The genetic conservation considerations should also be an integral part of tree improvement and breeding programmes.

Since genetic resources do not respect political boundaries, national efforts in their conservation and wise use, which must at all times form the basic building blocks of regional and global strategies, can be usufully complemented by international support and coordination to ensure complementarity and global coverage of action. Joining efforts across national borders will make best use of scarce resources and will help fill the considerable information gaps in the forest resources field more quickly. While countries have sovereign rights over their genetic resources, and should ultimately decide upon action and programmes, it is important to recognize that coherent action at regional and global levels will facilitate solving the problems in the longer term.

References

Documents mentioned in the text of this paper and information on FAO coordinated programmes in the field of forest genetic resources can be requested from the authors, or accessed on the Forest Genetic Resources Homepage quoted on page 1.

Guidelines for Gene Conservation Based on Population Genetics

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Abstract

The current levels of genetic variation, and the distribution of that variability within and between tree populations is due to hundreds of millions of years of interaction between the different evolutionary factors, mutation, migration, recombination, genetic drift and natural selection. Artificial selection, breeding, and silviculture have so far had minor genetic effects on most tree species. The same evolutionary forces go on dynamically changing the genetics of the populations.

We should not strive to maintain the current status, but the goal of gene conservation, be it *in situ* or *ex situ* will need to be to allow these evolutionary processes to continue. The biological characteristics of species will to a large degree dictate the possible approaches to gene conservation .While there is much variation between species of trees in their genetic characteristics, most tree species are characterised by an outcrossing mating system and high levels of inbreeding depression. This means that care must be taken to control and monitor the potential level of inbreeding in breeding and production populations. Most species also have high level of variability in the genome in general, and in important quantitative traits, even if the distribution of this variability may differ between traits. When the gene pools of the species are actively managed through breeding or silviculture, it will be important to be aware of the influence of the different evolutionary factors. These principles will be illustrated with examples mostly from temperate tree species.

Keywords: Gene conservation, Population genetics, Forestry.

Introduction

The title of this presentation is very broad. The population genetics principles underlying conservation of genetic resources are similar for all organisms. However, the priorities of gene conservation are different for instance in rare and endangered species or economically important species. Likewise, different groups of organism vary in the basic features of their biology, and thus different aspects of the population genetic processes must be emphasised. Here I will deal with forest trees, and will not consider the forest ecosystem with all its other species. Gene conservation of forest trees, as of other plant species, has several aspects (Frankel et al. 1995).

It has been estimated that among the 100 000 described forest trees species more than a thousand are endagered through forest management activities and many for other reasons (World Conservation Monitoring Centre 1998). Forest geneticists should contribute to identifying conservation priorities among such species. This is a task where the methods of molecular systematics are likely to be quite helpful (Crozier 1997; Soltis and Gitzendanner 1999). Molecular systematics methods can serve to identify ways to conserve the maximum amount of genetic information with the limited resources available.

Likewise, we should be able to point ways to utilise in a genetically sustainable way the resources of natural populations (Koski 1998; Namkoong et al. 1996). It is a demanding task to generate criteria that will identify the proper management methods for genetic sustainability, and the rules need to be applied in different ways in different environments.

Further, the genetic resources of domesticated species need to be conserved for the purpose of their continued ability to adapt to environmental conditions, and for the immediate needs of tree breeding and production populations. I will consider those populations that are close to the natural populations, and maintain the original breeding structure.

Conservation biologists often discuss evolutionarily significant units (ESU) and management units (MU) (Moritz 1994).

Evolutionarily significant units are due to long term genetic divergence, while management units owe their distinctness to a shorter history and still can continue gene exchange. It is obvious that the above description of the tasks of forest conservation genetics has to deal with both ESUs and MUs.

Forest trees share many biological features. They are predominatly outcrossing organisms with often large population sizes. Conifers form an important group of species with shared phylogeny and biological similarities. In contrast, angiosperm trees are spread all over the phylogenetic tree.

In the following, I will discuss different evolutionary factors, trying to emphasise the special features of trees relative to other species that have been genetically studied.

Quantitative Traits and Molecular Markers

Variation of most traits of adaptive or economic importance is governed my multiple loci, even if the exact number is never known. Many of these have been and are influenced heavily by natural selection. Currently we gain much information about the genetics of species through molecular markers(Savolainen and Karhu 2000). As I discuss the influence of different evolutionary factors, it will be evident that there are limits to the information that markers can provide. It requires careful consideration to use that information properly to make inferences about the variability and distribution of quantitative traits (Lynch 1996).

Evolutionary Factors

A classical listing of evolutionary factors could include mutation, recombination, mating system, selection and genetic drift and founder effects. For a review of the factors, the readers are referred to any current population genetics tesxtbook, such as Hartl (2000) or Hedrick (2000). For the purposes of this review, I will emphasize also the role of history, which then comprises the joint action of an unknown set of factors.

Mutation

Mutation is responsible for all the genetic variation, but its effects are normally seen only in the long term. However, in selection experiments running for a few tens of generations, such as can be carried out in model organisms, part of the response can be attributed to mutation (Falconer and Mackay 1996; Lynch and Walsh 1998). Understanding mutation rates is relevant for gene conservation for several reasons. First, mutation rates partly govern the rate at which populations or species diverge into evolutionarily independent units. Second, characteristics of deleterious mutation influence the behaviour of small populations where inbreeding can be high. Third, mutation rates influence the rate at which variation is replenished after genetic bottlenecks (Nei et al. 1975).

Direct estimates of mutation rate are not easily obtained, and they are only available for model organisms. However, the theory of molecular evolution predicts that at neutral sites of the genome, the rate of nucleotide substitution between two species will equal the mutation rate. This simple feature can be used to estimate the rate of mutation by comparing the divergence at the nucleotide level between species. Few such quantitative comparisons are available. They all show that compared to many other organisms, trees evolve slowly, and thus the mutation rates at individual loci per year are low. As most mutations are likely to occur at DNA replication, the per generation mutation rate in long lived species should be higher. A similar result seems to hold for both angiosperms (Frascaria et al. 1993) and conifers (Mikkonen, Dvornik, Sirviö, Savolainen, unpublished). In fact, the initial results on the low estimates of mutation rates are somewhat surprising, given the high levels of variation that have been found in many trees (Hamrick and Godt 1996).

In many cases, the parameter of interest may be the mutation rate per character or per genome. For instance, the genome wide mutation rate to deleterious genes governs the dynamics of inbreeding depression (Charlesworth and Charlesworth 1987; Lande et al. 1994). The level of inbreeding depression in conifers suggests that the genome wide mutation rates for deleterious genes are many times higher than in most other organims (Klekowski 1988; Koelewijn et al. 1999; Lande et al. 1994).

The rate of mutation is just one characteristic of deleterious mutation. Another issue of significance for conservation genetics is the size of the mutational effects, and their effect in heterozygotes. These two parameters can have a major influence on the fate of mutations in small populations (Hedrick 1994). These are difficult to measure, and there is no consensus on the size of effects even for model organisms (Keightley and Caballero 1997; Lynch et al. 1999). Unfortunately, no results on the size distribution of deleterious mutational effects are available for trees.

Recombination

New combinations of genetic factors can only occur at meiosis in double heterozygotes. The effect of recombination is to generate new combinations, but also to break up old combinations of alleles at different loci. This results in independent evolution of different genes. Unless there is some strong force, such as selection based on interactions between the two loci, alleles at the two loci will behave independently in a statistical sense. Alternatively stated, there will be no linkage disequilibrium between the loci. The potential for recombination is strongest where double hererozygotes are common and crossing over occurs frequently. Most, if not all trees are predominatly outcrossing. They also often have large effective population sizes (large numbers of trees participate in reproduction). Many genomes are known to be genetically large (with pine genomes about 2000 cM Sewell et al. (e.g. 1999). Tree population generate very efficiently novel combinations of alleles at different loci. Some rounds of recombination can regenerate allelic combinations efficiently, as long as the variation at individual loci is present.

Mating system

Many reviews show that the outcrossing versus selfing mating system is the most powerful single determinant of the level of variation in trees (Hamrick et al. 1992; Hamrick and Godt 1996). The average level of variation at marker loci for selfing plants is 0.12, for outcrossers 0.16, measured as expected heterozygosity at individual loci. The level of differentiation of populations for outcrossers is on average about 0.1, whereas for selfers it is 0.5, measured as F_{ST} (Hamrick and Godt 1996). Most trees are predominant outcrossers. Some eucalypts have rather high partial selfing (Moran 1992). The outcrossing rates of pines range from rare intermediate outcrossing rates of about 0.5 in oceanic islands of *Pinus radiata* (Savolainen, Moran and Bell, unpublished) to nearly complete outcrossing in some populations of *Pinus sylvestris* (Muona and Harju 1989). Fully outcrossing species have their genotypic frequencies in Hardy-Weinberg equilibrium. When there is some selfing, the genotypic frequencies at the seed stage deviate, such that there is an excess of homozygous genotypes (e.g.Yazdani et al. 1985). In many cases, the genotypes due to selfing are eliminated by inbreeding depression before the adult stage, and the adult genotypic frequencies are again in Hardy-Weinberg equilibrium.

Temperate and boreal trees, both conifers and deciduous species, are mostly wind pollinated. Earlier studies have shown that the genotypic distribution of such species is rather robust to many kinds of environmental change. For instance, changes in density following harvesting do not seem to have a major influence of reducing outcrossing (Neale and Adams 1985; Savolainen and Kärkkäinen 1992). However, many tropical species are animal pollinated, and in such cases the maintenance of the pollination system may be much more vulnerable to environmental changes that threaten the pollinators, even if they would not directly influence the trees (Namkoong et al. 1996). Lack of pollinators could in the extreme case lead to reproductive failure and reduced population size, as has been shown in mistletoes (Robertson et al. 1999), but it could also have more subtle genetic consequences. Fewer pollinators, perhaps in a reduced density of trees could lead under some circumstances lead to an increased level of self-fertilization, if the species is self-compatible. It could also lead to a much reduced effective population size.

Migration

Population geneticists prefer to define in detail their migration model, because the results depend on these specifications (e.g. Hedrick 2000). Classical models include the island model, where all subpopulations of equal size are assumed to be exchanging genes at an equal rate with all other populations. A more realistic version of this is the stepping stone model, where gene exchange is more likely between adjacent than more remote populations. A model relevant for species with very large distributions, such as Scots pine, would be an isolation by distance model, where gene exchange is limited between parts of the population. A more recent development is to consider migration in an ecological context, where populations can go extinct and the sites can be recolonised (a metapopulation) (e.g. Barton and Whitlock 1997). The genetic differentiation of populations for neutral genes depends on the balance of migration and genetic drift. Many wind pollinated trees have very low levels of differentiation (e.g. Muona 1990), mainly because of very efficient pollen flow (Koski 1970). The effect of much less gene flow through seeds is seen when differentiation of maternally inherited angiosperm chloroplast DNA is considered. For instance in European oaks, there is a very high level of divergence in cpDNA markers, whereas the nuclear markers are nearly uniform(Petit et al. 1997; Zanetto and Kremer 1995)].

In contrast, paternally inherited cpDNA markers of conifers are not quite as differentiated. The lowest level of divergence is expected when genes migrate through both seeds and pollen (Ennos 1994). Northern conifers often have very low level of differentiation at neutral markers, such as has been found in Scots pine (Karhu et al. 1996; Muona and Harju 1989), whereas animal pollinated e.g. *Acacia*s are be much more diverged (Butcher et al. 1998).

Genetic Drift

Genetic drift occurs in small populations, where the sampling effect can overcome the influence of other evolutionary factors. Genetic drift results in loss of variation within populations, and an increase in the differentiation of isolated subpopulations (e.g. Falconer and Mackay 1996). Overall, there will be a large decrease in the heterozygosity of the population. For a discussion of small population phenomena in a forest genetics perspective, (see Savolainen and Kuittinen 2000). The effects of drift cumulate over generations. In each generation, the variability, measured by average heterozygosity, is reduced by ($1/2N_e$). Thus, even a very small bottleneck for one generation does not reduce the average heterozygosity by very much. However, if the bottleneck is extended, then the effects are large even on average heterozygosity. Average heterozygosity is mainly influenced by common alleles, rare alleles make only a small contribution. However, bottlenecks have an immediate effect on rare alleles. The number of alleles is immediately reduced . After the bottlenceck, mutations start recovering variability. The dynamics of this process vary between different kinds of genes (Nei et al. 1975). The number of alleles recovers more rapidly than the average heterozygosity. Recovery of quantitative variation may be faster than variability at individual loci, because so many loci may contribute to this type of variation.

Genetic drift will be of little concern in economically important species, where populations are by definition large. However, founder effects refer to small population sizes when new populations arise e.g. through colonisation of a new area by a small number of individuals. These bottlenecks are often of short duration, but may have consequences for the genetic structure. Such effects could also be important if a breeding program is started with a very small number of individuals, as has repeatedly happened in the history of cultivated plants.

Natural Selection

Many of the evolutionary forces are expected to influence all genes equally. All loci have in principle the same effective population size, they migrate together in the same pollen grains or seeds. Selection may be very slight on large parts of the genome, such as in the nonfunctional parts of the DNA, and probably at introns, and at the nucleotide sites that do not change the amino acid in the protein

(Kimura 1983). In these areas, the patterns of genetic variation are likely to be governed by the balance of mutation, drift and migration. Natural selection, can however, give rise to a very different pattern of variation. The extensive provenance variation of pines is well documented in both Europe and North America. Traits related to adaptation to the local growing conditions have much variation between populations, such as cold tolerance in Finnish populations of Scots pine (Aho 1994; Hurme et al. 1997), or the timing of vegetative growth in the same populations (Hurme et al. 1997; Mikola 1982).

Similar strong differentiation has been found in several North American species, such as Ponderosa pine (Rehfeldt 1990). In some cases this genetic variation has been quantified as Fst for quantitative traits (or Qst), which is related to the analogous measure on single locus variation (see Prout and Barker 1993). In all trees studied so far, the quantitative trait Fst values have been considerably higher than at single, presumably neutral loci (Yang et al. 1996), and comparable work in Scots pine (Savolainen, Hurme, Repo, in prep.). For other species there may not be exactly similar quantitative resuls available, but the main conclusion remains the same. (Table 1)

Implication for Population Genetics of Trees

Inbreeding depression is high

Individuals due to mating between related individuals or selfs have low viability and fertility. This is due to homozygosity of deleterious alleles. Trees seem to carry many deleterious alleles at a large number of loci. Numerous studies have shown that most tree species have reduced viability and growth after selfing or other close inbreeding (reviewed in Williams and Savolainen 1996). This feature must be considered both in tree breeding and in the design of conservation populations.In natural populations, inbreeding may lower the viability of populations (Saccheri et al. 1998).

Genetic Equilibria are often Reached Slowly

Current population sizes, mutation rates and selection can account for many aspects of the amount and distribution of genetic variation of trees.However, empirical studies have shown that species with similar life histories and approximately similar current distribution areas (and hence effective population sizes) can vary much in the level of diversity.

The genus *Acacia* provides some good examples (Table 2). The average expected heterozygosity within populations ranges from about 0.02 in *Acacia mangium* to about 0.30 in *Acacia melanoxylon*, using the same set of marker genes (Moran et al. 1989). In fact, later work has shown that the level of variation found within individual populations of *A. mangium* is quite variable (Butcher et al. 1998). Similar findings have been made in the genus *Pinus*, where *P. sylvestris* is among the most highly variable species, and a rather close relative, *P. resinosa* is nearly devoid of variation at the isozyme loci (Fowler and Morris 1977) and most of the DNA markers studied (Mosseler et al. 1992). These markers behave as neutral markers, whose levels of variability are in principle governed by mutation rate and the genetically effective population size (= $4N_e$). Note that the genetic consequences of a long period of a reduced effective population size take very long to overcome. There is no reason to suspect that this anatomically similar plants would have very different mutation rates. Thus, we can only search for explanations in the history of the species, and conclude that after a glaciation related bottleneck, *P. resinosa* has not yet reached its equilibrium level of diversity. The implication for conservation biology is that even between closely related species, we cannot for certain predict the standing levels of variation, many species may be far from the equilibrium.

Table 1. Comparison of Fst statistics for marker loci and quantitative traits

Species	Average Fst for markers	Quantitative trait	Fst	Reference
Pinus contorta	0.02	Height	0.19 (largest)	Yang et al. (1998)
Pinus sylvestris	0.02	Bud set date	0.82	Savolainen et al. (in prep).
Quercus petraea	0.02	Bud burst	0.33 (assuming h^2 is 0.30)	Kremer et al. (1997)

Table 2. Genetic diversities at isozyme loci in *Acacia* species, following Moran (Moran et al. 1989).

Species	Expected heterozygosity
A. auriculiformis	0.084
A. crassicarpa	0.081
A. dealbata	0.085
A. decurrens	0.156
A. mearnsii	0.206
A. mangium	0.017
A. melanoxylon	0.300

Note that the levels of diversity found depend on what parts of the distribution, of the genome, are sampled. In a later study Khasa et al. (1994) found a somewhat higher diversity for *A. mangium*, and later work with RFLP markers also found more variation (Butcher et al. 1998).

Populations are Differentiated for Historical Reasons

Above I pointed to cases where natural selection has resulted in large genetic differences between populations. However, genetic differences will accumulate between isolated species or populations just due to mutation accumulation. This seems to be quite a slow process e.g. in conifers. Species of the genus Pinus diverged 100 MYA seem as diverged as some Brassicaceous species that have diverged less than 10 MYA((Savolainen et al. 2000, Mikkonen, Dvornik, Sirviö, Savolainen, in prep.). Such isolated populations can have a high level of genetic divergence overall in the genome. Many examples are provided by the glacial isolation and post glacial migration of trees. In Finland, the eastern and western populations of *Quercus robur* on the south coast may represent different colonizations (Ferris et al. 1998). Similarly, Petit et al. (1997) have recognised different glacial histories in other oak populations of Europe.

Another well documented case is that of Norway spruce, where the isozymes are slightly differentiated between populations, and still carry the footprints of the different refugia, in similar areas as the oaks (Lagercrantz and Ryman 1990). In this case, part of the variation in quantitative traits follows the differentiation of isozymes, and it is likely also a reflection of the historical patterns.

Such populations represent evolutionarily significant units, and will merit independent conservation, even if there are no apparent adaptational differences.

Trees have a Robust Genetic System

As described above, the genetic and life history characteristics make trees rather robust and resilient to genetic change. Many studies have found that different management practices have not had serious effects on the main aspects of genetic structure. This should be especially true if we consider natural regeneration after recombination, outcrossing and pollen migration have influenced the genetic structure of the next generation. Recently, Rajora et al. (2000) compared microsatellite allele distributions between a set of about 100 old growth trees, and those remaining after about 75 % of the trees were cut. They concluded that the potential for adaptation was seriously endangered by the reduced number of alleles. This conclusion seems quite exaggerated. It is self evident that highly polymorphic loci will be lost. The question can be answered only after studying the regenerated stand (which they did not do). Their own data suggest that there will be gene flow from other areas to replenish numbers of alleles, and recombination will provide new combinations of existing alleles. Further, microsatellites in trees have not been shown to be related to any functionally significant variation. The real issue is the genetic structure after regeneration. In fact, perturbing forest tree population may often have more significant consequences for other organisms than for the genetic structure of tree populations.

Implications for Gene Conservations

Below I present some general conclusions that can be drawn from considering the goals of conservation of forest gene resources and the evolutionary and life history characteristics of trees.

It is in general not possible to relate variability at neutral marker loci directly to population viability (Holsinger 1996). However, changes in variability of species may carry some risks.

It is important to identify the conservation needs with respect to the threatened tree species. Molecular population genetics and systematics can aid effciently in these goals.

Trees evolve slowly compared to many other groups of organisms. Nevertheless, during isolation genetically divergent units within species have evolved, and they merit individual consideration

Adaptive differences, such as those found between provenances of conifers from different latitudes can evolve rather rapidly due to strong selection. Their conservation is of extreme importance for immediate management concerns.

Many forest trees have a robust genetic structure. It is not necessary to conserve individual multilocus genotypes. Recombination, outcrossing and gene flow will efficiently generate new combinations.

Gene reserve populations help to maintain the genetic resources. However, in the domesticated and exploited species, also other populations, at different levels of management, can be managed in ways that can maintain the evolutionary processes. They can also contribute to the maintenance of the genetic resources.

Overall, the main conclusion is that conserving forest gene resources means maintaining the dynamic processess that generate and maintain it.

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Impacts of Silviculture and Forest Management on Genetic Diversity of Trees

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Abstract

Most forests must be used to satisfy the requirements of a growing human population wanting a better life. Forest management and silviculture affect gene diversity, positively or negatively, but almost all diversity may be maintained through a suitable combination of conservation areas and managed production forests. As long as due consideration is given to regeneration, most forms of harvesting have a limited effect on long-term diversity.

Regeneration is the key silviculture activity that determines the diversity of future forests and their capacity for sustainable production. Both natural regeneration and cultivation can produce new stands with acceptable diversity. Well-planned and implemented tree improvement helps maintain diversity and at the same time can provide more productive reforestation materials. Diversity patterns typically differ between production forests and conservation areas. Production forests have a simpler structure, less species and age class variation within stands. Much of the variation instead is among stands.

Many foresters do not fully understand the value of the genetic resources they handle. The scientific community must take the responsibility for making foresters more aware.

Keywords: Silviculture, Management, Genetics, Diversity, Regeneration

Introduction

Genetic diversity refers to the phenomenon that within a species all individuals are not identical by inheritance and consequently respond in different ways to their environment. The variation among individuals is not only genetic. Many characteristics like branchiness, stem form and diameter are strongly affected by the environment, for instance expressed as site fertility or stand density. In uneven aged stands older trees are typically taller and bear more fruit. In most cases one needs sophisticated genetic tests and analyses are needed to separate the effects of genetic differences from those caused by environmental factors.

In all forestry activities, regeneration in particular, the maintenance of genic (allelic) variations and systems of recombination should be considered. The desire of many conservationists to preserve all old trees (genotypes) of a forest is not the best option for future generations. Even trees get old and die, and their environment is exposed to catastrophic environmental changes, e.g. forest fires or flooding. Changes in species composition and genetic structures of protected areas depend on stochastic events and genetic processes. Through dynamic genetic improvement and gene conservation the genotypic variation can be produced as long as alleles are not lost from the population's gene pool. Active forest management with due consideration of genetic aspects is at least as effective a system for maintaining genetic diversity as increasing the volume of protected areas. This in no way denies the value of protected areas in ecosystem conservation.

Increasing human populations wanting improved living conditions put greater than ever pressure on the forests. More and more wood is needed for fuel and as industrial raw material. At the same time there is a strong call for setting land aside as reserves, where natural processes can go on with a minimum of human influence, or for recreational use. To make possible the production of more and more wood for human consumption at the same time as we want to set aside large areas for non-productive use, the productivity of the land used for wood production must be as high as possible. Tree breeding is probably, from the environment's point of view, the gentlest way we have of accomplishing this.

It is a fact that most forestry measures, like exploitation and regeneration activities, affect diversity. With a wise management it should, however, be possible to combine the use of trees for human benefits with the maintenance of genetic diversity needed for the long-term health and stable functioning of the forests.

The aim of this paper is to discuss the impact which various forest management and silvicultural activities may have on the genetic diversity of future tree generations. Relevant research on this topic is sporadic and scant, so we will have to present many hypotheses and urgent research needs.

It is crucial, however, to understand that exploitation of timber without concern for regeneration and sustainability has nothing to do with proper forest management and of course can cause large damage to genetic diversity. In situations where such activities go on, new legislation, setting up of supervising organisations, etc. must be considered. This situation falls outside the scope of this paper, however.

General

Genetic variation in adaptive traits is advantageous to tree species. It gives them the possibility to evolve and adapt to changes in the environment. The actual value of variability in morphological or so called neutral traits is not known, but can hardly be seen as disadvantageous.

Forest trees mainly exist as wild populations. Most species show a wide genetic diversity, which so far has not been greatly changed by man. The wide genetic diversity of most species of forest trees has been shown in field tests for adaptive traits and in recent years, through various forms of isozyme and DNA analyses, on molecular levels. The patterns of variability are important and studies have shown that genetic variation exists on several levels:

1. Variation among species
2. Geographic (provenance) variation within species
3. Variation among sites within provenances
4. Variation among individual trees within stands.

Conkle (1980) found that conifers rank among the most variable plants studied by the use of isozymes. As always there are exceptions. There are some essentially monomorphic species like *Pinus torreyana* and *Pinus resinosa* (Ledig and Conkle 1983; Fowler and Morris 1977). Certainly most hardwood species are also extremely variable.

In general, provenance and tree-to-tree differences make up the majority of the genetic variation within tree species in natural stands. Adaptive traits of major species with large continuous distribution show clinal patterns of variation. That is, the change in gene frequencies is gradual and proportional to gradients of respective ecological factors. So called neutral marker characters display less geographical differentiation. In a study of cone morphology in *Pinus* sylvestris (Koski 1970) 70-80 percent of the total phenotypic variance was observed to be within population, and this in a material from 40° N (Turkey) to 70° N (Finland). Often, the variation among trees in a stand itself can make up most of the total genetic variation within large regions. In terms of isozyme variation Muona and Harju (1989) reported that more than 98 percent of the overall variation in central Finland *Pinus sylvestris* was within stand.

This paper mainly discusses the direct effects of forest management and silviculture on tree species. It should, however, be emphasised that even if a species is not directly subject to forest operations, such operations may well have an indirect impact on the species. An insect or bat pollinated species may suffer, if the management operations somehow harm the pollinator species.

Appropriate forest management comprises all the activities that lead to sustainable production under ecologically acceptable conditions. Management has the fundamental feature that it deals not with single stands but numbers of stands over entire landscapes. It is a process that works over long times, at least in temperate forestry reaching 100 or more years. An almost unavoidable effect of forest management is a simplification of the structure of each individual stand. Age-class and species variation is reduced. But on a larger scale this is not necessarily critical for the genetic diversity. All stands in the landscape are normally not cut at the same time. On a landscape level the ecosystems vary considerably and so must the silvicultural systems do as well. Over a rotation age, in most forests the goals for forestry tend to change, as do standard forestry practices. In most cases neither a single management system nor a single regeneration material will be used on a landscape scale. Stands on different sites or of different age will be genetically different from each other. All variation does not have to be represented in each stand.

While there is a choice of methods to study and evaluate the effects of forestry activities on the genetic diversity within species, there are also ways to study the effects on species mixture compared to pure stands. Foresters get into problems when they have to study these two phenomena simultaneously. What is the relative value to overall tree genetic diversity of adding a new species compared to that of increasing within species diversity? We have no good suggestions.

The following discussion will concentrate on the effects of harvesting, regeneration and domestication on the genetic diversity of tree species. It must be emphasised, however, that almost any management activity implemented in the forests will affect the genetic diversity of the trees and stands. Drainage operations, often necessary before a harvest, can radically change the environment so entire ecosystems are destroyed or significantly modified. Fertilisation can change the species composition directly or indirectly, for instance by affecting the conditions of critical symbionts like mycorrhizae.

The paper does not in depth consider the situation in high yielding industrial tree plantations, often established with exotics and on non-forested lands. This is something that should be seen as a form of "agriculture" or tree farming rather than sustainable forestry.

Harvesting

Harvesting may cause the most dramatic and lasting effects on the genetic diversity of the forests. Certainly a clear-cutting followed by no regeneration activities would be disastrous for tree genetic diversity. But this is not forest management, it is simply a mining of a biological resource. In terms of proper forest management, harvesting is always followed by regeneration. The mode of regeneration, whether natural or artificial, has a fundamental influence on the way harvesting operations should be carried out. In natural regeneration, prerequisites of sufficient flowering and mating must be met. In artificial regeneration, a preceding harvest can be total, but a reforestation material of sufficient variability must be available.

The effects of thinning within a species can be expected to be dependent on the type of thinning. If a thinning from above leads to the removal of superior genotypes at a young age, before they have been able to pass on their genes, this would have negative effects.

An example of thinning regimes affecting the genetic composition of the remaining stand can be found in a study of a 70 years old *Picea abies* stand in Germany (Hosius 1993). Parts of the stand were thinned from above and parts from below and the trees remaining after the treatments were then assessed for variation at 5 allozyme loci. The results were not consistent over all the loci, but still indicate that the two thinning forms resulted in changes of the genetic composition of the remaining stands.

In mixed stands, it goes without saying that a thinning operation can lead to dramatic changes in species composition of thinned and non-thinned areas. One of the primary aims of thinning is after all to concentrate the growth to the best trees of the economically desirable species.

On larger harvesting areas certain land should be left with untouched forest. This can often be land which is, for example, too steep for easy logging or on wet areas along streams or lakes.

Regeneration

Forest managers often have a choice of methods with which to regenerate a stand or tree population after or in connection to the harvest. All methods will influence on the genetic diversity of the new stand in one way or another.

The choice of regeneration methods is not always wide. Species with short-lived recalcitrant seed are certainly hard to handle in plantations, because of the logistical problems in collecting, transporting and processing the seed in time to seed them in a nursery while the seed is still viable. This is a major problem with certain important tropical species like the dipterocarps. Natural regeneration is often not possible or desirable. The quality of the existing stand may be poor, a change of species desirable, or the circumstances too harsh for seed germination or seedling development. Many commercially important tropical hardwoods do not germinate and grow well in full light, but require an over-storey for a number of years. They would certainly not do well as plantation species after a clear-cut. With more and more genetically improved regeneration materials and expectations for higher yields the interest in using artificial regeneration is also increasing.

Today the importance of using adapted seed sources is well understood. This is particularly true for species of major economic importance. For them there is also sufficient knowledge about how to obtain satisfactory regeneration. The future existence of these species is rarely at risk. The situation of especially rare non-commercial species is much more difficult. They are often not the target of a harvest, but incidental felling or changes in the environment caused by the harvest of other trees may leave conditions under which the species cannot survive or reproduce. Even when the problem is understood, the lack of basic information about the silvicultural requirements of many minor species often makes rescue attempts in the form of for instance enrichment planting fail. Marginal population and rare species with no commercial value are the most sensitive to the negative effects of harvesting.

Natural Regeneration

Natural regeneration is based on the reproductive potential of the stand itself, as a rule on the seed crop. The number of seed and seedlings is normally huge, up to millions per hectare as reported already in early literature (Lönnroth 1925). At germination and seedling stages mortality is predominantly random. At later stages stabilising selection eliminates many extreme genotypes from the population.

The diversity and quality of the new regeneration will largely depend on the trees left by the forester to take care of the regeneration. The importance of using local seed sources and having natural selection working on a large number of seed should not be given too much importance. As already pointed out, in most species the within stand genetic diversity is very large, so adaptation in most cases cannot be very precise. Random effects probably have a much stronger influence than natural selection on which seed will grow and develop and pass their genes on to coming generations. Natural selection works very slowly over a number of generations, and it alters gene frequencies only if the selection pressure, i.e. the environment, has changed.

Relatedness is common in natural populations of some species, often occurring in neighbourhood patterns (Coles and Fowler 1976). Using related trees as parents in natural regeneration will lead to increased relatedness among the offspring, reduce its genetic diversity and at worst cause inbreeding effects.

The changes in tree genetics following a harvest operation can be studied in terms of selection intensity. Harvesting of a few individuals trees in a wind pollinated pine forest should have little or no effect on the future of the stand. The intensity of selection is very low and the trees that remain to reproduce the new stand will in all probability be able to regenerate a new generation very similar to that of an untouched stand. This can perhaps be understood by considering the effects of plus tree selection, where progeny tests have shown that very high selection intensity is required before any significant effects, at least on growth traits, are reached.

Harvesting and most silvicultural operations, affect the composition of the forests, typically simplify species and age structures and change the conditions for selection. Opening up a stand will obviously create problems for climax species and favour those that regenerate well in more light. If exploitation is intensive it can lead to species being almost eradicated from large areas. In this situation remaining isolated trees or small populations of trees may not be able to maintain sufficient variation for natural evolution. Genes or adaptive gene complexes will be permanently lost. High-grading, the removal of all commercially interesting trees of a species and leaving the worst ones to regenerate the stand will of course also have a negative dysgenic impact. *Cedrus libani* can serve as an example. In the past generation after generation of harvesting of the best stems without consideration for the future of the species left many populations of this wonderful species severely degraded. Fortunately, good cedar stands still exist at high elevations in Turkey.

Wickneswari et al. (2000) reported on the impact of logging in two forests in peninsular Malaysia. Single logging events in lowland dipterocarp forest in the 1950's did not cause adverse changes in genetic diversity of timber or non-timber species. On the other hand, immediate loss in genetic diversity was detected among adolescent and non-timber trees in a ridge forest after a single logging in 1996. The immediate losses in genetic diversity may be compensated for by an existing good seed or seedling bank in the stand or by migration from surrounding undisturbed forest areas.

Shelterwood harvesting is a partial cutting system, in many ways resembling thinning, but intended to encourage regeneration. Studies on shelterwood systems in *Pseudotsuga menziesii* in Oregon failed to find any clear differences in isozyme composition between the original stands and the regeneration following shelterwood cutting (Neale 1985). The explanations suggested for the similarity between the original stand and the offspring were high heterozygocity in the stands, high rates of outcrossing and a large effective population size in the parent generation.

Seed tree regeneration can be controversial from the point of view of genetic diversity. The problem basically comes from the fact that only few trees, , are left to take care of the regeneration, which samples poorly the variability available in the original stand. Studies on *Pinus sylvestris* in Sweden clearly demonstrate the importance of the density and numbers of seed trees left on the site. In a stand with 122 seed trees left per hectare the rate of selfing was 12 % rate whereas a stand with only 18 trees left per hectare had twice as much selfing (Yazdani *et al.* 1985; Yazdani and Lindgren 1992). In the stand with the low number of seed trees much of the regeneration did not come from the seed trees on the regeneration area but were thought to be from seedlings on the ground before the cutting or to be the result of immigrant pollen or seed.

In evaluating natural regeneration with seed trees, genetic factors like rate of inbreeding, selection pressure and gene flow must be considered together with other silvicultural issues. For example, the share of the overall regeneration that arises from the seed trees must be compared to that which has other origin, like small seed or small trees already existing under the original stand or starting from seed somehow transported onto the regeneration area from outside stands. Volunteers like this provide valuable added genetic diversity (Ackzell and Lindgren 1992).

In a Canadian study (Buchert *et al.* 1997) of seed tree regeneration in *Pinus strobus*, 54 loci were analysed in all seed producing trees. The study was carried out in very small stands, 0.7 ha, with some 100 seed producing trees before the harvest. Some 75 % of the trees were cut, leaving 25 seed trees. Certain effects were dramatic. 80 % of the rare alleles ($p<0.01$) were lost and allelic richness reduced by 25 %. Not all of this should be attributed to the effects of selection, however. As Mullin and Bertrand (1998) point out, in small population like the one studied, simply by sampling 25 trees out of 100, the probability of losing a gene with an original frequency in the population of $p=0.01$ is about 57 %. If instead 250 trees out of 1000 had been sampled, the loss would have been much lower. Buchert's *et al.* study found very little change in heterozygocity and no losses of common alleles ($p>0.05$). In a situation where a seed tree stand is surrounded by more trees of the same species, especially in wind pollinated species like pines, gene flow into the population from the surrounding stands can be expected to bring back many of the rare alleles.

Artificial Regeneration

Forest cultivation, through planting or direct seeding, has been successfully used for many tree generations in many species. It gives the forester a chance to select exactly the species and sources of the species he wants to use, whether they existed naturally on the forestation site or not. Artificial regeneration also lets foresters restore or introduce a tree cover to areas where forests have been destroyed or where forests have not existed naturally. For economical and silvicultural reasons, artificial regeneration is normally established by single species. Mixed stands will normally be the result only when there already exists wild seedlings or seed of other species on the planting site or other species naturally migrate into the plantation. This development is common in artificial regenerations of coniferous stands; broad-leaf species appear in abundance. According to most current silviculture instructions the species mixes should be favoured, which is enhances by the above mentioned spontaneous immigration.

Artificial regeneration also provides the opportunity to create new forests in situations where the environment has changed so rapidly that the local trees no longer are well adapted. This may well become very important with the possible dramatic climate changes the forests may have to face as the result of expected global warming. Without getting deeply into the question of exotics in forest plantations, it should be emphasised that there is little proof of local sources being better adapted to a changing environment than introduced ones (Mátyás 1995).

A major problem with plantations, especially in the tropics, is that there is sufficient experience in and knowledge about establishing plantations with a limited number of the existing species only. For the method to become more general, much more research by local foresters will be required.

Throughout seedling production genetic diversity among the seedlings can be lost. El-Kassaby (2000) describes how for example seed storage, extraction, seeding pattern and culling of seedlings all can lead to some, largely unrecognised, losses.

Modern nursery technology has developed to the point that a very high percentage of the seeds develop into a seedling. Using *Pinus sylvestris* in northern Sweden as an example, it only takes some 2500 seed to produce enough containerised seedlings in greenhouse nurseries to reforest one hectare with some 2000 seedlings/ha. To produce the same amount of seedlings of a bare-root stock on free-land nurseries, a slightly tougher environment, three to four times as a many seed are required. To produce an acceptable regeneration on a suitable site through direct seeding, to get an approximation of the number of seed that could re-establish the forest naturally, some 25-30 times as many seed are required. Some people have seen here a potential risk. The forest environment would select the very strongest of the seedlings from the multitude of seed in natural regenerated or direct seeded areas, whereas many of the seedlings produced in the favourable green-house environment would fail when they are planted in the harsh reality of the clear-cuts.

In a comparative study (Ackzell 1992, 1993; Ackzell and Lindgren 1994) looked into this but failed to show any negative results of the nursery environment. The study compared natural regeneration, high density sowing (50000 seeds/ha), and planting with *Pinus sylvestris* in Sweden. No positive effects were detected which could be attributed to higher selection or mortality among the seedlings produced from seed, either those from natural regeneration or direct seeding. The study also included comparisons of local seed and seed from two seed orchards. There was no indication of the local seed being better adapted than either of the orchard seed lots.

In artificial regeneration, the selection of seed source is of fundamental importance. The quality of the reproductive material determines, throughout the rotation, the survival, growth performance, and genetic diversity of the stand.

The adaptation of indigenous stands is inherent, but not always perfect. Thus, a local indigenous seed source is usually a safe choice. However, strictly local seed is not always available, and the concept of local seed needs to be defined. As mentioned earlier, studies on the genetic structure of many forest trees consistently show that genetic differentiation is not very fine grained. Therefore a local seed refers to seed from ecologically uniform area, i.e. what is often called a seed zone, breeding area, or region of provenance. It is impossible to give any universal geographic dimension, since e.g. both latitude and altitude, among other factors, will affect the size.

Non-local origins are sometimes more productive or otherwise superior to local ones. The justification of non-local origin must be based on empirical knowledge from provenance studies in the region of interest.

Domestication

Domestication is the process through which "wild" plants, after repeated selection and breeding operations, each modifying the genetic set-up of the trees, leads to cultivars and varieties, which survive in cultivation and under consistent control. Genetically improved reforestation materials are still very close to their wild relatives and far from domesticated crop plants like the cereals or potato.

There is a widespread opinion that tree breeding in combination with artificial regeneration has a negative effect on genetic diversity in the forests and often can lead to loss of adaptation. But, the opposite is closer to the truth. A phenotypic selection of potential parent trees to create a founder population is the normal first step in a breeding program. El-Kassaby (2000) summarises the results of a number of studies comparing heterozygocity measures between natural populations of 5 boreal conifer species and those found in seed orchards of the same species. His conclusion is that the amount of genetic variation found in natural populations was retained or increased during the phenotypic selection. There are many examples from other species to support this. Plus tree selection does not necessarily lead to reduced genetic variability and breeding populations at least as variable as natural ones can be formed.

Breeders also know how to maintain this diversity. In most breeding programmes a careful separation is made between long term breeding populations and short term multiplication populations. The long term breeding populations are typically managed to provide a potential for long term gains and a large gene pool diversity. So, requirements on trees to be included in the breeding population can be quite separate from those wanted in trees planted today. A typical tree improvement programme handles its breeding population by carefully controlling the number of selected parent trees, dividing them into a number of sub-populations kept separate and bred in ways which minimise the build-up of relatedness (Namkoong *et al.* 1988). The genetic variance of a well-composed set of breeding populations can be larger than the genetic variability of a single large population (Koshy *et al.*1998) and definitely larger than populations in nature, with uncontrolled pollination and seed dispersal. The described form of breeding programme, with separate sub-populations bred to minimise the build-up of relatedness, is probably the best form of *ex situ* gene conservation available.

From the breeding population is then selected a multiplication population, typically in the form of seed-orchards, in which seed of a number of selected trees, having the properties required for production forestry in a certain area or region, are mass produced for seedling production or direct seeding.

In this way tree breeders can provide for immediate needs in today's forestry and provide a potential to satisfy future requirements. It also opens up possibilities to prepare for expected changes in the environment. It is already today possible to prepare for global warming, by testing our trees in environments with a climate like what is expected as the result from environmental warming. A multiplication population can then be ready to produce seed for trees that will thrive in the expected warmer climate of an expected future. The method is already included in the Swedish breeding strategies for *Picea abies* and *Pinus sylvestris* (Danell 1993).

Seed orchards are set up with a selected number of trees from the breeding populations, the trees that most completely carry the characteristics wanted by today's foresters. El-Kassaby and Ritland (1995 a,b) carried out a study following the genetic variability, in terms of heterozygocity parameters, through to the process of a breeding program in *Pseudotsuga menziesii*. The study compared the original natural population, and then the breeding and production populations selected from it. The study also analysed a number of first and second-generation seed orchards. The findings were, that phenotypic selection can capture most of the genetic diversity in the species natural range and that breeding and production populations are as variable as the natural ones. The comparison of 12 first and 3 second generation orchards found very small differences between the two groups. This indicates that the variation will remain relatively stable over plantation generations.

On a single stand basis, a plantation from orchard seed is normally at least as variable as a natural stand. But, on a landscape level, widely used seed from a large productive orchard could well lead to a reduced genetic diversity in a species. Much works against this, however. Not all regeneration is from planting and many species are normally used. Orchards also have a limited life span often much shorter than a rotation, so over a length of time seed will come from different orchards.

Recent research, e.g. Rosvall 1999, demonstrates how breeding for increased productivity can be carried out for many generations at a very limited cost in the form of loss of diversity.

Clonal Forestry

Foresters working with artificial regeneration are often seen as stepping outside of what nature does. Clonal forestry has for instance been blamed for creating stands with a too limited genetic diversity, vulnerable to changes in the environment, or attacks from pests and diseases. But let us not then forget that Mother Nature herself for many species, like the aspens (*Populus tremula, Populus tremuloides*), creates monoclonal stands, when individual trees through sprouting regenerate considerable areas. Clonal propagation in itself does not increase the susceptibility of a genotype.

Clonal plantations established with clone mixtures can be made much more variable than natural stands. But how much diversity is wanted when it costs productivity, because when there is an increase in the number and diversity of clones, of course the share of better clones must go down? The question is difficult. To summarise a discussion by Lindgren (1993) about the number of clones that should be included in a mixture:

1. The more is known about a clone, i.e. the more it is tested, the more it can be used,
2. the more intensive the forest management system is, the lower the number of clones that can be tolerated, and
3. the shorter lived the species is, or the shorter the plantation rotation is, the lower the number that must be included.

Libby (1982) and Park *et al.* (1998) both set a moderate number, both give maximum number of clones to 25, as the number of clones that from a variety of reasons should be sufficient. Opinions still vary about the importance of planting the clones in mixtures or in mosaics of pure blocks. Economically there are certainly some easily seen advantages with pure blocks. On the other hand, if the clonal plantation for some reason is abandoned or forgotten and let regenerate naturally, the regeneration from the pure blocks, even allowing for some outside pollen, would have very large share of selfed seed, which is undesirable. Legislation controls the use of clonal plantations in several countries.

There is a potential risk that stands made up by clonal plantations begin to regenerate spontaneously by seed. In a computer simulation such an option might lead to inbreeding and genetic erosion, but in nature biological mechanisms (diociousness, self-incompatibility, and embryonic lethals) reduce the risks considerably.

Conclusions

Most of the world's forests must be used to satisfy the requirements of a growing human population wanting a better life.

Really large-scale forest protection cannot itself maintain all forest biodiversity, conservation must be integrated as a part in forest management.

Exploitation of timber without concern for regeneration and sustainability has nothing to do with forest management.

Any forest management or silviculture activity will have an effect on genetic diversity, positive or negative. The effects can be particularly adverse if population structures and genetic systems are violated.

Almost all diversity can be maintained through a suitable combination of conservation and production forests.

The diversity patterns will differ between production forests and conservation areas. Production forests have a simpler stand structure, less species and age class within stands. Much of the variation is instead among stands.

As long as due consideration is given to regeneration, most forms of harvesting have a limited effect on long term diversity.

Regeneration is the key silviculture activity that determines the genetic diversity in the future forests and their capacity for sustainable production.

Both natural regeneration and cultivation can produce new stands with acceptable diversity.

Well planned and implemented tree improvement programs help maintain diversity and at the same time provide more productive planting materials.

Many forest managers do not fully understand the importance of the genetic resources they handle. The scientific community must take the responsibility for making foresters more aware.

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In situ Conservation, Genetic Management and Sustainable Use of Tropical Forests: IPGRI's Research Agenda

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In dedication to the late Dr. Abdou-Salam Ouédraogo, who established and led IPGRI's Forest Genetic Resources Programme with remarkable vision, professional dedication, and a contagious enthusiasm from 1993 to 1999.

Abstract

The research programme of the International Plant Genetic Resources Institute (IPGRI) on *in situ* conservation of forest genetic resources (FGR) in the tropics is discussed. The introduction highlights the value of forest genetic resources, stresses the importance of their dynamic conservation and opportunities for fulfilling basic human needs, and refers to constraints and challenges encountered in tropical environments. In the context of IPGRI's overall objectives and modes of operation, the FGR research agenda in relation to *in situ* conservation is described and illustrated with recent findings and on-going research activities. Selected priority areas for research include: 1) finding methods to prioritise species, populations, and conservation activities, 2) assessing patterns of genetic diversity and threats, 3) understanding biological processes regulating genetic diversity, 4) assessing the impact of human activities on genetic processes, 5) understanding local use patterns and devising participatory FGR conservation schemes. *In situ* conservation is a complex task, requiring a multidisciplinary approach integrating socio-economic, ecological and biological aspects. The need for additional technical and scientific knowledge, regional collaboration, appropriate policies, public awareness, and commitment at national, regional and international levels to enable more effective *in situ* conservation programmes and promote sustainable livelihoods is emphasised.

Keywords: *Insitu* conservation, Tropical forest, IPGRI

Introduction

Tropical forests, where around half of the world's higher plant species occur, are the source of multiple and fundamental values. Forest ecosystems fulfil basic life-support functions including watershed protection and soil conservation, climate regulation, carbon sequestration, biodiversity conservation, and pest control (Salati et al. 1999); they also contribute to society's recreational and cultural well-being, and support religious traditions and practices. In addition, they provide local communities and national economies with a variety of goods including food, fodder, gums, fibre, fuelwood, timber, medicinal products derived from plants and animals, and play a primary role in sustaining their subsistence and socio-economic development.

Due to their interdependence, all levels of biological organisation, i.e. ecosystems, species and genes are important for biodiversity conservation and the maintenance of forest ecosystem stability and productivity. Ultimately, the capacity of plants to adapt to changing environmental conditions and to continue evolving is ensured through their intraspecific genetic variation. Genetic variation also constitutes the foundation for improvement and breeding programmes that aim at meeting society's changing needs. Forest genetic resources (FGR), or the present and potential value of the heritable materials contained within and among species, are therefore among society's most valuable intergenerational resources.

However, threats to forest genetic resources in the tropics have considerably increased in past decades. Severe and continuous rates of depletion of tropical forests have taken place with deforestation through conversion of forest to other land uses, forest habitat degradation and non-sustainable exploitation practices. Forest area in developing countries in 1995 has declined by 65 million ha since 1990 and by 9.1% since 1980 (FAO 1999). This has had a direct impact on the amount and patterns of genetic diversity in forest trees. Many populations and species possessing unique and useful properties are presently being lost, sometimes without having been identified and studied (Mittermeier et al. 1999). While degraded ecosystems may be rehabilitated albeit with great difficulty and at high costs, extinction of species or the loss of unique forest genetic diversity within species is permanent and irreversible, with significant potential impacts for development. Therefore, conservation and sustainable use of forest genetic resources has been and remains a pressing and vital requirement for all local, national, regional, and international stakeholders (Ouédraogo 1997).

The task at hand is not easy. Gene conservation strategies should not aim to conserve the genetic makeup of forest species as it stands today, but allow the maintenance of evolutionary processes which will allow species to adapt to future conditions (Eriksson et al. 1993, Namkoong 1986). In this respect, a primary issue is the definition of the amounts and proportion of genetic variation that should be maintained to allow species to do so (Palmberg 1999). At the same time, gene conservation programmes should help prevent or reduce genetic erosion and species extinction, as well as preventing strong directional change of the genetic composition of conserved populations (FAO 1993).

Conserving Forest Genetic Resources *In Situ*

Forest scientists and the wider conservation research community have actively worked at developing conservation and sustainable use strategies, while sometimes pursuing conflicting objectives and approaches. Conservation can be achieved *in situ* and *ex situ* (Ledig 1986), and the two should be implemented in a complementary manner. However, several advantages make the conservation of forest populations, species and genes *in situ* i.e. within their original/natural environment (Frankel 1976), the preferred method. This method permits the maintenance of basic evolutionary processes and provides breeders with a dynamic source of variation. It is particularly recommended for species that cannot be grown outside their natural habitats, including those requiring complex ecosystem interactions to subsist, and species with recalcitrant seed behaviour. Furthermore, *in situ* programmes for target forest species will often result in the protection of associated animal and plant species and whole ecosystems in which the species occurs. Lastly, *in situ* conservation allows resource utilisation. It can and should plan to purposefully associate the simultaneous, sustainable use of resources by various stakeholders, thus also improving cost effectiveness of conservation.

It is worth emphasising that conservation and sustainable use of forest genetic resources is not just a problem for the future. It affects millions of people now. Therefore conservation cannot be viewed separately from development or human needs and demands. Perhaps the greatest challenge of *in situ* conservation strategies lies in the fact they should reconcile conservation activities with immediate human needs, recognise the importance of different stakeholders as potential suppliers and managers of genetic diversity and the link between biological and socio-economic objectives.

Production of forest-derived goods and environmental services will require that basic genetic and silvicultural guidelines be incorporated in forest management prescriptions and interventions (Kemp 1992). Conservation of genetic resources through sustainable management is a primary necessity for the large majority of forest tree species, which are not used in plantation and domestication programmes (National Research Council, Board on Agriculture 1991). The role of local communities in the selective regeneration, dissemination and planting of forest germplasm should be further investigated.

Whereas the *ex situ* conservation strategy is well known, widely used and fairly well developed, relatively little action has yet been taken for *in situ* conservation especially of intraspecific diversity. This may be due to the prevailing attention given to *ex situ* methods, and a limited co-operation between breeders and foresters as well as conservationists. Furthermore, the early focus of *in situ* conservation has been on the establishment of protected areas systems for ecosystem and endangered species conservation with little regard to within-species diversity (FAO 1989). The awareness that the development of effective *in situ* conservation, management and sustainable use strategies needs to take the dynamics of intraspecific variation into consideration has grown steadily. However advances in developing *in situ* programmes are limited by the lack of understanding and scientific knowledge on the extent, spatial and temporal organisation of genetic diversity in forest trees, genetic processes and the impact of socio-economic activities on forest genetic resources.

Challenges of Conservation of Forest Genetic Resources In tropical Forests

While *in situ* conservation of forest genetic resources is a complex field, its progress has been relatively slower in tropical regions in comparison to temperate areas due to the following general constraints and challenges (Bawa 1997, Ouédraogo 1997):

- The large number of species to be studied, low infrastructural development of local institutions, the lack of a critical number of personnel and difficulty in meeting the high costs of training and research have contributed to the relatively slow progress in bridging considerable knowledge gaps in botany, plant taxonomy, biology, and genetics of tropical forest species;
- The diverse biological characteristics and ecological relationships including diverse pollinator requirements and interactions, highly variable tree densities and spatial distribution of species, mixed mating systems, variable phenological patterns, necessitate that conservation methods and strategies be tailored to individual species;
- Evaluation and comparison of morphological and heritable characters has only been undertaken on a few species. Similarly, the development of tools and biotechnologies to assess genetic diversity is recent and genetic markers need to be identified and characterised. Also, despite the new range of molecular techniques and simulation models for genetic conservation, there is a need to go beyond molecular markers data collection;
- Sustainable management practices have been limited in tropical forests due to the large number of species present, many of which are non-commercial, difficulties in regeneration of target species, fragility of soils, and difficulty of access;
- The restricted availability of economic options for development enhances poverty and leads to short-term perspectives in conservation and use practices. The development of strong partnerships of local communities, indigenous people and other stakeholders represents both a continuing challenge and a strong driving force for the implementation and adoption of effective conservation and use strategies;
- National policies and legal frameworks which are conducive to resolving problems of conservation and sustainable use of forest genetic resources are strongly needed, yet can be complicated by the variety of actors and interests, and the gaps between local and national laws.

IPGRI's Research Agenda for *In situ* Conservation and Sustainable use of Tropical Forest Genetic Resources

The overall mission of the International Plant Genetic Resources Institute (IPGRI) is to encourage, support and undertake activities to improve the management of genetic resources world-wide, as well as to help eradicate poverty, increase food security and protect the environment. The conservation and use of FGR is one of eight priority domains on which the Institute has chosen to concentrate its efforts (IPGRI 1999). The objective of IPGRI's Strategic Action Plan on Forest Genetic Resources is to ensure the continuous availability of forest genetic resources for future use through (1) strengthening institutional frameworks and contributing to international collaboration; (2) generating knowledge and developing appropriate methodologies; (3) devising and providing practical tools for measuring genetic diversity and for the improved conservation and use of FGR (IPGRI 2000). Reflecting IPGRI's overall mode of operation (Box 1), the Global Forest Genetic Resources Programme conducts its research agenda through partnerships with national programmes in collaboration with international research institutions.

Box 1: IPGRI's modes of operation

IPGRI works through partnerships, complementing its partners' resources with those of its own to provide a collaborative research and implementation effort that is highly cost-effective. Savings accrue through the sharing of staff time, laboratory and field facilities, and so on. In addition, technology and information are transferred to partners who might otherwise have limited access to them because of their own shortage of resources. IPGRI operates directly or as a catalyst on almost any part of the research and development process related to the conservation and use of plant genetic resources. With its partners, IPGRI identifies which points in the process would benefit most from its involvement and would bring maximum gains in terms of exercising the greatest leverage over the process as a whole. In this way, both partners optimise the impact from the resources they invest in the collaborative effort. In undertaking its programmes of work, IPGRI takes particular account of the way in which networks can support its activities ensuring that research is conducted cost-effectively, and that materials, methods, results and information are widely disseminated. It also places emphasis on research that is contracted with partners. Contracting research helps to ensure that projects are well designed and that the resources are made available for their implementation (IPGRI 1999).

The objective of this paper is to describe IPGRI's general research framework for the *in situ* conservation of forest genetic resources, incorporating effective gene management and sustainable use of tropical forests. The paper also illustrates achievements and ongoing research activities of the Programme. As a result of extensive consultation with and field experience of partners in FGR conservation and use including national programmes, advanced research institutions and international organisations, the Programme has identified the following priority research areas for the development of *in situ* conservation strategies (IPGRI 2000, Ouédraogo 1997).

- Information allowing selection of priority species;
- Patterns of species distribution, intra-specific genetic diversity and threats;
- Biological characteristics and ecological processes regulating genetic variation;
- Impacts of human activities on genetic processes;
- Local use patterns and participation in forest genetic resources conservation

Priority Setting

Tropical forests host a large number of species that are threatened or at risk of extinction. These species fulfil a variety of functions and services and their value is recognised by several user groups at different scales (local communities, private enterprises, national governments, international institutions). On the other hand, a large number of potentially useful species are little or unknown. Therefore, the amount of information needed in the ecological, genetic and socio-economic aspects of FGR conservation and use is considerable. This demands the most efficient use of the limited resources and time available. An important task, therefore, is the prioritisation of research activities.

A central goal of IPGRI's Global Forest Genetic Resources programme has been to provide national programmes with adequate tools to develop strategies and to identify priority actions for effective conservation and use of FGR. For this purpose, the University of British Columbia, Canada, in collaboration with IPGRI has undertaken the development of a framework for prioritising species, populations, and conservation management interventions integrating genetic diversity, threat and management data (Namkoong and Koshy 1999). This project involves the development of three major components. The project is assembling a classification system of threats, which includes their types, frequency of occurrence in species, impact, monitoring requirements and potential to cause genetic erosion in relation to ecological and reproductive characteristics of species.

Furthermore, information on field and laboratory techniques for estimating genetic diversity has been compiled. This manual provides guidance on the suitability of available tools for different geographical locations, species and other biological considerations as well as equipment, personnel and cost requirements and comparative advantages. Work is also in progress to develop the overall priority-setting decision framework which includes factors of the estimated state of genetic variations, threats, and opportunities for recovery and sustainability of the resource for production and conservation. The draft framework is being tested in a field study in Brazil and experimental results from its use will yield useful information for its further refinement and greater applicability.

Patterns of Species Distribution, Genetic Variation and Threats

Once priority species have been identified, the development of adequate conservation programmes will require information on patterns of species distribution, level and spatial organisation of genetic diversity, and threats. This information is widely lacking. IPGRI's programme therefore collaborates with national programmes to generate information for priority conservation species which are recognised as threatened and/or having current or potential socio-economic value. A summary of the results achieved so far is presented in Table 1.

The different information layers can be combined to provide a current assessment of genetic resources. This superimposition provides spatially explicit framework for *in situ* conservation by identifying optimum areas for conservation to be ranked according to the level of threats they are subject to and the genetic diversity they hold. Marginal and isolated populations that may possess unique adaptations such as drought resistance, tolerance to given soil conditions, insect resistance should be carefully considered for selection. Genetic diversity evaluation will be important for protected areas designed for biodiversity conservation, so their contribution to the conservation of intraspecific diversity will be realised (Box 2). This exercise should also reveal locations where extreme threat levels preclude *in situ* conservation. Identified populations should then be subject to *ex situ* conservation.

Unfortunately, full knowledge of the genetic structure of the species may not be rapidly available. Nor is phenotypic evaluation data except for a restricted number of species. Therefore, a number of conservation areas covering the main occurrences of the species as well as outlying populations will be needed in order to expect to capture a considerable amount of the species intraspecific variation.

The identification of priority genetic populations is greatly facilitated by computer technologies including Geographical Information Systems which can integrate multiple data layers and has various data processing and modelling capacities.

Biological Characteristics and Ecological Processes Regulating Genetic Variation

The dynamics of genetic diversity in forest populations is influenced by a variety of factors including reproductive biology, dispersal mechanisms, regeneration patterns and ecological relationships. Tropical forest species display wide variation in their biological and ecological characteristics that in turn have considerable implications for their conservation and management. Yet even for prominent species such information is scant and incomplete.

To cite only a few, numerous questions remain about the effect of variation in flowering density on the genetic quality of seeds, interactions between patterns of seed production and seed dispersal by frugivores, the dependence on pollinators and how changes in the frequency and composition of forest species influence them (Bawa and Krugman 1991). Therefore, in view of the existing variability, there is a need to examine how contrasting modes of distribution, pollination and seed dispersal mechanisms influence the amount and spatial organisation of genetic variation in species.

Table 1: Outputs of research activities undertaken by IPGRI's FR programme in collaboration with national programmes.

Species and locations	Research activities			
	Species-level information	Genetic diversity	Threat assessment	References
Lophira alata Cameroon	Ecogeographic surveys in 3 ecological zones, data collected on population history, density, and health status. GIS distribution map.			Eyog-Matig 1998.
Anogeissus leiocarpus Burkina Faso	Populations sampled throughout national distribution range, data on tree stand characteristics (density, soil type, association, land use, regeneration rates). GIS distribution map.		Local perceptions of threat status and conservation need through semi-structured interviews.	Nikiema *et al.* 1997.
Acacia senegal Burkina Faso	Ecogoeographic surveys conducted, data gathered on tree stand characteristics (density, soil type, association, land use, regeneration rates). GIS distribution map.		Local perceptions of threat status and conservation need through semi-structured interviews.	
Parkia biglobosa Burkina Faso	Populations surveyed throughout distribution range and samples collected for genetic diversity analysis. Data on taxonomy, phenology, reproduction biology, dispersal mechanisms.	Distribution of allelic frequencies through isozyme analysis, highly variable populations located.		Buitelaar 1996.
Vepris glandulosa Kenya	Ecosystem surveys, data on habitat characteristics, land use, conservation status. New population found during surveys.			Lengkeek 1998.
Phyllantus emblica India	Seven representative populations identified within 30 Medicinal Plant Conservation Areas.	Seeds collected for isozyme analysis		Shaanker and Ganeshaiah 1997.
Ochlandra scriptoria India	Distribution information gathered from local forest divisions. Spatial location of selected populations marked on a map.	Allele diversity studied through isozymes, highly variable populations located. No evidence of geographic segregation among populations.		Shaanker *et al.* 1999.
Bambusa arundinacea India	Data on actual distribution gathered from forest maps, historical sources, aerial photographs, satellite imageries. GIS distribution map. Bamboo densities in forest areas calculated.	Allele frequency assessed through isozyme analysis. Genetic segregation between populations from northern and southern districts.	Change in bamboo cover during 1935-1970 evaluated. 90% of bamboo lost in the Northern portion of BRT Wildlife Sanctuary.	Shaanker *et al.* 1998.
Santalum album India	Information regarding past and present distribution of sandal gathered from aerial photointerpretation and historical records.	Allele frequency assessed through isozyme analysis along a disturbance gradient. Undisturbed populations harbor higher level of genetic diversity.	Change in sandal cover during 1935-70 assessed through satellite imageries. Some populations totally lost, others disjunct. Large decline in quantities of sandal extracted from 1980 to 95, despite increasing value. Trend reflected in supply to local industry. Annual poaching estimated 100-500 tons.	Shaanker *et al.* 1999.
Cotylelobium melanoxylon Thailand	Populations surveyed in four sites, including a genetic resource area.	Higher genetic diversity found in a population located in a Genetic Resource Area, than in three natural populations.		Chaisurisri 1998.
Dalbergia oliveri Vietnam	Field surveys on taxonomy, morphology, ecology, distribution, regeneration rates, land use and protection status. Data gathered on species composition, ratio and relationship between species within each stand. Taxonomic studies showed that *D. oliveri* is synonym of *D. bariaensis*		Assessment of forest cover changes over 22 yrs comparing satellite imageries of two distribution areas. 8% average reduction of forest cover recorded.	Le and Nguyen 1999.
Xylia xylocarpa Vietnam	Field surveys on taxonomy, morphology, ecology, distribution, regeneration rates, land use and protection status. Data gathered on species composition, ratio and relationship between species within each stand.		Assessment of forest cover changes over a 22 yrs comparing satellite imageries of three distribution areas. Peaks of 35% reduction of forest cover recorded.	
Pterocarpus macrocarpus Vietnam	Field surveys on taxonomy, morphology, ecology, distribution, regeneration rates, land use and protection status. Data gathered on species composition, ratio and relationship between species within each stand.		Assessment of forest cover changes over a 22 yrs comparing satellite imageries of four distribution areas. Peaks of 20% reduction of forest cover recorded.	

Box 2: Assessing the effectiveness of protected areas for intraspecific genetic diversity conservation

In Southern India, levels of genetic diversity in sandal (*Santalum album*) populations were assessed along a gradient across a protected area, and surrounding buffer zone as well as highly disturbed area (villages and agroecosystems adjoining the forests). Higher levels of diversity found in the core populations than in both the buffer zone and disturbed areas indicate that protection has had a significant genetic diversity impact. The lack of difference between the latter zones revealed insufficient protection of sandal populations in the buffer area, as supported by a large proportion of small size class individuals, the extraction of sandal heartwood being selectively done on larger trees (Shaanker et al. 1999). In Thailand, genetic diversity estimates of *Cotylelobium melanoxylon* populations obtained with isozyme markers indicate that a genetic resource area (GRA) established locally for *in situ* conservation harboured higher levels of variability than observed in three other populations studied. Such methodologies are useful for testing and monitoring the effectiveness of protected areas in conserving valuable germplasm (Chaisurisri 1998).

These parameters have a direct bearing on the number and distribution of unrelated, inter-breeding individuals needed to constitute a viable genepool of target species. In order to promote applied and management-oriented research, the Global FGR programme has tended to handle research on these subjects in combination with the study of impacts of human activities described below.

Impact of Human Activities on Genetic Processes

The inseparable goal of forest genetic resources conservation is to sustain the economic development of local communities and nations in which they occur. Therefore, a major component and challenge of *in situ* conservation programmes is to understand the effect of human management and use activities on processes which regulate genetic diversity. Conservation strategies including sustainable management plans can then be developed. The most relevant anthropic activities including deforestation, forest fragmentation, selective logging, extraction of non-timber forest products all of which might have detrimental effects on forest genetic resources and yet the magnitude and dynamics of their effect remains poorly understood.

Forest fragmentation resulting from the conversion of forests to other land uses is a reality that increasingly prevails in most tropical countries and therefore represents a critical area of study. A central concern is that reduced gene flow and increased genetic drift in fragmented populations can lead directly to the loss of genetic diversity. In addition, decreased fitness as a result of increased inbreeding in fragments will reduce population viability and may lead particularly in combination with other consequences of small population biology, to extinction. Advances in our understanding of the impact of human activities on mating systems, gene flow and genetic diversity also rely on the development of variable genetic markers to estimate gene flow and effective population size in many species. Collaborative studies between IPGRI, and Universities of Costa Rica and Massachusetts are addressing several of these components, including the characterisation of genetic markers and the impact of forest fragmentation on the reproduction, gene flow of tropical dry forest species used for timber in Costa Rica (Box 3).

Box 3: Impact of fragmentation on the reproductive biology of *Enterolobium cyclocarpum* and on geneflow of *Carapa guianensis* in the Guanacaste National Park, Costa Rica

In a first study, a range of characteristics in *E. cyclocarpum* trees located in continuous forests and pastures was compared. Reduction of continuous habitat was accompanied by a decline in flower visitation rates and likelihood of pollination as well as fruit set, and seed production per fruit. Yet the fact that when pollinated, the number of flowers with pollen on their stigma and the number of pollen grains deposited were similar, and that more flowers are pollinated than fruits mature, suggest that factors other than pollination determine the likelihood of fruit maturation. As ways through which plants may regulate the quality of their progeny, competition among developing fruits and genotype interactions between paternal and maternal parents may be responsible for differential seed abortion. Because progeny vigour among seedlings from pasture trees was significantly lower than from continuous forests, it can be assumed that habitat fragmentation disrupted mechanisms regulating progeny vigour and quality, possibly through inbreeding. In this study, fragmentation had no effect on outcrossing rates. This study also shows the importance of isolated trees in fragmented landscapes for the movement of pollinators and gene flow, and the inferiority of seeds from fragmented sources for the establishment of commercial plantations (Rocha *et al*. 1999).

Another study has undertaken to identify and characterise Simple Sequence Repeats (SSR) loci in *Carapa guianensis* that may then be used to detect polymorphism in related species. Using these markers, the study also tested the effect of fragmentation on gene flow and differentiation among fragmented and continuous forest populations by comparing them among pre-fragmentation adult cohorts and post-fragmentation sapling cohorts. Genetic distances between adults and saplings were greater in populations in forest fragments than in continuous forest sites. Average allelic richness of the sapling cohort was also lower than in the adult population in the site subject to cattle ranching and selective logging, while the opposite was true in the untouched and selectively logged continuous forest populations. Also, the larger genetic distance among all cohorts than adult cohorts was mostly due to differences between the fragmented site and the two continuous populations. In conclusion, while selection during life cycles may need to be accounted for, this project suggests that fragmentation decreases gene flow and increase allelic diversity. Yet additional comparisons between finer population samples aiming at characterising paternity, mating systems and gene flow events will be needed to have a more thorough understanding of the complex changes induced by habitat fragmentation and degradation (Sanchez and Bawa 1999).

Science should also be able to provide forest managers with prediction tools for assessment of genetic erosion to optimise the management of fragmented forests. A collaborative project between the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), IPGRI and the Centre for International Forestry Research (CIFOR) in Costa Rica is attempting to identify conditions regarding species, fragment as well as tree characteristics which allow sufficient gene flow between fragments to counteract the expected effects of fragmentation-induced genetic drift. It also addresses how these conditions affect outcrossing rates and the effect of their decline on population fitness (Box 4). The research undertaken in Sumatra on *Scaphium macropodum* and *Fordia johorensis* indicates that high tree density in fragments for species considered can at least partially offset the loss of heterozygosity which may result from fragmentation (Sudarmonowati 1999).

The task of monitoring all biological and ecological interactions between species which are necessary to maintain evolutionary processes, is enormous and totally impracticable for highly diverse tropical forest ecosystems. Thus, research partners from Escuela Superior de Agricultura, University of São Paulo and Centro Nacional de Pesquisa de Recursos Geneticos y Biotechnologia - Empresa Brasileira de Pesquisa Agropecuária (CENARGEN-EMBRAPA) are focusing on the response to disturbance of 'model species' as representative of ecological/genetic guilds forming the forest community (Kageyama et al. 1998). Specifically, demographic (abundance, age distribution, mortality and growth rates) and genetic (expected heterozigosity, outcrossing rate, and spatial autocorrelation) parameters are monitored for a few model species (Box 5). Five groups of model species based on contrasted densities, responses to disturbance, canopy position and light requirements, as well as successional stage have been identified. Being highly dependent on these interactions, the stability of these demographic and genetic parameters would indicate the interactions of a considerable part of the community are maintained. It is hoped that data obtained from these few model species can then be extrapolated to the community

Research is also needed on the effect of other major human activities affecting forest genetic resources, including selective logging and extraction of non-timber forest products. By extracting well-formed trees of reproductive size, selective logging lowers the density of flowering trees, which can diminish pollinator densities and alter foraging patterns. When effective population size is reduced and includes a disproportionate number of poorer genotypes, the species may become less adapted to its environment (dysgenic selection) and inbreeding occurs (Murawski et al 1994). Similarly, the extraction of non-timber forest products depending on modalities and parts harvested may impede natural regeneration, reduce population size and density and result in inbreeding. Changes in genetic diversity should be examined under a range of different intensities, in order to determine critical levels that result in significant losses so that management guidelines on allowable harvesting intensities can be defined.

Local Use Patterns and Participation in Forest Genetic Resources Conservation

In the tropics, where the fate of forest populations and species is dictated by every-day activities of local communities to satisfy basic needs, a major objective of *in situ* conservation should be to reconcile conservation activities with immediate human needs. Historically, however, management of protected areas has often been under the control of national governments and local people have had to bear the costs associated with access restrictions. *In situ* conservation programmes should devise local participatory development schemes that ensure the sustainable management, production and conservation of forest genetic resources while providing benefits to local users. To implement such an approach, it is necessary to first identify human activities that have an impact on forest genetic resources and assess forest use patterns and socio-economic factors which influence them. It is important to disaggregate uses by user groups based on gender, age, ethnic group and relevant socio-economic parameters. In order to understand the underlying causes of forest use patterns, on the one hand, the contributions of timber and non-timber forest products to local livelihoods and regional economies need to be assessed. On the other hand, local forest management institutions as well as national forest policies should be identified and described and the ways through which they promote sustainability or degradation analysed. Patterns detected in the present should be understood dynamically in relation to changes in the historical past in land use, forest cover, demography, socio-economic trends, activities and policies. It will also be necessary to assess the possible costs of applying conservation-oriented management guidelines resulting from biophysical research and how to optimise benefits in order to promote participation (Boyle and Ouédraogo 1995).

Multidisciplinary research is therefore essential for addressing conservation challenges in tropical forests and is an integral part of IPGRI's strategy. Research objectives and activities listed above are currently being applied through participatory methodologies in a project on conservation and management of forest genetic resources in Brazil and Argentina funded by the German Ministry of Foreign Affairs. Participatory research is also undertaken in the Western Ghats province of Southern India with the Soligas, an indigenous forest-dwelling community and the University of Agricultural Sciences in Bangalore for the long-term monitoring and conservation of local FGR (Shaanker et al. 1998).

Box 4: Impacts of fragmentation on genetic diversity in riverine forests of Costa Rica

Over a 350 km^2 area in northern Costa Rica, thirty-four forest fragments have been selected, ranging greatly in population size, size, shape, composition, land-use type and spatial characteristics. More than 1000 individual explanatory data values have been collected, mostly at individual-tree level, for two species (*Anacardium excelsum* and *Plumeria rubra*) which represent contrasting seed and pollen dispersal mechanisms. Factors affecting gene flow in fragments are investigated using two large populations serving as putative 'sources' and a number of surrounding smaller fragments serving as putative 'sinks'. Genetic diversity is measured using RAPDs in pre- and post-fragmentation cohorts and the proportion of extrafragmentary pollen parents will be estimated in progenies. These data should lead to the identification of fragment, tree and species characteristics that contribute to a resistance to genetic drift due to a propensity to receive immigrant alleles. In addition, inbreeding coefficients and outcrossing rates are being estimated in all study fragments and related to potential putative explanatory factors. This information, together with measures that can be employed to reduce such risk, will be of direct interest to managers of forests and protected areas (Cornelius 2000).

Box 5: Strategies and parameters for *in situ* conservation of tropical forests in Brazil

Research is conducted in four fragments ranging in size from 2 to 70 ha located around the Rio Doce State Park in the eastern part of Minas Gerais State, which contains continuous primary forest. Fragmentation is primarily the result of forest clearing and eucalyptus tree planting for the charcoal supply of the heavy steel industry. Preliminary findings indicate that rare species in primary forests which become abundant after disturbance such as *Dalbergia nigra,* may lose polymorphism and heterozygosity probably as a result of fragmentation-induced genetic drift and become further impoverished in density and genetic diversity if selectively logged (*Cedrela fissilis*). In contrast, shade tolerant or climax species such as *Sorocea guilleminiana* which are not subject to exploitation are probably genetically well conserved even in fragmented lands. But fragmentation is likely to have a drastic impact on species that are rare in primary forests and absent in secondary (*Hymenaea courbaril*) to the point that they become absent in fragments.

The development of comprehensive *in situ* conservation programmes relies on the integration of the methodologies, tools and management guidelines resulting from the various research components described in previous sections. Successful integration requires strong collaboration between the various conservation-related disciplines as well as a co-ordinated approach between national, regional and international partners. The institutional capacity strengthening at the level of scientists, national programmes, and through linkages between conservation players, which IPGRI invests in through its research and co-ordination activities, is an important step in the development of these programmes (Box 6) (Ouédraogo 1997).

Conclusions

The effective conservation of forest genetic resources is complex and requires improved methods of establishing priorities and tested procedures for supporting decision making on species, populations and conservation activities. A balance should be sought between corrective measures to conserve species and populations directly threatened with extinction and preventive measures for maintaining the viability of useful characteristics in commonly used species.

There is a strong need to expand scientific research on the patterns and processes that regulate genetic diversity at both species and ecosystem levels as well as on the impact of human activities on these mechanisms. Efforts should be made to further assess and classify differences in biological and ecological requirements among tropical forest species and to test prediction tools for genetic impact assessment. Advances are also needed in the definition of critical use levels and the promotion of the genetic agenda in sustainable forest management.

Box 6: Capacity building and regional collaboration for effective forest gene conservation

Strengthening capacities of national programmes to assess, prioritise and meet their own needs for FGR conservation and sustainable use is a direct way of contributing to genetic resource conservation. The Programme actively pursues opportunities for promoting national agendas in forest genetic resource conservation by bringing together partners in national programmes to assess the state of forest genetic resources at the national level, establish species and research priorities and implement recommendations. The programme pursues similar prioritisation and planning approaches at regional levels in collaboration with partners such as the Food and Agricultural Organisation of the United Nations (FAO), the International Centre for Research in Agroforestry (ICRAF) and CIFOR. It supports and actively participates in the development of regional or sub-regional plans for the conservation, management and use of FGR, which is being spearheaded by FAO (Sigaud et al. 2000). It also provides assistance to the establishment of regional instruments for international collaboration towards the effective conservation and sustainable use of forest genetic resources. For instance, IPGRI has helped countries establish an operational framework for a Sub-Saharan African regional programme on forest genetic resources, SAFORGEN which will assist countries in developing concepts and methodologies, strengthen national capacities and promote information exchange on FGR. As countries enlist for participation, this programme will be a useful platform to carry out research activities listed in the sub-Regional Plan of Action on forest genetic resources for Sahelian Africa. IPGRI also promotes linkages between partners, co-ordination of FGR conservation activities and exchange of information in other regions depending on needs and demand.

Successful *in situ* conservation also depends on the integration of broader rural development objectives. Through the involvement of local people, forest use practices need to be carefully examined and the constraints to sustainable use of FGR need to be addressed through active collaboration with other forestry and agricultural development sectors. In this respect, policies should be scrutinised and adapted to participatory development for the sustainable management, production and conservation of FGR. Information flow on the values of FGR, and the biological, genetic and socio-economic requirements of conservation and strong linkages between stakeholders is essential to give forest genetic resources the high importance they deserve on the national and international agenda.

National programmes represent the foundation of any enduring effort in FGR conservation. However they are often insufficiently equipped for the task at hand and therefore need to be strengthened and supported. This requires a continuing commitment at the national, regional and international levels. Regional networking should be seen as a primary means of strengthening national capacities through scientific collaboration and the exchange of information and germplasm, while avoiding wasteful overlaps and enhancing co-ordination and complementarity.

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Impacts of Air Pollution and Climate Change on Forest Tree Populations

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Abstract

Globally, anthrogenically-linked atmospheric pollution by the greenhouse gases, such as carbon dioxide, ozone, nitrogen oxides and methane, are increasing in phase with increasing human population. In addition, the global climate is being impacted by the greenhouse-gas-induced changes in the balance between solar radiation absorbed by the earth and the radiation re-emitted into space. The increased radiative forcing caused by the greenhouse gases is causing a general global warming. In this paper, I will document previous air pollution-induced changes in forest tree populations, review the current predictions for genetic consequences of rising atmospheric pollution and climate change, and propose some genetic management strategies to minimize future impacts.

Keywords: Genetic structure, Gene conservation, Air pollution, Climate change

Introduction

Impacts of atmospheric pollution on forest tree populations have included increased mortality of sensitive genotypes (Karnosky 1981, 1989) leading to changes in population sensitivity (Berrang et al. 1986, 1989, 1991), changes in the ability of a given species to compete with other species (Miller 1973, Miller et al. 1996), changes in gene frequency and/or occurrence of rare alleles (Mejnartowicz 1983; Muller-Starck 1989; Scholz et al. 1989) and, in occasional worst case scenarios, localized population extinction (Kanak 1986). While many of the localized emission problems in developed countries have been decreased with improved technology, localized severe pollution problems with sulphur dioxide (SO_2) and/or heavy metals are becoming more common in developing countries. In addition, the occurrence of greenhouse gas pollutants, such as carbon dioxide (CO_2), ozone (O_3), nitrogen oxides (NO_x) and methane (CH_4), are increasing globally (Roeckner 1992). These anthrogenically linked pollutants are increasing at approximately the same rate as the world population in increasing. In addition to impacting forest tree populations directly, these increased levels of greenhouse gases are causing global climate changes including a general warming (Bloomfield 1992) which is expected to have major impacts on species ranges (Iverson and Prasad 1998).

The management of forest genetic resources for future generations of productive forests becomes an increasingly complex problem when as forests planted today will be facing very different pollutant and climate scenarios than under which they were originally selected (Ledig and Kitzmiller 1992; Karnosky and Scholz 1995). In this paper, I present some examples of adverse impacts of air pollutants on forest tree populations, review the current predictions of genetic impacts of global warming, and speculate as to the strategies for the genetic management of forest resources in the face of increasing pollutant loading and changing climates.

Sulphur Dioxide and Heavy Metals

The impacts of localized emissions of sulphur dioxide (SO_2) and/or heavy metals during the past few centuries on forest tree populations within a few kilometers of the emission source has been well documented (Mejnartowicz 1983; Prus-Glowacki et al. 1992). In developing countries these emission problems were gradually corrected by technological developments such as stack scrubbers and filters to reduce emissions and taller stacks to dilute emissions. More recently, the tremendous volume of sulphur emissions from burning high sulphur coal in former eastern bloc countries has created another intensive selection pressure on forest tree populations as vast areas of the Czech Republic, Germany and Poland (in the area known as the Black Triangle) were impacted by air pollution (Kanak 1986; Karnosky 1997). Even more recently and now projected to be the most difficult sulphur dioxide and heavy metal emission problem of the new millennium are the rapidly developing countries in Southeast Asia, Latin America, and South America (Hongfa 1990; Klumpp et al. 1999).

Adverse genetic impacts on forest tree populations attributable to emissions of sulphur dioxide have been documented by Mejnartowicz (1983) and Müller-Starck (1989). Similarly, adverse genetic impacts on forest tree populations attributable to heavy metal deposition have been documented by Prus-Glowacki et al. (1992).

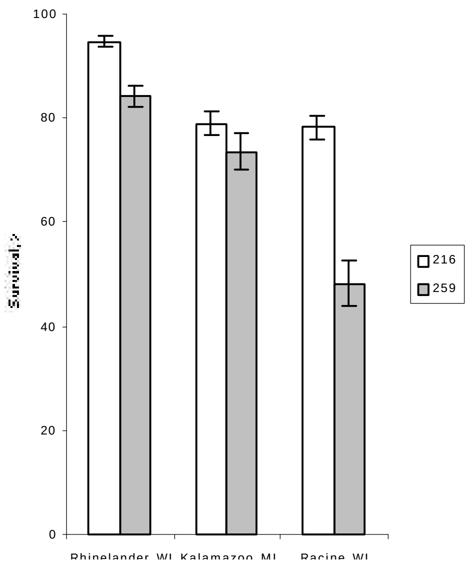
Ozone

The first and now most well documented case of adverse impacts of O_3 on forest tree populations occurred in the San Bernardino Mountains of Southern California where ponderosa pine was put under a competitive disadvantage because of its O_3 sensitivity compared to more O_3 tolerant species as a fir (Miller 1973; Miller et al. 1996). This was also one of the first cases of documented long-distance transport of air pollutants as the impacts were occurring hundreds of miles from the pollutant source (Los Angeles). The negative impacts of O_3 on other ponderosa pine populations in California have also now been described (Peterson et al. 1989; Patterson and Rundel 1995). In addition, a similar pattern of O_3 impacts on pine populations has been reported on the hillsides and mountains surrounding Mexico City (Hall *et al.* 1996). During a recent visit to Beijing, China, I found evidence of the impacts of O_3 on the lacebark pine in some of the most highly prized historical regions of Beijing (Figure 1).

While the selection pressure of O_3 on forest tree populations is thought to be quite low and the time of impacts are thought to be quite long (Parsons and Pitelka 1989; Taylor and Pitelka 1992), we have recently found evidence of a very rapid change in the intraspecific population diversity in trembling aspen under ambient O_3 in the southern Great Lakes region (Karnosky et al. 2000) We found evidence of an increasing mortality level among O_3 sensitive individuals over a five-year study along an ozone gradient from relatively clean air (Rhinelander, Wisconsin) to moderately high ozone (Kenosha, Wisconsin) (Figure 2). This study suggests that O_3 at moderate levels can be a strong selective force over the early regeneration period of a forest stand.

Figure 1. A dying lacebark pine in the old city center of Beijing, China. Needles showed classical O_3 symptoms including tipburn, chlorotic mottle, and premature abscission.

Figure 2. Survival of an ozone-tolerant (clone 216) and an ozone-sensitive (clone 259) trembling aspen clone planted in competition plots at low, moderate, and high O_3 sites in Rhinelander, Wisconsin, Kalamazoo, Michigan, and Kenosha, Wisconsin, respectively. The duration of the study was 5 years. (From: Karnosky et al. 2000).



Greenhouse Gases and Climate Change

The greenhouse gases including CO_2, O_3, NO_x and CH_4 are all increasing 1 to 2% per year (Roeckner 1992, Figure 3). With the exception of previously mentioned effects of O_3, little is known about the direct impacts of greenhouse gases on forest trees. Generally, trees respond favorably to elevated CO_2 (Ceulemans and Mousseau 1994; Norby et al. 1999), but since genetic differences occur in the magnitude of the positive growth response to CO_2 (Houpis et al. 1999), it is likely that elevated CO_2 will also affect tree-to-tree and species-to-species competition (Karnosky et al. 1999). In addition to the direct impacts of greenhouse gases on forest tree populations, these gases are contributing to a changing climate (Bloomfield 1992; Roeckner 1992, Figure 4). Since the climate is likely changing faster than trees can adapt or migrate, large scale impacts of climate change are predicted to occur (Iverson et al. 1999). These predictions must be tempered by the realization that large amounts of plasticity and adaptability occur in most forest tree populations (Loehle and LeBlanc 1996). However, there is little doubt that the mean summer and winter temperatures will be much warmer and the growing seasons will be longer towards the end of the rotations of trees planted today than they are at the time of planting (Rehfeldt et al. 1999).

Nitrogen

As with elevated CO_2, trees respond generally in a positive manner to elevated nitrate additions as nitrogen is often a limiting factor to growth (Norby 1998). However, excessive nitrogen deposition can lead to nitrogen saturation levels at which time several negative impacts can occur such as increased fine root mortality, increased susceptability to low temperatures in the autumn due to the nitrogen fertilization effect which tends to keep conifers from properly winter hardening in the autumn, and increased nutrient leaching from foliage and soils (Norby 1998, Sogn et al. 1999). High elevation spruce-fir populations are especially susceptible to the adverse effects of elevated nitrogen deposition as has been reported in both the United States (Aber et al. 1989) and Europe (Grennfelt and Thörnelöf 1992). Silver fir, a species of depauperate genetic variability (Ziegenhagen et al. 1995) is a particularly sensitive species to environmental stresses such as excessive nitrogen deposition.

Figure 3. Concentration of atmospheric greenhouse gases over the last 200 years. (From Roeckner 1992)

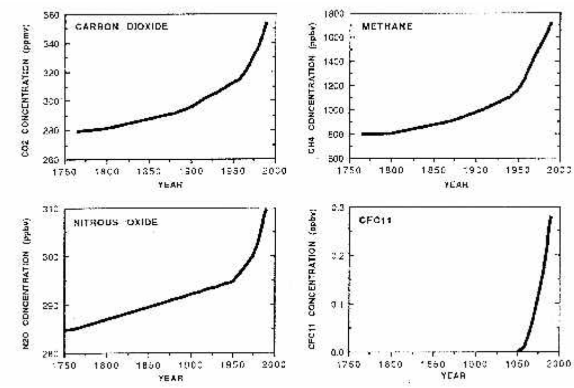
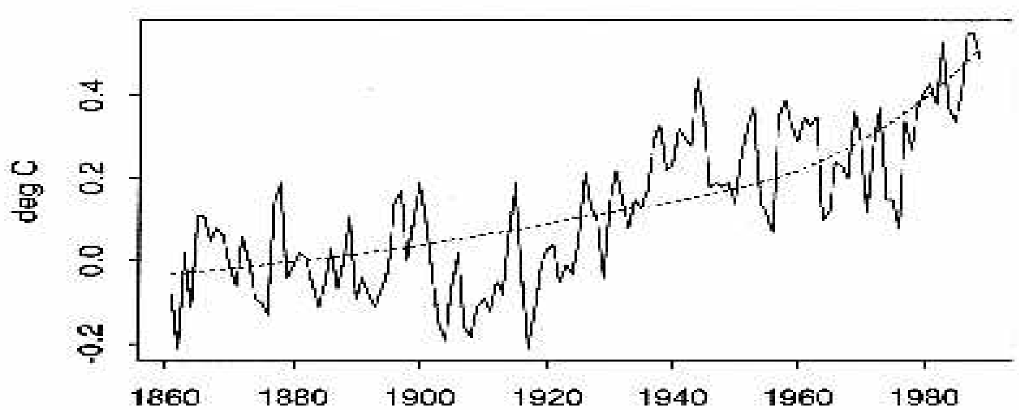


Figure 4. The IPCC global temperature record and a set of predicted temperatures. (From Bloomfield 1992)



Management of Genetic Resources for Future Forests

Tree breeding and genetic selection has generally involved either plus tree selection followed by progeny testing or provenance testing followed by progeny testing of superior phenotypes. Then, seed orchards have been established and rogued to provide the seed for the next generation. This process has continued with advanced generation selection and breeding in a few commercially important tree species. In all facets of these programs, selection is done based on the conditions prior to selection and for the most part these selections are not done on the basis of predicted pollution and climate scenarios that will be in place during the rotation of the commercial forest. Screening and selection of genotypes suitable for future pollution and climate scenarios is generally thought to be nearly impossible because of the complexity and cost of such programs. Thus, an alternative strategy in which a wider genetic base is maintained in our breeding population is essential for developing future forests (Namkoong 1991). Maintaining large amounts of genetic diversity will increase the probability that adequate adaptability is maintained to meet rapidly changing environmental conditions (Gregorious 1986; Müller-Starck 1989).

Alternative strategies are also needed to insure that gene banks, clone banks, seed zones, seed collection areas and other "in situ" conservation strategies are maintained in multiplicative manner such that the changing pollution and/or climate scenarios will not result in the loss of such collections from single vulnerable test sites. Given the past several decades of "laissez-faire" attitude towards traditional genetic field trials and field conservation efforts, this need to conserve forest genetic resources in multiple amounts may help genetics regain prominence amongst the forestry community.

Knowledge Gaps and Conclusions

Population changes due to air pollution or climate change are difficult to detect because of the many years or decades needed for responses to occur. However, such long-term studies are needed to document impacts of air pollution and/or climate change on biodiversity. In the short-term, studies of competition in impacted areas around point source pollutants and along pollutant or temperature gradients are valuable substitutes for long-term studies. Recent findings with competition between clones of trembling aspen differing in O_3 tolerance suggests that the establishment phase of forest regeneration is a vulnerable time for sensitive genotypes. Population changes in relation to global warming will be particularly difficult to detect but will likely occur at the margins of species ranges. New and innovative ways to conserve forest genetic resources "in situ" are needed in light of the ever-changing global climate.

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Sub-Plenary Session :   A4

Sustainable Management of Natural Resources:

Impact of Forest Pest and Air Pollution on Forest Sustainability

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Forest Insects and Forest Sustainability in the Next Millennium

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Abstract

Forest sustainability refers to a forest's long term, unfailing capacity to grow, reproduce, and to deliver all of the essential ecological and economic services that human expect from it, while coping with myriad environmental vicissitudes, not the least of which are rapid global climatechange and chronic herbivory. As global temperatures rise along with carbon dioxide, there will be inexorable and unpredictable changes in the community structure of native insects which live on and in trees. This will very likely lead to new "pests", more frequent outbreaks, and higher ambient levels of herbivory. Throwing yet another wildcard into the mileu, the continuing influx of exotic herbivores caused by expanding world trade and travel, are leading to an ever burgeoning list of exotics inforests.

Their impacts on forest sustainability are particularly worrisome because they have historically had substantial and long-lasting negative impacts on biodiversity and forest productivity. The next millennium will bring many new challenges to land managers whose responsibility it is to ensure sustained outputs from the world's forests.

Keywords: Forest sustainability, Forest insects.

Bioecology and Management of the Pine Wilt Disease -Its Epidemics and Environment-

by
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Abstract

Pine wilt caused by pine wood nematodes, which is endemic to North America. In 1999, pine wood nematode, is a devasting epidemic disease of pine forests in Japan and which has already spread to East Asia, including China, Taiwan, and Korea, and *Bursaphelenchus xylophilus*, was discovered in Portuguese forests. If it were to become established in the pine forests in Europe, it could become one of the most serious threats to coniferous forests worldwide. The objectives of this paper are to clarify the wilting mechanism of the disease and to consider control measures.

Keywords: Pine wilt disease, *Bursaphelenchus xylophilus*, Pine wilt mechanism, Epidemic disease, Disease control programme

Pine Wilt Disease in the 20th Century

Since the end of the Second World War, pine wilt disease, incited by pine wood nematodes, has caused the total loss of 28 million m^3 of timber in Japan. Presently, losses due to the pine wood nematode amount to some 1 million m^3 of timber annually. Initially, the disease was recognized as an epidemic in 1905 in the major port city of Nagasaki, located in Kyushu in southern island of Japan. Since then, pine wilt disease spread from many port cities in western Japan both before and after World War II. In 1950, Dr. R.L. Furniss of General Headquarters (GHQ), who belonged to the bureau of Entomology and Plant Quarantine of the USDA, made recommendations to develop a pine bark beetle control program in order to control this disease. Owing to Furniss's recommendations, pine timber losses fell to 200-300 thousand m^3 annually. However, for reasons which remain unclear, pine timber losses again increased from the late 1970's, reaching 2.4 million m^3 in 1979, an amount equivalent to the timber required for the construction of 160,000 wooden houses in Japan. The susceptible species are Japanese black pine (*Pinus thunbergii*) Japanese red pine (*P. densiflora*) and *P. luchuensis*, which are also the most predominant pine species in Japan.

Until now, more than two thousand papers have been published on pine wilt disease. The causal agent of the disease, the pine wood nematode *Bursaphelenchus xylophilus*, was recovered from dead Japanese black pines in 1969 and was determined as the causal agent of pine wilt disease by innoculation experiments in 1971. In 1979, the pine wood nematode was discovered in Missouri, USA, by Drs. V.H. Dropkin and A.S. Foudin. Most pine species in the US seem to be moderately resistant to the pine wood nematode. Following an investigation of pine wilt disease distribution, the pine wood nematode was determined as being endemic to the US, and had seemingly been introduced into Japan in 1905. In recent years, pine wilt disease has spread to Nanjing, China in 1982 on Japanese black pine and southern red pine (*P. massoniana*), to Taiwan in 1985 on *P. luchuensis* and Japanese red pine, to Pusan, Korea in 1988 on Japanese black pine and Japanese red pine, and to Lisbon, Portugal in 1999 on maritime pine.

The pine wood nematode has been found in many pine species in Asia, North America and Europe. In addition to these pine species, it is also naturally found in diseased Eastern larch and European larch (*Larix* spp.), balsam fir (*Abies* spp.) and both blue and white spruce (*Picea* spp.), Atlas cedar and deodar cedar (*Cedrus* spp.) in North America.

Meanwhile, a closely related pine wood nematode, *B. mucronatus*, is found in declining pines, and is distributed over a geographically wider area than *B. xylophilus*. The hosts of *B. mucronatus* are *Pinus* spp. in Japan, China, Korea, Russia, France, Austria, Italy, Finland, Sweden, Norway, and Canada. In addition to *Pinus* spp., *Abies* sp., *Cedrus* sp., *Larix* sp. and

Pseudotsuga sp. are its host trees in the US and the former two in Japan. In 1989, Dr. G.de Guiran proposed that, based on hybridization and phylogeny of the pine wood nematode, the Japanese and American strains of pine wood nematode are derived from common stock originating in western Europe.

Pine Wilt Disease Control Program

Before the discovery of pine wood nematode as the causal agent of pine wilt disease, control methods based on the recommendations of Dr. Furniss consisted mainly of felling damaged pines, de-barking and burning. These measures immediately proved effective against the disease, however, in practice, they required a huge input of manpower. With the high level of economic growth in the 1960's, felling and burning were replaced by the spraying of BHC insecticide for the direct control of "Matsukuimushi", a general term covering more than 70 species of pine bark and wood borers which were thought to be concerned with pine wilt disease. Since 1971, when BHC was banned, other organophosphate insecticides having a shorter residual activity, such as fenitorothion (sumithion), have been used. Following the discovery of the pine wood nematode as the pathogen responsible for pine wilt disease, the Japanese pine sawyer, *Monochamus alternatus*, one of the "Matsukuimushi", was determined as a vector of the nematode. Accordingly, control measures were redirected to the destruction of the Japanese pine sawyer by the spraying of insecticide. A large scale, 5 year control project for pine wilt disease was initiated in 1977 by the Special Law in Force. It was characterized by implementation of aerial spraying to prevent Japanese pine wood sawyer maturation feeding. In spite of many efforts, severe damage was not completely controlled and the disease spread widely from the southern to the northern part of Japan, with the exception of Hokkaido, the northern island of Japan. The reasons for complete control failure are thought to be 1) the limitations of aerial spraying, 2) too great a reliance on the Special Law in Force, and 3) those people concerned not recognizing the severity of the threat to pine forests. In 1997, the Special Law in Force came to an end without a significant outcome even after 3 revisions and enforcement for 20 years since 1977. Currently, annual timber losses still amount to 1 million m^3, a similar level to the period immediately following the Second World War.

Wilting Mechanism and Environmental Conditions

Pine wood nematodes introduced into the shoots of young pines during maturation feeding of Japanese pine sawyer migrated rapidly into the whole trunk of pine trees at a maximum speed of 40-50 cm a day. The nematode density is very low at an early stage of disease development, often as low as a few nematodes per 100 gram fresh weight of wood, even following highly concentrated inoculations. After the entry of pine wood nematode into living pines, a slight reduction in the flow of oleoresin exudate is observed as a unique symptom at an early stage of the disease. This is due to the movement of pine wood nematodes through resin canals at early disease development and epithelial cells around resin canals are destroyed. Nematodes then eventually move from rays to tracheids through pits. At the same time, enhanced ethylene production is observed 2-3 days after invasion by pine wood nematodes. While the exact mechanism remains unknown, this increase, soon after infection, seem to be incited by the excretion of a considerable amount of cellulase by the nematodes.

As a general rule, symptom development may be divided into two stages following invasion of the wood by nematodes, namely an early stage and an advanced stage. In the early stage, cytological changes in the xylem parenchymatous cells occur, and these are soon followed by cavitation and embolism formation within a number of tracheids. Such internal symptomatology is induced not only in compatible but also in incompatible combinations of pine and nematode isolates. However, growth of the nematode population in living wood under conditions unfavorable to the nematode is not assured, even if a high concentration of nematodes is inoculated. Therefore, this stage is considered to be latent, that is, denaturation of parenchymatous cells by nematode invasion results in cavitation and embolism of some tracheids.

At the onset of the advanced stage of disease development, visible symptoms are expressed as a severe reduction of the oleoresin exudation rate, and chlorosis of 2-3 year-old needles, accompanied by a decrease in transpiration. Furthermore, cambial death and cavitation occur within a large part of the outer xylem and result in a water deficiency which induces a decrease in both transpiration and photosynthesis in leaves, accompanied by a further increase in ethylene production. At this time, other pathophysiological phenomena are observed, for example, electrolyte leakage from pine tissues occurs, and a number of abnormal metabolites such as benzoic acid are produced. From the onset of water stress, the nematode population begins to increase in remarkably close correlation with time.

In terms of pine wilt disease development, the water status of pines plays a very important role in the pine-nematode relationship. Experimental results suggest that pine seedlings do not wilt solely by virtue of the number of nematodes existing under conditions unfavorable to them, such as a well-watered environment. On the other hand, inoculation of a low density of nematodes was lethal to water-stressed seedlings. Empirically, pine wilt disease seems to occur more frequently and to be more destructive in summers with little rainfall. At present, surface tension of sap are examined in relations to the cause of cavitation during disease development of pines.

Present Pine Wilt Situation and Threat of Epidemics

Control measures against pine wilt disease are aimed at breaking the pine-pine wood nematode-pine sawyer disease triangle. Present control measures consist for the most part of aerial spraying of insecticides effective against pine sawyer as a preventative of disease, spraying of insecticides on timber damaged by infestation, and trunk injection of chemicals active against pine wood nematode. In spite of various efforts, the total amount of pine timber lost to the disease is not decreasing. A further environmental factor discussed, which may influence the incidence of pine wilt disease, is some effect of acid precipitation. I believe this arises in part from discontent regarding incomplete control of pine wilt disease despite many years of concerted effort. Furthermore, pine wilt disease has the potential to become a major threat if it were to be exported to European countries as in Portugal, particularly as increasingly warm and unusual weather conditions are expected in the near future.

In conclusion, pine wilt disease, which is endemic to North America, has already spread to East Asia, including China, Taiwan and Korea. If it were to become established in the pine forests of Europe and/or Siberia, it could become one of the most serious threats to forests worldwide in 21st century.

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Potential Roles of Global Change in Forest Health During the 21st Century

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Abstract

The atmospheric environment in many forested regions of the world is changing. Levels of tropospheric O_3 are generally increasing and higher seasonal sums of O_3 are anticipated with warmer summers. In developed countries, anthropogenic emissions of SO_x have decreased dramatically in the past decade while emissions of NO_x are stable or increasing. The acidification potential from acidic deposition remains nearly constant. Nitrogen saturation is an increasing threat to the sustainability of some essential ecosystem processes. In developing regions of the world, emissions of SOx and NOx are expected to increase dramatically within the next 50-100 years. Coincidentally, the global climate is changing. The frequency of extreme climatic events appears to be increasing against a backdrop of a general global warming trend. Concentrations of atmospheric CO_2 continue to increase with modelled predictions suggesting significant forest fertilization while empirical evidence points strongly to a significant offset due to O_3 and N saturation. Stratospheric ozone depletion has resulted in large increases in biologically-effective UV-B radiation reaching forests. Reports and predictions of increasing forest growth due to increasing CO_2 should be considered a shorter-term phenomenon. Investigation of forest air pollution case histories reveals indications of increased levels of environmental stress on forest growth and essential cycles such as water, carbon and nutrients. Current research indicates that climate change may lessen or enhance air pollution effects. In this paper, we review the evolution of approaches used to investigate air pollution effects on forested ecosystems and propose the essential elements of a new integrative concept.

Keywords: Forests, Forest health, Global change, Air pollution, Climate change

Introduction

Forests internationally are growing in a changing atmospheric environment. The major components of this change that now, or are expected to affect forest health at regional, national and multinational scales include increasing tropospheric ozone (O_3) concentrations, increasing carbon dioxide (CO_2) concentrations, and acidic precipitation. Actual and potential impacts of these have been investigated to varying degrees and risk analyses have been completed, again at varying levels of resolution. Increasing levels of ultraviolet-B radiation (UV-B, 280-315 nm) resulting from stratospheric ozone depletion are a serious threat over the medium term, but the risks to forests are unquantified to this point. At a more local scale, emissions of sulphur dioxide (SO_2), fluoride (HF), heavy metals, fine particulates (< 2.5 um dia.) and a number of other pollutants will continue to affect forests in the downwind vicinity of point sources, particularly in developing or rapidly-industrializing regions of the world.

Against this backdrop of changing atmospheric chemistry, there is clear evidence that the world's physical (temperature, precipitation patterns) climate is changing and the consensus view is that anthropogenic influences are implicated (IPCC 1995). The most damaging aspect of climate change is thought to be the increasing frequency of extreme events, rather than the general increase in mean temperature. Coupled with atmospheric change and climate change, additional pressures are being exerted by changing forestry practices and patterns of land-use.

Together, atmospheric change and climate change, along with increasing demands (practices/land-use) upon the forest resource, are now considered the three key factors comprising the global change threat to forest health and sustainability. Considerable scientific effort world-wide, particularly in the northern hemisphere countries, has been devoted to the enhancement of our understanding of forest responses to global change at the process, organ, system, stand and ecosystem levels. In many cases, value-added has been achieved through development and use of new forest indicators and mathematical models that have greatly increased the ability to predict and prepare for the consequences of global change. Much work, however, remains to be done, especially in the area of scaling up to the landscape in the context of multiple stressors and in the transfer of knowledge from developed country programs to those of developing countries. Here, respected international NGO's like IUFRO (and, in particular, its SPDC) and multilateral processes like the Montreal and Helsinki Processes have leading and pivotal roles to play.

It is impossible to review in the allotted space for this paper, all the literature on global change effects on forests. Therefore, we shall concentrate below upon a presentation of the major atmospheric change issues as they are known or predicted to affect international forest health. This is accomplished in the context of air quality trends, state of effects science, current risk analysis, and uncertainties in our understanding.

Global Change and Forest-Health

Tropospheric Ozone

Tropospheric O_3 is a secondary air pollutant formed in the atmosphere under bright sunlight from the oxidation of the primary pollutants oxides of nitrogen (NOx) and volatile organic compounds (VOC). Ozone is the most prominent of many secondary pollutants formed, including nitric acid vapour (HNO_3), peroxy-acetyl-nitrate (PAN), aldehydes and others. Its photochemistry has recently been comprehensively reviewed by Finlayson-Pitts and Pitts (1999). Ozone is the most pervasive of all air pollutants affecting or potentially affecting global forests. Levels appear to have been about 10-15 ppb a century ago, compared to 30-40 ppb measured as "background" around the world today (Finlayson-Pitts and Pitts 1999). National daily maximum 1 hour O_3 concentrations in the US have decreased by about 10% since 1987 at 194 rural monitoring sites (EPA 1997). Average numbers of days per year (1986-1993) exceeding the 82 ppb 1 hour National Ambient Air Quality Objective (NAAQO) in Canada were 18 or less. Systematic monitoring throughout Europe began only in the late 1980's and trends are less certain (Matyssek and Innes 1999). There are no clear trends in alpine regions with episodes in northern and central regions occurring downwind of industrialized areas. Much of Europe's forest is exposed to O_3 levels above 40 ppb in excess of 10,000 ppb hrs, the threshold believed to be associated with significant reductions in tree growth (Fuhrer *et al*. 1997). Analysis by Stevenson *et al*. (1998) of past and future O_3 concentrations indicates that much of the world forest area will be regularly exposed to concentrations above 50-60 ppb by 2100. Fowler *et al*. (1999) have calculated the forest area at risk, assuming risk occurs at concentrations > 60ppb. In 1950, O_3 exceedance is largely restricted to the temperate latitudes and extended to 1.7 x 10^6 km^2, or 9.2% of the temperate and subpolar forest (Table 1). In 1970, 6.3 x 10^6 km^2 or 18% of the world's forests was exposed to phytotoxic O_3 concentrations, of which only 2/3 was in the temperate and subpolar regions. By 1990, almost 25% of the world's forest was exposed with a significant increase in the tropical and subtropical forest area to 3.0 x 10^6 km^2 (Table 1). In 2100, an astonishing 49.8%, or half of the world's forests, some 17.0 million km^2 will be exposed to damaging O_3 concentrations, or 6 million km^2 tropical and subtropical, and 11 million km^2 in temperate and subpolar regions (Fowler *et al.* 1999).

Increasing Sulphur Dioxide Concentrations and Acidic Precipitation

While emissions of sulphur (S) have declined significantly in North America (-25%) and Europe (-48%) since the early to mid 1980's (Fowler *et al*., 1999) due to enactment of strict pollution control strategies, those of all pollutants, including S, in the rapidly developing economies of south and east Asia, as well as Africa, South and Central America have been increasing quickly to the point where Southeast Asia now emits more S into the atmosphere than either Europe or North America (Galloway and Rodhe 1991).

Acidic precipitation arises from the oxidation of sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) in the atmosphere to form sulphuric and nitric acids that are deposited onto forests via precipitation (rain, fog, cloud) or by dry deposition (gases, vapour). Organic acids play an important role (Finlayson-Pitts and Pitts 1999) and deposition may occur close to the point or area source as well as over long-distances of 1000 km or more. Fowler *et al.* (1999) have estimated the area of global forests at risk from acidification (> 2 keq H^+ ha^{-1} yr^{-1} as S). There is a predicted 624% increase in area of global forest at risk between 1985 (0.28 million km^2) and 2050 (5.9 million km^2), the majority of the increase being in sub-tropical and tropical forest regions (0 km^2 in 1985; 2.3 million km^2 in 2050) (Table 2). Many developing countries are already experiencing significant acidification problems (Innes and Haron 2000).

Table 1. Global forest area at risk to surface ozone concentrations > 60 ppb.

	Potential area of exceedance		
	all foreststropical + subtropical		temperate + subpolar
1860		no exceedance of 60 ppb	
19502	2.1 x 10^6 km^2	0.5 x 10^6 km^2	1.7 x 10^6 km^2
.%	6.3	2.9	9.2
1970	6.3 x 10^6 km^2	1.9 x 10^6 km^2	4.4 x 10^6 km^2
%	18.5	12.1	24.1
1990	8.3 x 10^6 km^2	3.0 x 10^6 km^2	5.3 x 10^6 km^2
%	24.4	19.1	29.1
2100	17.0 x 10^6 km^2	6.0 x 10^6 km^2	11.0 x 10^6 km^2
%	49.8	37.9	60.2

Reproduced from Fowler et al. (1999).

Table 2. Global forest area predicted to receive in excess of 2 keq H^+ ha^{-1} yr^{-1} as S per year and be at risk from acidification.

	Potential area of exceedance		
	all forests	tropical + subtropical	temperate + subpolar
1985	0.28×10^6 km^2	0	0.28×10^6 km^2
%	0.8	0	1.5
2050	5.9×10^6 km	2.3×10^6 km^2	3.6×10^6 km^2
%	6.0	4.4	7.3
% change 1985 to 2050	624	-	376

Increasing Carbon Dioxide Concentrations

Emissions from fossil fuel combustion and deforestation have been rapidly increasing CO_2 concentrations in the atmosphere (Schlesinger 1997). Concentrations have risen from about 280 ppm in the pre-industrial period to approximately 360 ppm today, with doubling anticipated by 2050-2100. On the one hand, global forests have considerable potential to reduce the anthropogenically-driven increase in CO_2 as they are generally (C3 system) carbon-limited at current atmospheric concentrations (Drake *et al.* 1997). However, significant knowledge gaps remain, especially in light of known potential of other air pollutants such as O_3 to reduce productivity gains under enriched CO_2 atmospheres (Karnosky *et al*. 2000). In addition, the role of long-term adaptations to higher CO_2 concentrations is unknown. A considerable literature is available on tree/forest response to enhanced CO_2 (Saxe *et al*. 1998; Norby *et al.* 1999).

Increasing Ultraviolet-B Radiation

Ozone (O_3) is the most important trace constituent in the stratosphere. Although present in relative concentrations of less than a few ppm, it is an extremely efficient absorber of highly-damaging UV at altitudes between 10 and 50 km. Biologically-effective UV-B that damages plant DNA and essential physiological processes is absorbed by O_3 with an efficiency that increases exponentially with decreasing wavelength (Tarasick and Fioletov 1997). Anthropogenically-induced stratospheric O_3 depletion was first confirmed over Antarctica in the early 1980's but has since been identified elsewhere, with peak depletions in the spring of 1993 over Canada reaching 30% at 16 km (Tarasick and Fioletov 1997). Measurements point to resultant large increases in ground-level UV-B radiation at high- to mid-latitudes of both hemispheres during 1979-1993 (Madronich *et al*. 1995). Further increases are expected to occur until at least 2050. Effects on photosynthesis, growth and biomass, vigour and the DNA of sensitive tree species are predicted in the next 100 years, although the magnitude of risk to global forests remains unresolved (Percy and Gordon 1998).

Interactions of Atmospheric Change and Climate Change

There are many known interactions between atmospheric pollution and climate change. For example, sulphate and nitrate particles and other fine particulate can act as condensation nuclei, increasing the formation of clouds. The incidence of clouds has an impact on global temperature. In relation to the impacts on forests, there are a number of important interactions. The occurrence of drought reduces the uptake by trees of gaseous pollutants. However, the exposure of trees to pollutants prior to drought may reduce the stomatal control of the trees, making them more drought-susceptible. These, and many other interactions, means that climate change and pollution must be considered together when examining the effects of global change on forests.

What is Forest Health?

Perhaps the most logical task beginning the discussion, is the definition of forest health. The Oxford Dictionary (Hawkins 1983) defines *health* as "the state of being well and free from illness...". While this definition is anthropocentric, it does relate, at least in part, to trees. However, as with the extension of human health to the health of cities, there are major problems in extending the concept of health from single trees to forests. To the best of our knowledge, at this time there remains no universally-agreed upon definition of *forest health*, or what constitutes a *healthy forest (*Edmonds *et al*. 2000). Certainly, resilience to disturbance(s), proper ecosystem functioning, productivity and a certain state of biodiversity must be considered some of the major attributes that would constitute a *healthy forest*. There also exists some confusion over the international usage, sometimes simultaneously, of the terms *forest health* and *forest condition*; the latter term was initially adopted as it was believed to be more appropriate to the descriptive measures used in many forest inventories. In contrast, the term tree health was considered to be best used in relation to the degree to which pathogens were disrupting normal tree processes.

O'Laughlin *et al.* (1994) defined forest health as "...a condition of forest ecosystems that sustains their complexity while providing for human needs." In the context of forest response to atmospheric change, the sustaining of ecosystem function is especially important when one considers that stress responses are not monotonic and usually begin with sensitive individuals and proceed from leaf to branch, to tree, and then to stand and ecosystem levels (Hinckley *et al.* 1992). Clearly, process-oriented and pattern-oriented considerations are essential to any definition of forest health. A recent summary of the divergent definitions of forest health, with their implicit assumptions, can be found in McLaughlin and Percy (1999). Here, we choose to discuss global change impacts on forest health from the ecosystem-based perspective, believing it to represent best the underlying values that contribute to a healthy forest. For the purposes of the following discussion, therefore, we use the perspective of McLaughlin and Percy (1999) who defined forest ecosystem health as "*The capacity to supply and allocate water, nutrients and energy in ways that increase or maintain productivity while maintaining resistance to biotic and abiotic stresses*."

How Are Impacts of Global Change on Forest Health Monitored?

Forest health has been continuously measured subjectively or quantitatively, at single points in time or over many years, and at stand to regional to national and international scales for several hundred years. During the past 20 years, considerable development in North America and Europe has occurred in the indicators being employed, techniques used to assess forest health or condition and in monitoring network design. Concepts of decline have been expounded (Manion and Lachance 1992) specific to individual forest declines, whether due to single or multiple agents. The most complete review of international forest health status and assessment was compiled by Innes (1993) and the reader is referred to this volume for a detailed presentation of international forest health in the early 1990's, as well as a summary of assessment methodologies. However, we would point out that since this compilation, the concept of forest health has continued to evolve and now, as our definition above suggests, encompasses the forest ecosystem as a whole. In this paper we shall focus upon programmes in North America and Europe.

Specific recognition of the policy requirement to monitor health effects of global change was evident in North America in the early 1980's, coincident with growing concern over the impacts of acid rain. It was then that the rationale and approaches for the North American monitoring programs changed due to studies that indicated that widespread changes in forest condition could be occurring in North America and Europe (Rehfuess 1981; Ulrich 1984; McLaughlin 1985). Prior to then, monitoring was largely restricted to assessment of tree and soil conditions in the vicinity of large, stationary point sources of sulphur dioxide (SO_2) and other gaseous air pollutant emissions. The extensive studies (Freedman and Hutchinson 1980 a,b) carried out in the Sudbury, Canada, area reporting on increasing degrees of forest decline and ecosystem modification with proximity to a nickel smelting complex represents the most noteworthy example. For O_3, the excellent long-term studies of Miller (summarized in Miller and McBride 1998) initiated in the late 1950's and reporting on tree condition and ecosystem shifts in the Southern California Air Basin is the classic example of earlier work. Substantial impacts on forests are still being noted around point sources today and have been described by Innes and Oleksyn (2000).

North America

The Acid Rain National Early Warning System (ARNEWS) was initiated in 1984 and consisted of 150 rectangular, 10m x 40m plots with 2m x 2m subplots stratified by forest region. Representing one of the best and most comprehensive forest health monitoring programmes conducted to date, soil samples, foliar samples for nutrient analysis, and radial growth measurements were collected every five years adjacent to the plot (soil) or from numbered off-plot trees (foliage, increment cores). Indicators were sampled on all plots at varying frequencies (Table 3). Foliar symptoms, hardwood seed crop, pest conditions (type of foliar insect/disease, woody tissue insect/disease and severity) and tree condition (mortality, live crown height, crown damage, needle retention) were measured seasonally and/or annually. Regeneration, saplings and ground vegetation (mosses, herbs, shrubs) were assessed biennially (D'Eon *et al.* 1994).

In the United States, the Detection Monitoring component of the US Forest Health Monitoring Program (FHM) was implemented in 1996 (USDA 1996) on about 40% of approximately 4000 forested plots in the lower 48 states. A spatially and temporally systematic sample has been based on a national hexagonal grid (27 km between grid centres). The plot size and sampling frequency format (Table 3) results in all circular 1 ha plots being sampled every 4 years with annual estimates of change being derived from smaller subplots (Smith and Mangold 1996). This design yields: 1) a base-line condition the first year; 2) a direct measure of 1-year change for sub-plot samples after two years; and, 3) a direct measure of 4-year change after five years.. Indicators (Table 3) being measured in Detection Monitoring include lichen communities, ozone bioindicator plants, tree growth, crown condition, damage, mortality, regeneration, vegetation structure and plant diversity.

In 1988 the Canadian Forest Service and USDA Forest Service joined with state and provincial departments to establish the North American Maple Project (NAMP). NAMP consisted of a network of 233 sites extending across the natural range of sugar maple (Millers *et al.* 1991). Sites were five-plot clusters of 20m x 20m plots. Variables assessed annually included defoliation, tree vigor, new damage to boles and crown condition (dieback, transparency).

These systems were designed to address unique agency mandates and have individual strengths and weaknesses in monitoring forest health response to global change. Alone, none has enabled policy makers to relate effects to causes with the required degree of scientific certainty. Also, re-ordering of priorities and shifts in resource allocations have resulted in the phasing out in 2000 of ARNEWS in Canada. The Canadian Forest Service aims to replace it with a new Three-Tier Strategy (Percy 1999), combining national-level assessment, case-studies and long-term ecosystem-level monitoring and research. In the United States, shifts in FHM have witnessed an increased emphasis upon data collection for carbon stocks inventory and the extension of the programme to a variety of different countries and issues (such as forest cover in the mountains of East Africa).

Europe

During the 1970's, concerns about freshwater acidification, particularly in Scandinavia, led to the United Nations Economic Commission for Europe (UN/ECE) initiating the Convention on Long-Range-Transboundary Air Pollution (LRTAP). Several impacts studies were started under the auspices of the LRTAP Convention. With the establishment of the International Cooperative Programme on Assessment and Monitoring of Air Pollutant Effects on Forests (ICP Forests) and a similar programme within the European Union, forest condition has been monitored using harmonized methods and criteria since 1986/1987 (UN/ECE 1994). In contrast to ARNEWS, Level 1 monitoring was carried out over an extensive area using a systematic sampling design (16 km x 16 km), but with a low-intensity of observations on a fixed number of trees per plot (Table 3). Crown condition was assessed annually in all plots, and the presence-absence of easily-identifiable damage such as biotic or climatic stress was assessed in many. A portion of the UN/ECE plots was also sampled for soil condition and foliar element concentrations. In 1994, a programme of intensive monitoring (Level II) was instituted on a much smaller number of plots. Level II features monitoring of factors believed to be affecting forest health including bulk deposition and soil chemistry, but still contains no detailed assessment of the incidence of pests and disease. A third level (Level III) has been called for, but never implemented, although its functions are largely duplicated by a small number of catchment studies set up under the International Cooperative Programme on the Integrated Monitoring of Ecosystems (ICP Integrated Monitoring).

State of Science on Forest Health and Future Prospects

North America

Air pollution is an important component of the atmospheric environment in which North American forests grow. McLaughlin and Percy (1999) have recently reviewed forest health as reported through national-level networks and through detailed analysis of the four most-important air pollution-forest case studies. Mortality in northeastern hardwood forests in the early 1980's was linked to acid rain, although sugar maple condition has improved (Stoyenhoff *et al.* 1998; Hall *et al.* 1998) while rainfall acidity remains largely unchanged. Analysis of soil buffering has correlated exceedance of S/N critical loads with branch dieback (Arp *et al.* 1996). Tree response has been primarily linked to soil sensitivity to acidic deposition (including N saturation). Acid rain is known to have caused the loss of soil base cations resulting in reduced Ca, Mg and K concentrations in sugar maple stands (Foster *et al.* 1992). Circumstantial relationships between increased seasonal O_3 exposure and increased crown transparency have been noted. In coastal birch forests field studies have documented a correlation between H^+ ion and NO_3 in fog with leaf browning (Cox *et al.* 1996) in an area that also receives significant O_3 from urban conurbations to the southwest. Fog frequency itself may also play a key role in modifying leaf surface properties and consequential enhancement of pathogen infections (J. Skelly, personal communication).

Table 3. Comparison of the United States Forest Health Monitoring Program (FHM), the Canadian Acid Rain National Early Warning System (ARNEWS), the North American North American Maple Project (NAMP) and the Eurpoean (UN/ECE ICP) forest health Level 1 monitoring programs.

System	No. plots	Plot Strat.[1]	Plot visitation all	subset	Associated process studies	Individual tree dia.	ht.	dom.	form	crwn.	ht./closure	mort.	cond.	sympt.
FHM	4000[2]	grid (27X27 km)	1st	1/3 = 2nd, 1/3 = 3rd, 1/3 = 4th, 5th etc	intensive site monitoring[3]	E	E	E	X	X	X	1-4[2]	1-4[2]	1-4[2]
ARNEWS	150	forest region	1	na	Indicators of Global Change[5]	5	5	5	5	5	5	1	1	1
NAMP	166[6]	na	1	na	none	E	X	X	X	X	X	1	1	X
UN/ECE ICP Forests	20,345	grid (16X16 km)	1	na	none	X	X	X	X	X	X	X	1	1

System	Crown ins./dis.	foliage	defol.	Ground woody	seed	Pests regen.	veg.	Nutrition foliar	org. soil	min.soil	Met./Air temp.	precip.	SO_4/NO_3	O_3	Other
FHM	1-4[2]	1-4[2]	1-4[2]	1-4[2]	X	1-4[2]	1-4[2]	1-4[2]	X	X	X	X	X	X	B
ARNEWS	1	1	1	1	1	2	2	S	5	5	5	X	X	M	P
NAMP	1	1	1	1	X	1	X	X	X	X	X	X	X	X	X
UN/ECE ICP Forests	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X

Sampling frequency: 5=5 yrs; 4=4 yrs; 2=2 yrs; 1=yearly; S=seasonally (several times per year).
1. Stratification design as basis of plot selection/location.
2. All plots year 1, 1/3 in year 2, continues to year 5 when all plots remesured (USDA, 1996)
3 About 40% implemented as of 1996.
4 Not yet implemented.
5 Implemented 1998 through an eastern pollution gradient of 22 ARNEWS + 3 NAMP + 3 new global change plots
6 166 sites represents 22? Plots with clusters and site pairs included
B: bioindicator plants
P: passive O_3 monitors.
X: not assessed
M: modelled from regional networks; no on-site monitoring
I: instrumented
L: lichens

Winter injury was first observed in the late 1950's on red spruce growing at high elevations, resulting in decreased radial growth/increased mortality in both cloud and O_3-exposed mountain forests, as well as fog - and O_3-exposed coastal forests (Jagels *et al.* 1989; Johnson *et al.* 1992). Experimental studies, however, have not been able to reproduce symptoms at ambient levels of acid exposure. A summary of research on decline of red spruce is available (Eagar and Adams 1992). Dendro-climatological analysis (Cook and Johnson 1989) has shown that growth decline was associated with increased sensitivity of trees to winter (northern Appalachians) and warmer late summer (southern Appalachians) temperatures. Field studies have further shown reduced net carbohydrate production in foliage, reduced photosynthesis, and increased respiration (McLaughlin *et al.* 1993).

Growth declines in un-managed south-eastern pines were reported in the early 1980's by Sheffield and Cost (1987). Fox and Mickler (1996) have compiled a summary of forest characteristics, biotic and abiotic stresses along with the results from a large number of integrated field and experimental research projects. Ozone is known to significantly increase effects of soil moisture stress on stem growth of loblolly pine (McLaughlin and

Downing 1996). Somers *et al.* (1998) were recently able to correlate visible O_3 injury with radial growth of individual yellow-poplar trees. Acidic deposition effects in the short-term are not expected to be significant (Teskey 1995) in the southern pines and the main effects are expected to occur through primary impact on nutrient cycles.

Since at least the mid 1950's, much of the mixed conifer forest in Southern California has been exposed to some of the highest concentrations of O_3 in North America. The detrimental role of N deposition is also well established, and is unique in that most occurs in dry form as acidic vapor, gaseous and particulate species. Deposition as high as 25-45 kg N ha^{-1} yr^{-1} has resulted in localized N saturation (Bytnerowicz and Fenn 1996) affecting ponderosa and Jeffrey pine ecosystems. The complete history of the multi-disciplinary case study in the San Bernardino Forest has been published (Miller and McBride 1999). Uniquely, effects from foliar level to successional stage have been documented. Concentrations of 50-60 ppb O_3 were sufficient to cause foliar injury, early needle loss, decreased nutrient availability, reduced carbohydrate production, lower vigor, decreased height/diameter growth and increased susceptibility to bark beetles (Miller et al. 1982). It is interesting that under diminishing annual average O_3 concentrations, Miller *et al*. (1989) have reported an improvement (1974-1988) in the foliar injury index.

Europe

Spiecker (1999) has recently summarized growth trends in European forests and reports an increasing (management practices) growth trends (wood volume, up to +50%; height, up to +5 cm) in southern regions of northern Europe, most regions of central Europe and in some parts of southern Europe. No clear trend was evident in the most northern regions, in rare cases in central Europe and in some areas of southern Europe. Decreasing growth trends were found in cases where “extreme growth conditions such as intense exposure to pollutants (O_3, SO_2, N) or exceptional climatic conditions (drought, storms etc) occurred” (Spiecker 1999), such as close to Monchegorsk smelter on the Kola Peninsula of northern Russia. Air pollution is clearly affecting forest health and productivity in a number of regions such as the Kola Peninsula and parts of eastern Europe, although the evidence of continued impacts elsewhere is much more circumstantial. An exception is the evidence of ozone injury to trees in several central and south European countries, including Greece (Velissariou *et al*. 1992), Italy (Busotti and Ferretti 1998), Switzerland (Skelly *et al.* 1999) and Spain (Skelly *et al*. 1999). Elsewhere, ozone concentrations may be impacting tree health, and acidification has caused the disruption of ecosystem functions in a number of more sensitive forest ecosystems (e.g. Van Breemen and Van Dijk 1988). An additional, but localized, problem is the very high levels of ammonium deposition that occurs in some areas of the Netherlands and elsewhere (van der Eerden *et al.* 1998; Van Dobben and Ter Braak 1998). The abundance of nitrogen has severely disrupted the more sensitive components of the forest vegetation, in some cases resulting in the loss of species from particular areas.

A distinct deterioration in forest condition has been identified for seven of the most frequent tree species and importantly, distinct regional differences were observed at the European scale (Muller-Edzards *et al.* 1997). For many Level I plots, the analysis that was undertaken was unable to explain the deterioration through site factors such as altitude, location and climate. In parts of central and eastern Europe and in the Iberian Peninsula, clusters of plots (in areas of significant S and O_3 pollution) had crown condition deterioration which could not be explained by stand characteristics. However, there were also other clusters of plots with deteriorating crown condition (in areas without significant S and O_3 pollution) that were not explained by stand characteristics, suggesting that the problem is still some way from explanation.

Forest dieback due to air pollution in parts (1.1 million ha or 2.8%) of the 39 million ha of forest in 13 Central and Eastern European countries is mainly concentrated, but not restricted to the so-called “Black Triangle” (Czech Republic, Germany and Poland) (EC 1999). Air pollution is considered the most important anthropogenic factor (others are grazing/pruning, war in Bosnia and

Herzegovina, and fires) affecting CEEC forests. It remains the most important stress factor for forests in the central region (Czech Republic, Slovakia, Poland). Country emissions of SOx have decreased considerably (up to 50%) between 1980 and 1994, while only moderate decreases in NOx and ammonium were recorded. Ammonium emissions in Poland actually increased 7-fold (EC 1999). Average defoliation levels in Poland, the Czech Republic, Slovakia and Bulgaria are the highest in Europe. In Albania, Bosnia and Herzegovina, Estonia, Hungary, Latvia, Lithuania, FYRO Macedonia, Romania, Slovakia and Slovenia, low defoliation levels are typical.

Modelled estimates showed that calculated critical levels were exceeded at 20% of the plots for SO_2 and approximately 90% of the plots for O_3. Exceedance of critical threshold values for acidity and N occurred at 10-25% of the plots, although the thresholds related to effects on ground vegetation rather than crown condition (Muller-Edzards *et al.* 1997). While the atmospheric concentrations of sulphur and nitrogen can be correlated with increased foliar S and N contents (Innes 1995), it has been difficult to draw similar relationships with crown condition, and by far the clearest and most severe impacts have occurred amongst the ground flora, with substantial changes in species composition being recorded in some areas (Brunet et al. 1997). Although a number of correlation studies have been undertaken between forest condition and environmental variables, including pollution, major difficulties have been encountered with the interpretation of the results due to the large number of confounding factors (Muller-Edzards et al. 1997). It is possible that the more detailed environmental data that will be collected in the Level II plots will help resolve this problem, but it is likely that substantial problems will remain associated with the scaling of these individual case studies to wider areas.

Innes (1993) has pointed out that just because visible injury to foliage from air pollution is not recorded in national-scale monitoring programs, we should not assume that injury is absent. This is one reason behind the UN/ECE decision in 1995 to institute more intensive monitoring (Level II) to provide detailed surveys of soil, foliage and deposition and to allow for investigation of correlations between forest condition data and stress factors in Europe. Certainly, O_3 concentrations in many regions of Europe today are sufficient to adversely affect tree growth (Matyssek and Innes 1999). The sampling design, however, may be inappropriate to allow for analysis of such relationships, particularly in relation to the numbers of trees assessed per site.

Air Quality Standards, Guidelines, Critical Levels and Policy Concerns

North America

Canada and the United States differ in their approach to air pollution regulation. In Canada, the federal government sets (not legally enforced) National Ambient Air Quality Objectives (NAAQOs) on the basis of recommendations from the Canadian Environmental Protection Act/Federal-Provincial Advisory Working Group on Air Quality Objectives and Guidelines (Table 4). NAAQOs are designed to provide protection to human health, vegetation, animals and materials. In the United States, the US Environmental Protection Agency (EPA) is responsible for setting National Ambient Air Quality Standards (NAAQS) for criteria pollutants (Table 4). Unlike the Canadian NAAQO, the NAAQS are legally enforced. Primary standards are designed to protect human health; secondary standards to protect welfare including vegetation. NAAQS are based upon extensive consultation, scientific review and are examined by the Congressionally-appointed Clean Air Scientific Advisory Committee prior to recommendations being made to the EPA Administrator. Unfortunately, it is not meaningful to compare NAAQO with NAAQSs due to the differences in units of measurement (SO_2, O_3, NO_2), as well as form and level of standards/objectives.

Europe

In Europe there are UNECE, World Health Organization (WHO) and European Union (EU) limit values and critical levels published for O_3, SO_2 and NOx. The UNECE and WHO critical level for forests that is not to be exceeded for cumulative O_3 exposure over a growing season is 10 ppm hours in daylight hours over 6 months (April-September) (Table 4). This critical level is designed to indicate where there is a risk of growth losses associated with ozone. It is not designed to protect vegetation, and visible injury is known to occur at concentrations below the threshold (VanderHeyden *et al*. 2000). In view of this and a number of other difficulties, a "Level 2" standard is being considered. This will take into account species phenology, differential species sensitivity, climatic factors and a number of other variables.

The UNECE and WHO critical level for SO_2 forest exposure is defined under an annual or winter mean of 20 ug m^{-3} or 15 ug m^{-3} in "harsh climates". The EU lists 20 ug m^{-3} for all ecosystems away from the vicinity of sources (Table 4). The NOx level is listed as the annual mean of sum of NO and NO_2 concentrations (ppb), expressed as ug m^{-3} based on conversion for NO_2 and listed as 30 ug m^{-3} by all agencies.

Although direct comparisons between forest responses to different air pollution climates in Europe and North America cannot be made (Percy *et al*. 1999), in part due to centuries of forestry practices and land-use policies, clearly there is a need to standardize approaches to air quality standards and critical levels. Given the significant differences in factors (climate, latitude, elevation, disturbance history, species, genotype etc.) which combine to affect the magnitude and direction of stand or ecosystem response, perhaps it is time to converge upon a single form for an index which is most scientifically-defensible and has some biological base to it. The level within the form can certainly be adjusted then to account at the regional and national level for some of the confounding or predisposing factors. The Level 2 standard being considered for O_3 in Europe seems to be one such approach and needs to receive greater attention in North America.

New Approaches to Meet Policy Requirements

Utilitarian approaches commonly used to assess forest health are likely inadequate for the detection of future change and elucidation of the roles of natural and anthropogenic stressors. Integrated approaches linking process-oriented empirical studies (FACE) with pattern-oriented monitoring along defined pollution gradients (clones; ecological analogues), ecosystem-based research on essential cycles (calibrated watersheds) with new approaches to monitoring will be required if the interactive effects global change (air pollution + climate change) on forest health and sustainability are to be understood in the 21st Century.

One new forest health approach to addressing the policy requirement for enhanced linkage of cause and effect in a timely fashion is represented by the new CFS Three Tier Strategy. This design (Table 5) comprises elements of the North American and UN/ECE experience in that it integrates new approaches to national-scale forest health assessment with process research. Essential elements defined are : 1) a national-level synthesis of forest health stratified upon an national forest inventory inventory grid (Tier 1); 2) for health problems reported under Tier 1, and once spatial and temporal extents have been elucidated, individual shorter-term, multi-disciplinary case-studies to identify cause-effect linkages (Tier 2); and 3) longer-term ecosystem-level monitoring and research at the watershed level and beyond to support activities under Tier 2 and monitor policy performance (Tier 3). Tier 1 data will be collected under cooperative arrangements with provincial agencies by supplementing existing inventory and protection mandates with some health variables.

Table 4. Air quality objectives, standards, guidelines and levels for protection of forests.

	Ozone	Sulphur dioxide	Nitrogen oxides (Nitrogen dioxide)	Suspended particulate matter PM 2.5[3] PM10[4]
Canada NAAQO[1]	1 hr 82 ppb 24 hrs 25 ppb annual 15 ppb	1 hr 334 ppb 24 hrs 115 ppb annual 23 ppb	(1 hr 231 ppb) (24 hrs 106 ppb) (annual 53 ppb)	24 hrs 120 $\mu g\ m^{-3}$ annual 70 $\mu g\ m^{-3}$
United States NAAQS[2]	8 hrs 0.080 ppm	annual 15 $\mu g\ m^{-3}$ 2 4 hr 65 $\mu g\ m^{-3}$	(annual 0.053 ppm)	PM2.5 annual 15 $\mu g\ m^{-3}$ 24 hr 65 $\mu g\ m^{-3}$ PM10 annual 50 $\mu g\ m^{-3}$ 24 hr 150 $\mu g\ m^{-3}$
UNECE	10,000 ppb h in daylight hours over 6 months	annual 20 $\mu g\ m^{-3}$	annual 30 $\mu g\ m^{-3}$ (from annual mean sum of NO and NOx ppb)	
WHO	10,000 ppb h in all hours over 6 months	as for UNECE	as for UNECE	
EU		20 $\mu g\ m^{-3}$ (away from vicinity of sources)	30 $\mu g\ m^{-3}$	

[1] National Ambient Air Quality Objectives (NAAQO) are defined in terms of maximum desirable, maximum acceptable and maximum tolerable levels. Maximum acceptable levels are listed and considered to provide adequate protection against adverse effects on humans, animals, vegetation, soil, water, materials and visibility.
[2]National Ambient Air Quality Standards listed are Primary Standards. All values are means.
[3] PM2.5 : particles 2.5 µm in diameter and smaller
[4] PM10 : particles 10 µm in diameter and smaller

The Canadian Forest Service will provide national synthesis, quality asurrance, indicator performance evaluation functions. Selected ARNEWS monitoring indicators are combined with new indicators, such as needle surface wax chemical characteristics used to relate tree condition with "pollution climate" (Cape and Percy 1998), while broadening the forest values being assessed to include measures of resilience, biodiversity and essential cycles. An example of national-level forest health reporting combining essential elements of the three tiers and addressing a range of ecological and more anthropocentric forest values can be found in the first overview report on Canadian forest health (FHN 1998).

It is abundantly clear that existing air quality standards, objectives or guidelines do not afford an adequate degree of protection to sensitive trees and plant communities. This is not unexpected as most were designed to protect human health, and are more tools for regulators.

Table 5. Essential features of the new Canadian Forest Service Three Tier System for integrated forest health monitoring and research.

Tier	Objective	Duration	Stratification	Outcomes	Key Components[1]
One	Synthesis of national forest health	continuous on 10 year cycle 10% plots per year	statistical grid system (20 km x 20 km)	assessment trends health index	site quality pest condition stand integrity structural diversity species diversity wildlife trees coarse woody debris natural disturbance seral stage
Two	Case studies of cause-effect	< 5 yrs	gradient stand-level geographical region	cause-effect linkage critical loads/levels indicators	crown condition insects/diseases foliar condition increment soil indicators physiological indicators biochemical indicators site instrumentation deposition pollutant concentrations
Three	Longer-term ecological research and monitoring	> 5 yrs	ecozone watershed landscape	mechanisms models policy performance evaluation	carbon cycles N/S cycles water flux scaling up stand age pest history fire history

[1]At time of writing, key components of each tier are still under discussion

Considerable effort over the past 15 years has been devoted, particularly in Europe under UN/ECE auspices, to the development of critical levels (SO_2, O_3) and loads (S, N, heavy metals) for the protection of forests.

This work is now at a relatively advanced stage, and detailed maps of exceedances are available for most countries. The maps have been extremely useful for decision makers in choosing which sources address first, and have enabled a more cost-effective, scientifically based approach to pollution control (Bull and Fenech 2000). It seems likely that this is one of the most cost-effective ways of reducing air pollution impacts on forests.

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Smoke Emissions from 1997 Forest Fires in Southeast Asia

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Abstract

The widespread bush and forest fires that occurred in Indonesia between April and October 1997 caused extensive episodes of haze or smoke throughout the region, particularly in Indonesia, Malaysia, Singapore, Brunei and parts of the Philippines and Thailand. Satellite imagery analysis has revealed that most of the fires started in the plantation areas in Borneo and Sumatra as a result of burning for land clearing and preparation for agricultural practices. The dry conditions in Southeast Asia resulting from the 1997 El Niño - Southern Oscillation (ENSO) climate phenomenon exacerbated the problems and made forest fire control more difficult. At least three combustion processes with specific characteristics were identified, namely, flaming, smoldering and mixed. More than 1,000 fires affected an estimated 300,000 ha or more, with some estimates extending to 800,000 ha. The question of biodiversity loss has yet to be assessed. The severity and extent of the smoke haze pollution were unprecedented and the region experienced extended periods of high particulate levels and severe reductions in visibility. The haze pollution also resulted in considerable health impacts to the people although the long-term health effects are yet to be determined. Long- and short-term implications of visibility reductions during the haze period on the survival of light-demanding and shade-tolerant species on the forest floor and their potential to shift species compositions in forest ecosystems due to changes in ecophysiological processes are also discussed.

Keywords: Forest fire, Haze, Health Impact, Haze particle, Forest Ecosystem, Ecophysiological processes.

Introduction

The recurrence of widespread bush and forest fires in Indonesia in 1997 caused extensive, although as yet unquantified, economic, social, and environmental impacts in Indonesia and its neighboring ASEAN countries. Fires occurred in Kalimantan, Sumatra, Java, Sulawesi and other islands. Satellite imagery analysis has shown that most of the fires started in plantation areas of Indonesia as the financially cheapest means for land clearing and preparation. The concurrent dry conditions in Southeast Asia resulting from the 1997 El Niño - Southern Oscillation climate phenomenon exacerbated the problem and made forest fire control more difficult. The area affected by burning is related to the length of the dry season. According to the ADB Report (1997), since 1987 the affected area has increased with each successive extended dry period (e.g., in 1987 (49,000 ha), 1991 (119,000 ha), and 1994 (162,000 ha)). In 1997, more than 1000 fires affected an estimated 300,000 ha or more, with some estimates up to 800,000 ha. Consequently, there was a widespread accumulation of haze or smog that covered neighboring countries and caused widespread economic, social and environmental impacts. The regional haze seriously affected Indonesia, Malaysia, Singapore, Brunei and parts of the Philippines and Thailand. It has been estimated that the regional haze crisis resulted in a one-percent reduction in national economic growth in some affected countries. Tourism in the region has been severely hit. The World Health Organization has predicted that the haze will result in lung ailments and breathing discomfort for about 20 million people in the region. Malaysia, Singapore, Australia, Japan, USA, and other countries as well as international organizations have provided rapid material support and technical assistance to Indonesia in combating the fires and assisting in relief efforts for the affected populations in Sumatra and Kalimantan. In short, the haze episode that occurred in the region from July to the end of October 1997 is on record as one of the historical air pollution disasters of the world, affecting nearly 300 million people over an area exceeding 2 million km^2. The incident has left a legacy of impacts on human health, the economy, the ecology, and on political systems as well as many more that need to be determined and investigated for the benefit of mankind.

Nature of Forest Fires

Within a framework of technical cooperation between the Government of Malaysia and the Republic of France, a team of multi-disciplinary remote sensing experts coordinated by MACRES (Malaysian Centre for Remote Sensing) was assigned to work on the 1997 forest fires and smoke haze. The study utilized high spatial resolution SPOT satellite data and low-resolution satellite images (NOAA-AVHRR satellite) for the purposes of disaster prediction, early warning, and damage assessment in the Southeast Asian region (Mahmood and Bolhassan, 1998) with special reference to Banjarmasin (Kalimantan) and South Sumatra. In the case of the maximum development of fires in Banjarmasin, the total area burnt by 7 August 1997 reached 50,550 ha, representing approximately 20% of the study area, whilst a total of 1,380,814 ha in South Sumatra accounted for 14.6% of the study area (9,415,375 ha). Mahmood and Bolhassan (1998) also pointed out that the burnt areas affected two land-cover types. In cultivated areas, fires exhibited geometric boundaries following the limits of the fields and of the deforested areas. This is considered to be the normal process of field clearing before cultivation. In natural vegetation areas, the fire patterns were more complex, and followed roads and tracks.

Analysis of the fires demonstrated that fire patterns could be broadly related to different vegetation structures. The direction of fire propagation seemed to be related to openings in the natural vegetation, such as drain channels, tracks and roads. Fire propagation followed the natural pattern of networks, such as rivers, sparing dense forest patches. In areas dominated by agricultural activities, natural vegetation, sparse forests and bushes border the river networks, and are connected by patches of dense forest cover. In this situation, the fire patterns followed these lines of natural vegetation, resulting in the propagation of fires over long distances. Wind direction plays an important role in determining the direction and extent of the spread of fires in these areas.

Brunei Darussalam

Vegetation fires occur in Brunei Darussalam during dry spells. As recorded by the Fire Department, there were a total of 740 reported cases of vegetation fires in 1997 between the months of January and October, which destroyed around 878 ha of vegetation cover. This is significantly more than what had occurred during the whole of 1996, when there were only 470 reported cases of vegetation fires destroying 474 ha of vegetation. The highest reported occurrences of fires were from May to September. The cause of the majority of the fires was unknown. Of those fires for which a cause was known, the most important source was open burning activities. Local vegetation fires are probably the major contributor to occurrences of localized haze in the country. However, in 1997, there were only a few incidences of vegetation fires that were of significance for the development of haze.

Indonesia

The results of actual and on the spot field inspections in Riau on 24 May and 23 August 1997, Jambi on 13 September 1997, South Sumatra (in Central Kalimantan) on 16 September 1997 indicate that ground and forest fires first originated from new investments in the agribusiness, especially large scale plantations violating bans on land-clearing fires issued by the Ministries of Agriculture, Forestry, Transmigration and the Settlement of Forest Squatters in effect since 1995. In addition, there was a lot of small-scale burning by individuals for agricultural purposes; this has become habitual each dry season in anticipation of the rainy season. As the conditions were extremely dry, fires set to clear land developed into uncontrolled wildland fires.

Hot spots in Sumatra and Kalimantan increased from February until July 1997. In August these hot spots tended to decrease at night and increase again during the day. This was an indication of controlled burning. Data in September indicated that hot spots were seen both day and night, implying that the fires were out of control.

Smoke pollution affects human beings by causing health problems and a rising number of cases of asthma, pneumonia, upper respiratory tract infection, eye irritation, diarrhoea and DHF has been identified. It was anticipated that all these effects would combine with the other normal effects of the prolonged dry season and with disturbances to air, land and river transportation routes.

Of estimated 121,626 ha of forests burned, 22,816 ha had being due to burning for land clearance, 10,103 ha due to fires spreading out of control and 88,707 hectares of existing plantations. In addition, 731 ha of food crops and horticulture were burned in South Kalimantan, Central Kalimantan, South Sumatra and Riau, consisting of 209 ha of rice crops, 1.5 ha of second crops and 520 ha of horticulture. At least 88 of 300 houses located on a 300 ha piece of land that was once peat soil were burned at the Sinunukan Transmigration settlement in South Tapanuli, North Sumatra province, and 149 houses were burned on a 800 ha piece of land at the Peat Soil Development Project at Muara Dadahup and Lamunti, Kuala Kapuas, Central Kalimantan. At the same time more than 268 houses were destroyed by fire on 800 ha of peat soil at the former Pegambit 2 transmigration settlement area, Pulau Laut Timur, Kota Baru, South Kalimantan.

Accordingly, 96,693 ha of forests were burned, consisting of 10,552 ha of protected forests, 70,259 ha of productive forests, 3,896 ha of natural conservation forests, 5 ha of provincial recreational forests and 35 ha of other natural forests. The Timber and Plantation Estates (HTI) suffered an estimated loss of Rp 45.7 billion. There was a decrease in income originating from the airline business, plane passengers, landing fees, and the directing and parking of airplanes due to the 1,037 flights that were cancelled at 11 airports in Sumatra and 2,027 other cancelled flights at 12 airports in Kalimantan.

The end of the transitional period between the dry and the wet season in Indonesia was accompanied by a change in wind directions and an increase in humidity and was helpful in slowing down the burning process. The winds that were first blowing towards the west and then turned on Sumatra to the north (similar to the pattern in Kalimantan) changed direction from the northwest to the south (Indian Ocean). This change in wind direction improved the air quality in Singapore and Malaysia. Following this, Malaysia lifted the emergency conditions in Sarawak.

This situation was followed by relatively heavy rainfall in several areas including Riau, South Sumatra, West Sumatra, Lampung, Jambi, West Kalimantan, Southeast Kalimantan, South Kalimantan and several areas in Java. The rainfall extinguished several hot spots in some areas and reduced smoke pollution. Visibility increased to more than 600 meters, which in turn resulted in the reopening of several airports that had stopped operations. However, some resumed operations in part only.

Malaysia

The haze episode in Malaysia was primarily due to the exceptionally high concentration of suspended particulates in the air. Smoke from ground and forest fires from Sumatra and Kalimantan, Indonesia aided by westerly and south-westerly winds caused serious reductions in visibility and high suspended particulate levels below PM_{10}. Malaysia experienced serious health, ecological, economic and political impacts during the period mid-July to early November 1997. Following the haze episodes of the 1990s, Malaysia established the National Haze Committee to examine the sources, preventive measures and responses needed.

The Haze Action-Lines (HAL), which use the PSI-based Air Pollutant Index (API), were drawn up to provide a coordinated response during haze episodes. These however mainly targeted the control of domestic sources and the actions taken are only effective if local sources are involved. In this connection, the HAL provided a good basis for the National Disaster Relief Committee to adopt a threshold enabling environmental emergency to be proclaimed after taking into account political and economic considerations. For example, instead of accepting 300 as the hazard level, 400 was adopted to close schools and 500 to declare an emergency for people to remain indoors.

The data collected during the episodes are being analyzed. Generally, East Malaysia experienced higher peak PM_{10} particulate levels than other parts of Malaysia – in September 1997, there were 10 days when concentrations exceeded the health standard, eight days when they exceeded the extremely unhealthy level and six days when they were extremely hazardous. In West Malaysia, the Klang Valley had more than 2/3 of the month of September above the threshold for health effects, but the peak values remained lower than the extremely unhealthy (300) level, with only one area (Gombak) crossing momentarily above 300 on 20 November 1997.

The good air quality normally prevailing throughout the country was adversely affected in 1997, largely by the forest and peat fires in the region (DOE, 1997b). All the 29 (CAQMS) stations, except the latest one in Miri, Sarawak, which came into operation only in October 1997, recorded hourly measurements of PM_{10} exceeding the MAQG of 150 g m^{-3}. Exceedances occurred for up to 15% of the year, about 1300 hours in Kuala Lumpur, and the two other most affected places were Klang (12%), and Gombak (10%). Although the hours exceeding the acceptable level were less than those in the Klang Valley, Kuching recorded about 8% exceedance, and registered the highest API ever recorded in Malaysia (839 over a 24-hour average on September 23rd, 1997). The maximum API values registered at other places in the country were less than 460. In atleast 5 of the 22 stations, sulphur dioxide concentrations were also high, and exceeded the acceptable level for 16% of the time at the Prai Industrial Estate in Pulau Pinang. Four other affected areas were Pasir Gudang-Johor (2%), Kajang-Selangor (0.4%), Johor Bahru-Johor (0.2%), and Shah Alam- Selangor (0.1%).

During the haze episode, the authorities and the public and private sectors were concerned about the synergistic effects of the pollutants. Of particular importance, particulates combining with SO_2 can be fatal, as experienced during the London smog of early December, 1952. During this period, there were 4000 deaths associated with concentrations of sulphur dioxide reaching almost 0.75 ppm (Awang, *et al.*, 1998). Fortunately, such an episode did not develop in Malaysia. Ozone (O_3), a secondary pollutant, particularly affected those places within highly urbanized valleys, namely Selayang-Gombak (1.3%), Kajang (0.7%), Shah Alam (0.6%), Kuala Lumpur (0.2%), Klang (0.1%) as well as Johor Bahru (0.1%), Ipoh (0.01%) and Pasir Gudang (0.01%). In Kuala Lumpur, but not the other stations, the measurements of CO and NO_2 exceeded the acceptable levels for 0.2 and 0.01 per cent of the time, respectively. These were due to motor vehicle emissions.

With the cessation of the El Niño conditions, the overall conditions improved in 1998, except at a few places during the early parts of the year that were adversely impacted by local peat-forest fires in Miri, Sarawak. Thirty per cent of the time in Miri, the measurements of PM_{10} exceeded the acceptable concentrations of 150 g m^{-3}. Exceedances also occurred at Kota Kinabalu (0.4%), Sibu (0.3%), Seberang Jaya (0.3%), Gombak (0.3%), Pengkalan Chepa (0.1%) and Kota Bahru (0.02%). Other places, though not adversely affected by particulates, continued to register SO_2 measurements that exceeded the acceptable level of 0.04 ppm averaged over 24 hours, namely, Prai Industrial Estate (5.1%), Prai Seberang Jaya (3.1%), Johor Bahru (2.35%), Pasir Gudang (2.0%) and Nilai 0.2% (all in the % of total monitored time).

The Philippines

As reported in the weather observations prior to the September haze intensification, light haze observations could be traced back during the summer months to September 12. As there is only limited information related to forest fires in Indonesia, the intensity of the haze is unknown. However, as the wind was coming from the southwest, it is likely that the source of haze particles during this period was not very intense.

The 4:30 am 24-hour weather forecast for September 12 indicated that typhoon *lbiang* was heading toward Japan-Taiwan area. Although typhoon *lbiang* did not have a direct impact on any part of the country, as it entered the Philippine Area of Responsibility (PAR) it enhanced the Southwest Monsoon flow. Consequently, on September 13 (8:00 am), the horizontal visibility in Zamboanga City was reduced to 5 km. The enhanced Southwest

Monsoon may have carried the smoke from the forest fires in Kalimantan, Borneo, to Zamboanga City, causing the reduction of visibility in the area. Incidentally, after almost three hours, rainshowers occurred that cleansed the air, eventually improving visibility. This scenario prevailed until September 17, 1997.

On September 18, a cyclonic circulation developed west of Mindoro. The system further enhanced the Southwest Monsoon flow although the effect was only in the Visayas and Mindanao including Metro Manila. The 20 km visibility over Zamboanga was again reduced to 6 km, a condition that persisted for 18 hours. This was followed by a 2 km improvement in visibility. The fluctuations in horizontal visibility in Zamboanga City may be due to the occasional precipitation in the area. The minimum visibility recorded in the area was 4 km (September 22, 2:00 pm). At 8:00 pm the same day, the visibility observed in Metro Manila was only 5 km.

The worst effects of haze were in Puerto Princesa. From September 21-29, the minimum visibility fluctuated between 2 and 5 km. The fluctuation may have been attributable to the wind direction and precipitation in the area, although the wind speed ranged from calm to 5 m s^{-1}. There were three sources of haze particles, namely: Indonesia (the north of Sumatra), South Borneo, and Buru in the Molluccas area. However the source of the haze affecting the country was Kalimantan in South Borneo. Based on the analysis, it was also there that the largest fires occurred. The fire in Borneo may have intensified on September 21, so that a combination of the extensive production of haze particles and the existence of a low pressure system west of Mindoro resulted in the haze occurrence in some parts of the country becoming very alarming.

This claim is supported by the 8:00 am satellite imagery for the period September 23-26, 1997. The satellite pictures also revealed the extent of haze that spread in the region during the intensification period. In all five stations under study, the greatest impact of haze was found in Puerto Princesa and Zamboanga.

From the beginning of the critical period, PAGASA released haze information and a bulletin to the Chair of the Task Force Haze and to the media. The first haze bulletin was released on September 25, 1997.

Starting on September 27, the wind direction in Zamboanga City started to shift from the southwest to the northeast while at the other four monitoring stations, the shift occurred in the early part of October. The wind shift gradually diminished the effect of haze in the country, and the southeasterly wind diverted the haze particles to the Malaysian Peninsula. Also, during the haze dissipation, there was occasional precipitation in the affected areas that cleared the atmosphere of the haze pollutants. This resulted in the improvement in horizontal visibility in the affected areas. During October, a light haze was observed although this gradually diminished, particularly in the latter part of the month.

Singapore

Satellite pictures showed some hot spots and smoke plumes in Sumatra and Kalimantan in late May, and again in mid-July. The hot spots appeared on intermittent occasions, and the accompanying smoke plumes were fairly localized. There was little impact on Singapore's air quality at that time.

The hot spots became more persistent after mid-July and began to show some effect on Singapore's air quality in August. This effect became significant in late August, and the air quality measured by the 24-hour Pollutant Standards Index or PSI went into the 'unhealthy' range for the first time on 13 September 1997. From August 1997, the 24-hour PSI readings had remained largely in the 'moderate' range (i.e. between 51 and 100). There were, however, 12 days when the readings went into the 'unhealthy' range; the highest reading recorded was 138 on 19 September 1997. During the 1994 smoke haze episode, Singapore's air quality went into the 'unhealthy' range on 17 occasions. Therefore, in terms of the deterioration in air quality, the impact in 1997 was not worse than that of the 1994 episode.

In addition to the daily announcement of the 24-hour PSI at 4:00 pm, the Ministry of the Environment also decided to provide hourly air quality updates based on a three-hour PSI. This was in response to public requests for more current air quality data. The hourly updates were released between 6:00 am and 10:00 pm each day. Whenever the three-hour PSI exceeded 100, health advisories were also issued. This information was made available to the public through the media, a haze info-line, and a PSI web-page on Internet.

Meteorological Factors in Relation to Haze Episode

During the cloud seeding operations conducted between September and November 1997 by the Malaysian Meteorological Service Department and the Royal Malaysian Air Force (Lim and Ooi, 1998), the haze appeared to be well mixed from the ground up to the haze top. The maximum observed haze height in the region (Peninsular Malaysia, Sarawak, Southern Sumatra and Kalimantan) varied from 7,000 to 14,000 feet, with the maximum thickness observed on 23 September 1997 corresponding with the highest air pollution index ever recorded. Lim and Ooi (1998) also observed that in association with the strong positive anomaly in sea level pressure particularly over the eastern Indonesia – northern Australia region, equatorial southeast Asia was dominantly influenced by southwesterlies and southerlies in the lower troposphere. In addition, south-easterly winds in the southern hemisphere in September 1997 were particularly strong compared to the same month in 1996. This led to the penetration of southeasterlies far northwards into the northern hemisphere, replacing the normal southwesterlies from the Indian Ocean and the Bay of Bengal. Geographically, both Peninsular Malaysia and East Malaysia lie at the downstream end of the southeasterlies which transported smoke particles from the forest fires in southern Sumatra and Kalimantan. Consequently, the steady and strong southeasterlies during the month of September 1997 culminated in the most severe haze event encountered, and by November 1997, the appearance of easterlies had virtually cleared the haze in Malaysia.

The study also revealed that a major El Niño event began in March 1997 (Lim and Ooi, 1998). The event, which was regarded to be equal or worse than that which occurred in 1982-83, was expected to fade away by June 1998. Being close to the core of the El Niño activity, Indonesia normally experiences a precipitation deficit from June to November associated with such an extreme El Niño situation (WMO, 1990). Climatologically, the southern parts of Sumatra and Kalimantan have rainfall peaks in the months of March/April, followed by a relatively dry period from June to September. Therefore, land clearing and open burning are usually carried out there after the peak rainfall period. Unfortunately, the major El Niño event in 1997 not only reduced the rainfall, but also caused a severe and extended drought, resulting in biomass burning becoming uncontrollable and extensive, especially when peat fires were involved. This major El Niño event also led to significant low-level wind anomalies favourable for the mass transport of smoke out of the southern parts of Sumatra and Kalimantan towards the Malaysian and the South China Sea region.

The severe haze episode had significant impacts on the global radiation received, which in turn, further stabilized the atmosphere. A closer examination of the temperatures during normal and hazy days revealed that the temperature in the layer between 700 and 600 hPa underwent stronger diurnal variation on hazy days. This phenomenon reflects the result of radiation heating during the day and radiation cooling during the night in the vicinity of the haze top, and the equivalent potential temperature structures on hazy days were relatively more unstable as compared to normal days.

Physico-chemical Characteristics of Haze

Scanning electron microscope (SEM) analysis of haze particles showed that majority of these particles were smaller than 2.5 m in diameter and were in the form of liquid droplets (Dzulkefly *et al.*, 1998). The percentage of particles less than 5 and 2 m were about 30% and 20% of the inhalables, respectively (Sulaiman *et al.*, 1998). Based on elemental analysis, the particulates contain amongst others Na, K, Ca, Pb, Al, Mn, Zn, Cu, Fe, Cd, Ni, Si, Ti and V (Wood *et al*. 1998). Polycyclic aromatic hydrocarbons (PAHs) concentrations, being the sum of concentrations of nine major non-alkylated compounds (fluoranthene, pyrene, benzo(e)pyrene, benzo(a)anthracene, chrysene, benzofluoranthenes, benzo(a)pyrene, indeno(c,d)pyrene and benzo(ghi)perylene) were predominantly present in the particulates (Zakaria *et al*., 1998), confirming that biomass burning due to forest fires was the main source of the haze.

Ayers *et al*., (1997) focussed on the haze event that occurred in Southeast Asia in September 1994. Their study showed that the general chemical nature of the haze aerosol at Petaling Jaya was that the PM_{10} component consisted of approximately 25% inorganic components, 25% elemental carbon and 50% organic material. Acid ammonium sulphate was the major component in the inorganic fraction. Even the "background" levels of PM_{10} at Petaling Jaya, at around 50-60 g m^{-3}, were primarily due to anthropogenic emissions. If forest fires were the primary cause of the three-fold increase in PM_{10} loading during the extremes of the haze event, then the aerosol composition data during that period would be dominated by biomass burning components. Tracers included in the samples were elemental carbon, aerosol potassium and gaseous NO_2. The time series of aerosol components indicated a correlation with the PM_{10} series during the haze event, suggesting a definite smoke component. Moreover, the time series of traces not related to biomass burning, such as sulphate and lead, showed significant correlations with PM_{10}. The study suggested that there were a number of different source-receptors (including a biomass-burning source) modulated by local and regional meteorology. Consequently, interpretation of the haze peaks in terms of a variety of strong local sources will be very difficult. In addition, Ayers *et al.,* (1997) concluded that smoke from fires at the two locations (Sumatra and Kalimantan) specified in the model was predicted to have reached Petaling Jaya during the haze event period although the temporal pattern of the modelled smoke transport to Petaling Jaya was not identical with the PM_{10} record. It was anticipated that the two fires may have played a part in the extreme haze peak near mid-September, but did not play a major part in the extreme PM_{10} peaks at the height of haze event at the end of September.

In another study, the DOE together with MMS (Malaysian Meteorological Service) and DANCED determined the origin, formation and composition of aerosol haze in Malaysia (DOE, 1997a). Approximately 200 representative samples collected by the MMS for total suspended particulate and PM_{10} measurements during the haze episode in 1994 and in the non-haze years 1995 and 1996 were analysed by Particle Induced X-ray Emission at the National Environmental Research Institute (NERI) in Denmark. The objective of the study was to apportion the sources of the 1994 haze episode, based on two mechanisms that have been proposed for the explanation of the haze episode. The first mechanism relates to the more stable atmospheric conditions that exist in the dry season. This would allow the rather continuous emissions from traffic and industry to build up high local concentrations of pollutants, which could explain why the heavily industrialised Klang Valley was often more polluted than other parts of the country during haze episodes. However, it does not explain why some localities with little traffic and industries such as Kuching in Sarawak, in some years were polluted with suspended particulate matter at levels of the same magnitude as in Klang Valley or even higher. The second mechanism relates to fire in South Sumatra and Kalimantan forests, which occur almost every year in the dry season, and in some years tend to get out of control.

The results of the analysis ruled out the first mechanism as there was a poor correlation with lead (Pb), the marker for local pollution. Conversely, the good correlation with sulphur supports the causal relation with forest fires or other biomass burning, as sulphur and potassium are the essential constituents in biomass. The SPM/sulphur ratios found at geographically widespread locations in the Peninsular Malaysia (Penang, Kuantan, Klang Valley and Johor) were very much the same, corresponding to almost constant contents of sulphur in the SPM (mass ratio 7-8%). This points to a common origin (and/or type) of source, perhaps the reported forest fires in South Sumatra. The high levels found in the

Klang Valley could be due to the combined effects of the geographical vicinity of the source area, an unfortunate position in the prevailing direction of wind flow, and perhaps some trapping of the biomass burning plume in the valley. The sulphur content found in Kuching was markedly lower (4%). This pointed to a different biomass burning source, probably fires in Kalimantan.

Effects on Agricultural Crops and Forest Species

Although growth limitations of agricultural and forest species due to air pollution in mid-latitude countries have been well documented (Awang, 1979), there has been no documented evidence that such problems exist in the region. The atmospheric pollutants that have the greatest potential for affecting the growth of crops and trees are oxides of sulphur, nitrogen and photochemical oxidants such as O_3 and peroxyacyl nitrate. As mentioned earlier, concentrations of these pollutants are frequently above the levels that could alter the biochemical and physiological processes of sensitive crops.

Measurements have shown that during the haze episodes, O_3, TSP and particulate matter with a diameter less than 10 m (PM_{10}) are the major atmospheric pollutants that might potentially affect the growth, development and yield of agricultural crops due to O_3 phytotoxicity and reduction in light intensity. It is important to emphasize that although the haze episode was a temporary phenomenon, it coincided with a critical stage of development of sensitive crop plants as the growing season of many major cash crops in Malaysia takes place between July and August. The observations also suggest that there were strong daily variations among the pollutants. Although the concentrations of oxides of sulphur and nitrogen were low, it is always possible that the combined presence of these two pollutants with O_3 may have a different effect and could have a significant impact on growth and performance of agricultural crops and forest species.

Impact of 1997 Haze Episode On Human Health in Malaysia

The major air contaminant during the 1997 haze period in Malaysia was suspended particle matter, whereas gaseous pollutants were not significantly different from normal days. During the period, PM_{10} concentrations rose beyond the MAQG (1989) level in almost all areas that were monitored. They increased 4-fold in the Klang Valley, and by up to 20 times in Kuching. Simultaneously, Hospital Kuala Lumpur recorded an increase in cases of upper respiratory tract infections (URTI), asthma and conjunctivitis; three diseases directly affected by the haze. The increase in asthma cases was found to have a two-day lag behind the Malaysian API as reported by the Ministry of Health Malaysia in 1998. However, no changes were observed for mortality cases during the haze period.

For respiratory diseases, Selangor recorded a significant increase in the total number of cases during the September haze period. Asthma cases increased from only 912 in June to more than 5000 in September 1997. The total number of Acute Respiratory Infections (ARI) cases increased from about 6000 to more than 30,000 during the same period. However, the number of cases gradually decreased towards the June value as the concentration of PM_{10} began to decrease after September. In Kuching, Sarawak, a significant increase in the number of these cases was also observed due to extreme API readings during the last half of September 1997. However, when the air quality was almost back to the values of a non-haze period in October, the incidence of the cases returned to normal. The trend indicated that short-term exposure to high levels of PM_{10} is detrimental to human health. However, the effect is apparently reversible, and no increase in mortality was reported during the period.

Besides respiratory diseases, there was also a significant increase in conjunctivitis during the haze period. In Selangor, the total number of cases increased from 207 in June to 3496 cases in October 1997. The same trend was also observed in Sarawak. In addition, the daily incidence of conjunctivitis in Sarawak during September was positively correlated

with the API (representing PM_{10} concentration).
The data suggest that the adverse effects of haze on human health could be attributed to the elevated PM_{10} levels in the ambient air and are not likely to be due to other pollutants. Despite the reversibility of the acute effects, it is believed that exposures to haze may have a long-term effect on the community.

Besides the health data, a spirometry study done on sixteen-year old school children in Kuala Lumpur (KL) also revealed that long term exposure to a relatively higher PM_{10} concentration led to decreased lung functions and increased prevalence of respiratory symptoms. The school children in KL were naturally exposed to 103.27 g m^{-3} ambient PM_{10}, while the control group (matched for age, gender, height, weight and smoking habits) was naturally exposed to only 47.35 g m^{-3} PM_{10}. Significant reductions in spirometry parameters such as the vital capacity (VC), forced vital capacity (FVC) and forced expiratory volume (FEV_1) were observed in the KL school children.

A higher prevalence of respiratory symptoms was observed in the Kuala Lumpur school children population; the most commonly reported symptoms were chest tightness, followed by breathing difficulties, morning phlegm and coughs. In both groups, females were found to be more susceptible to the exposure, showing a higher percentage in the prevalence of the respiratory symptoms. The results suggest that prolonged exposure to a relatively high concentration of PM_{10} (even though below the set safety limit) is associated with reduced lung function and increased respiratory symptoms in school children.

There is ample evidence to suggest that the most susceptible group to exposure to air pollutants are the elderly and very young children, while youngsters are among the most resistant. However, the Kuala Lumpur study clearly indicated adverse effects of the exposure on the 16-year olds (the most resistant age group). In addition, a preliminary survey carried out among secondary school children in KL and Klang revealed that less than 50% of these school children went for medical treatment each time they fell sick. Therefore, the total number of respiratory cases reported in the clinical health data is likely to have underestimated the degree of adverse effects caused by the haze on the community.

Although analysis of the health and spirometry data revealed that short-term exposure to very high PM_{10} led to increased cases of related diseases, the effect was apparently reversible. Nevertheless prolonged exposure to PM_{10} even below the MAQG could reduce the lung function and increased the prevalence of respiratory symptoms. The studies conclude that the concentration of PM_{10} and the period of exposure may determine the nature of the adverse effects to human (Awang *et al*., 2000)

Conclusion

In conclusion, the haze episode was caused by forest fires and the nature of habitat damage and impacts on human and environment were similar throughout the region. As far as economic impacts are concerned, the haze episode caused considerable losses both directly and indirectly to the impacted countries.

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Forest Pathogens, Forests and Society

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Abstract

Tree diseases have greatly influenced the activities of humans. This is commonly experienced in forestry where the occurrence of fungal diseases limits the planting range of a specific species or clone. In agriculture, tree diseases have necessitated the use of expensive chemicals and the development of complicated management and quarantine practices to limit losses. Diseases have greatly influenced trade and export routes, with many countries not accepting any fruit or plant material from countries where a specific disease occurs. Diseases have also had a devastating impact on native forests. Examples such as Chestnut blight and Dutch Elm Disease in Europe and the U.S.A. and Phytophthora root rot in Australia are but three examples. As our environment is placed under more pressure from the increasing human population and its activities, so the impact of tree diseases is likely to increase in importance and severity. Only with careful management and a strong vision for forest protection will we be able to ensure the survival of this important resource.

Keyword : Forest pathogens, Forest protection.

Introduction

The fact that pathogens and particularly fungi cause diseases of trees was discovered relatively late in the history of plant pathology. Indeed it was only in the late 19th century that Robert Hartig showed that wood decay is caused by microorganisms (Hartig 1874). Hartig, who is generally recognised as the "father of forest pathology" subsequently proceeded to describe a wide number of diseases of forest trees. To our knowledge, there were no records of forest tree disease epidemics prior to this time.

Foresters generally recognise that diseases and pests cause significant damage to trees. Here, their focus is typically linked to losses in yield and productivity of plantations or managed natural forest. In the developed world, the general public is aware of tree diseases, especially where these have reached epidemic proportions, and have consequently been the focus of considerable media coverage. In less developed countries, the importance of tree disease can fade into relative obscurity, although small-scale and subsistence farmers often depend heavily on their tree crops.

The impact that tree diseases have on society is hugely underestimated. Indeed, it is our contention that this lack of comprehension resides not only amongst the public at large, but that it extends much further and exists even among professional foresters. This situation most likely arises from the fact that tree diseases are hugely complex, and the impacts are poorly understood. Only when tree diseases start affecting food or some other scarce commodity does publicity relating to the problem increase and people become aware of the impact that pathogens have on their lives.

In this brief communication, we hope to illustrate some of the many ways in which tree diseases are impacting on global society. While some of these tree diseases are relatively well recognised, others are somewhat obscure, and have hardly been considered. We, furthermore, contend that there are emerging trends linked to tree disease that are likely to result in significant disease epidemics in natural stands of woody plants in the future. It is our hope that by illustrating some of these problems, both professional foresters and the public will take notice of them. In this way, it might be possible to reduce negative impacts on ecosystems that appear to be threatened.

Well Recognised Epidemics

During the course of the 20th Century, diseases of forest trees have resulted in numerous ecological disasters. It is impossible to treat all of these comprehensively in this brief presentation. Thus, a selected number of examples that illustrate the trends have been chosen.

A relatively large number of tree disease epidemics in Europe and North America caused by pathogens of Asian origin emerged early in the 20th Century. There can be little doubt that these diseases resulted from increased trade between Northern Hemisphere countries. A lack of knowledge of the threat of introduced tree pathogens into native forest environments was clearly to blame for the tragic losses that emerged. Chestnut blight, caused by *Cryphonectria parasitica,* has all but eliminated the American chestnut as a major forest species in North America (Anagnostakis 1987, 1988, Carefoot and Sprott 1969, Hepting 1974, Schumann 1991). Dutch elm disease caused by *Ophiostoma ulmi* and more recently *Ophiostoma novo-ulmi* has devastated native elm in Europe and North America (Brasier 1990, Gibbs 1978, Schumann 1991). Likewise, white pine blister rust caused by *Cronartium ribicola* has had a dramatic impact on native white pines in North America (Liebhold *et al*. 1995, Peterson and Jewell 1968, Ziller 1974). These three diseases are now known to have originated in Asia. They were accidentally introduced into Europe and North America, bringing them into contact with tree populations related to their native hosts, but that lack resistance to invasion (Anagnostakis 1987, 1989, Brasier 1990, 1995, Hoff *et al*. 1980, Kaneko *et al*. 1995, Milgroom *et al*. 1992). The result has been epidemics that, despite significant investments, could not be contained.

There are more examples of tree pathogens introduced from East to West than in the opposite direction. This could reflect greater levels of trade between Asia and Europe/ North America. It is also possible that tree diseases in Europe and North America have received more attention than in Asia. Certainly one disease originating in North America and that has a dramatic impact on native Asian forests is pine wilt caused by the pine wood nematode*, Bursaphelenchus xylophilus* (Kiyohara and Tokushige 1971, Mamiya 1983, 1987, Wingfield 1987). This disease was recognised in Japan early in the 20th Century, but its cause was only elucidated in the 1970's (Mamiya 1987, Kiyohara and Tokushige 1971). Upon its discovery in the United States, pine wilt was thought to represent an emerging new epidemic (Dropkin and Foudin 1979, Dropkin *et al.* 1981), but it was later shown that the nematode is native to North America where native pines are resistant to infection (Wingfield 1983, Wingfield *et al*. 1984, 1986).

The best known example of a forest disease of native tree species that has been introduced into a Southern Hemisphere country, is Jarrah dieback in Southern and Western Australia. This disease is caused by the notorious root pathogen *Phytophthora cinnamomi* (Colquhoun and Hardy 2000, Podger *et al*. 1965, Shearer and Tippett 1989), which is believed to have been introduced into Australia from Papua New Guinea (Old *et al*. 1984, Zentmeyer 1988). It is believed that *P. cinnamomi* was most likely introduced into Australia by early European settlers who brought fruit trees and other garden plants to the country (Colquhoun and Hardy 2000). Although *P. cinnamomi* is best known for Jarrah die-back it affects more than 2000 other native Australian tree species resulting in major changes to the native ecosystem (Colquhoun and Hardy 2000, Weste and Taylor 1971, Weste 1974, Shearer and Tippett 1989).

Emerging Epidemics

All plant pathologists and breeders are familiar with the famous examples of epidemic diseases of forest trees. What is less commonly recognised, is that there appear to be a large number of new and emerging tree disease epidemics in many parts of the world. As mentioned previously, the best recognised and apparently most devastating tree disease epidemics have occurred in boreal forests of the Northern Hemisphere. Shared genera of trees and the movement of wood and plant products have apparently driven this process.

Countries of the Southern Hemisphere tend to be typified by a considerably wider diversity of forest trees than is found in boreal regions. It is possible that this diversity has accounted for the lack of disease epidemics equivalent to those that have occurred in the Northern Hemisphere. However, is less recognised that related families of woody plants are also found on different continents of the Southern Hemisphere. The spread of pathogens of these trees between Southern Hemisphere continents could lead to serious disease epidemics. Trade and tourism, and thus the movement of plant material between countries in the Southern Hemisphere, are increasing rapidly. This increases the likelihood that epidemics similar to those that have occurred in the Northern Hemisphere will emerge in analogous situations in the South. We might, therefore, predict that epidemic diseases of trees in families such as the Myrtaceae and Proteaceae, will emerge in the coming years.

The Role of Exotic Plantations

Plantations of exotic tree genera such as *Pinus*, *Eucalyptus* and *Acacia* have been established in many countries in the tropics and Southern Hemisphere. These plantation areas have increased dramatically in extent during the course of the last Century and now cover at least 20 million hectares. Diseases caused by both exotic and introduced pathogens have caused and will continue to result in significant losses in these plantations. Fortunately, the diversity in the tree species planted has generally lowered the risk of total destruction.

Evidence from forest plantation situations has led us to believe that there is an increasing movement of forest pathogens between countries of the Southern Hemisphere. Development of exotic plantations has substantially increased the movement of forest products such as seeds, and to a lesser extent timber, between Southern Hemisphere countries. This exchange, as well as that linked to other trade and tourism activities is leading to the introduction of pathogens into new areas.

Establishment of plantations of exotic trees has led to some fascinating, yet disturbing developments linked to the emergence of new pests and diseases. For example, pathogens of native plants have developed the capacity to infect exotic plantation species. One of the best examples is the rust pathogen *Puccinia psidii* that is native on Myrtaceae in South and Central America. In the 20th Century this rust fungus suddenly appeared on various species of exotic *Eucalyptus* spp. planted in South and Central America (Coutinho *et al*. 1998). This disease now threatens plantation *Eucalyptus* in other tropical and sub-tropical countries. What is of greater concern is the fact that there are no rust diseases of *Eucalyptus* in Australia, which is the origin of most species in this genus and a centre of diversity for this family (Eldridge *et al*. 1993). *Puccinnia psidii* clearly presents a considerable threat to Myrtaceae in Australia and perhaps in other parts of the world. The magnitude of this threat has recently been recognised by pathologists. Consequently, an intensive research programme supported primarily by Australia and including South Africa and Brazil has recently been launched to gain a more comprehensive understanding of the problem.

Another disease of increasing importance in *Eucalyptus* plantations is *Coniothyrium* canker, caused by *Coniothyrium zuluense* (Wingfield *et al*. 1997, Van Zyl *et al*. 1998). This disease was discovered for the first time in sub-tropical regions of South Africa where it has caused considerable damage. The origin of *C. zuluense* is unknown, but the pathogen has recently been discovered both in Thailand (Van Zyl *et al*. 1998), Argentina and Uruguay (Wingfield, unpublished). Introductions of this pathogen into South America are thought to have originated through trade in seed, possibly with South Africa. If *C. zuluense* does not naturally occur in Australia, it is likely to be a significant threat to trees in that country. Furthermore, nothing is known regarding the host range of this pathogen, and any number of genera or species of Myrtaceae in various parts of the world could be threatened by it.

Plantation forestry based on exotic species is evidently resulting in significant increases in the inoculum load of important tree pathogens. Many examples could be used to illustrate this point, but perhaps one that is most topical currently is pitch canker disease of pines. Pitch canker, is caused by *Fusarium subglutinans f.sp. pini* and has been known in the South Eastern USA since early in the 20th Century (Dwinell *et al*. 1981, Hepting and Roth 1946). Very recently, pitch canker has appeared in the South Western United States where it is associated with a severe epidemic on *Pinus radiata* (Correll *et al*. 1992, McCain *et al*. 1987). The disease is now thought to have originated in Central America (Owen and Adams 1999, Viljoen *et al*. 1997) and has been introduced into Thailand (Kobayashi and Muramoto 1989) and South Africa (Viljoen *et al*. 1994, 1995), apparently on seeds from

Central America. Outbreaks of the disease have also occurred in Japan (Muramoto and Dwinell 1990) and more recently in Korea (Lee, unpublished). As additional outbreaks of this disease occur, the likelihood that it will be introduced into new environments increases. Its impact could be devastating, both for commercial forestry in countries such as Chile, Australia and New Zealand, and also in native stands of pine elsewhere in the world.

Multifaceted Nature of Losses

The impact of diseases of trees is multifaceted and many aspects are easily overlooked. The importance of tree diseases is generally linked to direct financial losses incurred by them. There are many diseases of trees grown in plantations, both caused by native and exotic pathogens, that have led to dramatic losses in timber and fibre production. The impact of diseases of plantation-grown trees is usually reduced through a series of management strategies. These include efforts to reduce inoculum build-up, avoidance strategies linked to the deployment of disease tolerant planting stock and, less commonly, chemical control. The establishment of a reasonably wide diversity of species in plantations clearly reduces risks.

The extent of the impact of epidemic losses to native species due to diseases such as Dutch elm disease, chestnut blight, *Phytophthora* root and collar rot and others is almost impossible to comprehend. When a tree species is eliminated from the landscape, losses extend far beyond those that are obvious, such as the value of the timber and perhaps fruit. These trees provide niches for great numbers of animals and plants, many of which probably can not exist without them (Carefoot and Sprott 1969, Colquhoun and Hardy 2000, Liebhold *et al*. 1995). Because ecological impacts of tree disease epidemics have hardly been evaluated, and is little understood, their significance can hardly be evaluated.

Death of shade and ornamental trees is felt directly by the public. These losses are, however, not only emotional and linked to the aesthetic value of the trees, but property owners and city councils are often forced to incur considerable expense to remove dead and dying trees, which have become hazardous (Schumann 1991, Templeton *et al*. 1999). Trees also often have religious or cultural significance and their loss can be deeply felt by the public. An example of this situation is in the death, due to pine wilt, of ornamental pines growing around religious shrines in Japan. It is perhaps this aspect of the pine wood nematode that is most strongly felt and recognised by the Japanese public. Similarly, *Seiridium* canker that is causing devastation to Cypress (*Cupressus* spp.) in southern Europe has had a tremendous social and cultural impact. Apart from its great economic importance to Mediterranean countries, Cypress trees are considered by many to be sacred trees (Graniti 1998).

Future Prospects

Forest and shade trees form a hugely important part of modern life. Their role is multifaceted and often greatly underestimated. Most people recognise the value of trees for the production of solid timber products, paper and fruit. Their role in shade production and as ornamentals is also generally appreciated. However, few people recognise the importance of trees as carbon sinks or in terms of their importance in global biodiversity.

Based on current trends, it is most likely that increasing numbers of tree disease problems and epidemics will mark the 21st Century. This is despite the efforts to preclude the introduction of pathogens into new areas through quarantine. Although this view might be somewhat pessimistic, we are inclined to suspect that while these efforts must be encouraged, they will not be particularly successful. Trade and tourism in the emerging 'global village' will dominate and the capacity of pathogens to adapt and to damage trees will lead to tremendous challenges.

Efforts to deal with tree diseases during the course of the past Century have been noble, yet relatively minimal in relation to the extent of these problems. In the future, we would hope that significantly increased support will be offered to pathologists, entomologists and biotechnologists to enable them to offer the world novel solutions to diseases of trees. Education of the public as to the importance of tree diseases, and the rapidly growing numbers of forest bio-invasions, will hopefully also help to reduce their impact.

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Sub-Plenary Session: A5

Sustainable Management of Forest Resources:

Sustainable Forest Management and Productivity

Coordinators:

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A Look At The World's Timber Resources and Processing Facilities

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Abstract

Sustainable development has become the umbrella objective for forest management in many countries of the world, and managers are increasingly faced with the challenges of balancing environmental and economic health in their forest management and resource utilization decisions. It can no longer be assumed that abundant raw materials are available simply for the taking. Changing times require that we change how the forest resource is managed and used. As we look to the future, we must develop a better understanding of the complex interactions of wood use and the resultant social and ecological considerations. This paper addresses the value of wood in human societies, provides a brief review of the world's forest cover, discusses worldwide links and expectations, makes the case for forest products technology, discusses global trends in forest products, discusses future supply and demand for industrial roundwood and wood products, and examines ways to meet future challenges.

Keywords: Forest management, Sustainable development, Forests, Value, Forest products technology

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Introduction

A world without forests would be a world that is completely alien to the one we know today. Forests provide a wide range of benefits at the local, national, and global levels. Some of these benefits depend on the forest being pristine or subject to minimal interference. Others can only be realized through well-planned disturbances such as harvesting for wood and other products. The shrinking forest base and growing human population have heightened the challenge for forestry and forest products utilization to produce the needed types and quantity of trees and to prevent conversion of forestland to nonforest uses.

The concept of sustainability is central to sound forest management, and defining what it means is the subject of much current debate. Sustainability in all of its facets—ecological, economic, and social—is important today and will become increasingly important for stewardship of the world's forests. The benefits of forests are wide-ranging and diverse. These benefits include clean air and water, productive soils, biological diversity, goods and services, employment opportunities, community benefits, recreation, animal habitat, and naturalness. Forests also provide intangible benefits such as beauty, inspiration, and wonder.

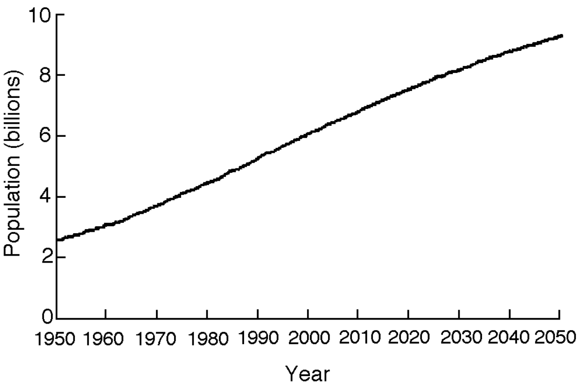
This paper will address the value of wood in human societies. It will provide a brief review of the world's forest cover and discuss worldwide links and expectations, make the case for forest products technology, discuss global trends in forest products, discuss future supply and demand for industrial roundwood and wood products, and examine ways to meet future challenges.

Value of Wood in Human Societies

A critical consideration in any discussion of future industrial raw materials demand is human population growth. All projections indicate a continuing increase in global population in the future. One way to view this is that a child born today will live in a world where the population will double during his or her expected lifetime. The greatest growth in population is likely to occur where the standards of living are also expected to show the greatest rise. The result is a world economy that will grow even more rapidly than the population. This means that demands for resources, which are already high on a per capita basis, will rise even higher.

The historical record of world population growth is dramatic (Fig. 1). World population doubled between 1850 and 1950 and then doubled again between 1950 and the present (Bowyer 1995). During each of the next four to five decades, global population is expected to increase by approximately 900 10^6. These figures make it dramatically clear that the world of tomorrow will place even more pressure on forests and forest resources.

Figure 1—World population 1950–2050 (From Youngquist and Hamilton 1999).



Tremendous quantities of wood are consumed each year throughout the world. Schulz (1993) reports that the world harvests approximately 3.5 10^9 m^3 of wood annually, with slightly more than half of this used as fuelwood. Approximately 63% of the annual harvest is comprised of hardwoods, which are mostly used for fuel in the developing countries of the world. The world's softwood use is primarily industrial.Sutton (1993) reports that the global per capita consumption of wood is approximately 0.67 m^3 per year, a figure that has remained largely unchanged since 1960 (Schulz 1993). This means that growth in world wood demand is closely following the growth in world population. With the assumption of a continuation of per capita consumption trends, population increases alone will add approximately 60 10^6 m^3 annually to world wood demand (Bowyer 1995).

The World's Forest Cover (FAO 1999)

Information on the status of the world's forests, their extent, location, type, and condition, is important for efforts to improve forest management worldwide and for assessments of the ability of the forest to provide the goods and services demanded of them. The area of the world's forests, including naturally occurring forests and forest plantations, was estimated to be 3,454 10^6 ha in 1995, or about one-fourth of the land area of the Earth. About 55% of the world's forests are located in developing countries, with the remaining 45% in developed countries (Fig. 2). The world's forests are almost equally divided between tropical–subtropical forests and temperate–boreal forests. Only about 3% of the world's forests are forest plantations. The remaining 97% are natural or seminatural forests. Data published in FAO (1997) provide a picture of the trends in forest cover for a 15-year interval (1980–1995) and allow a comparison between the 1980–1990 and 1990–1995 periods.

Between 1980 and 1995, the extent of the world's forests (including both natural forests and forest plantations) decreased by some 180 10^6 ha, or about 5% of the total forest land base. There was a net increase of 20 10^6 ha in developed countries but a net loss of 200 10^6 ha in developing nations. The change in forest area by region between 1980 and 1995 is shown in Figure 3.

Between 1990 and 1995, there was an estimated net loss of 56.3 10^6 ha of forests worldwide. This represented a decrease of 65.1 10^6 ha in developing countries and an increase of 8.8 10^6 ha in developed countries. Although the global loss of forests was very high, the figures suggest that the rate of deforestation might be slowing.

Figure2- Forest areas by main regions in 1995. (From FAO 1999)

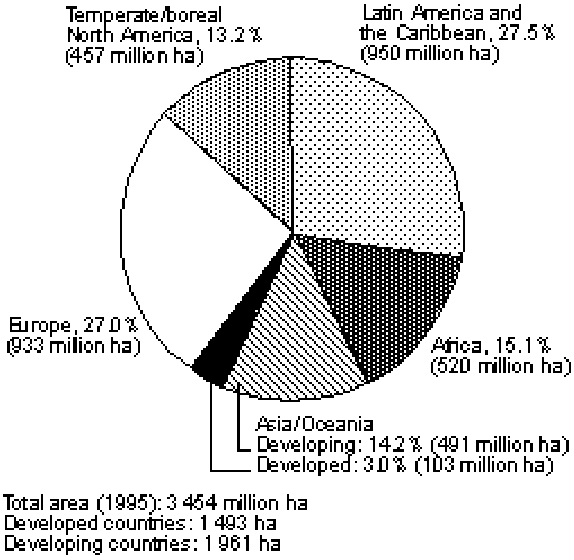
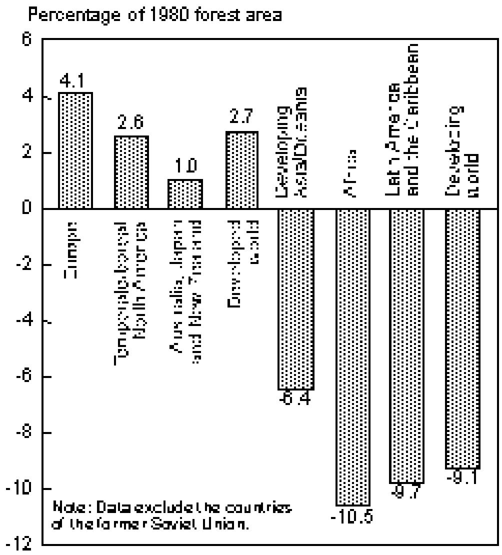


Figure 3—Forest area in 1995 as compared with 1980 (From FAO 1999.)



The estimate of forest cover change in natural forests of developing countries (which is where most deforestation is taking place) was a loss of 13.7 10^6 ha of forests per year between 1990 and 1995 compared with a 15.5 10^6 ha loss per year during the decade of 1980 to 1990. The major causes of change in forest cover in the tropics appear to be expansion of subsistence agriculture in Africa and Asia and large economic development programs involving resettlement, agriculture, and infrastructure in Latin America and Asia (FAO 1996). The net increase in forest area in developed countries is largely a result of afforestation and reforestation, including natural regrowth on land abandoned by agriculture. This increase has more than compensated for the clearing of some areas of forest in various developed countries, which is mainly due to urban expansion and infrastructure development.

The Approach to Environmental, Social, and Economic Concerns

Environmental, social, and economic concerns must be considered together. Ecological sustainability must provide a foundation upon which forest management worldwide can contribute significantly to economic and social sustainability. Conservation and wise management of forests can promote sustainability by providing for a wide variety of uses, values, products, and services and by enhancing society's capability to make sustainable choices. In a like manner, social and economic sustainability provides a foundation for ecological sustainability by broadening forest management perspectives through improved standards of living.

When the concept of sustainable development was presented in 1987 by the United Nation's World Commission on Environment and Development (United Nations Commission 1987), attention shifted to environmental concerns. However, the concept was one of balance—the environment and the economy cannot be treated separately. Material needs must be met in ways that preserve the biosphere, and concern for the biosphere must recognize material needs. Another important concept imbedded in this strategy is recognition of both the short and long term. The Commission's report clearly stated that sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Worldwide Linkages and Expectations

The question of conservation and utilization of forest resources must be balanced and is at the very essence of the work of all of us who are concerned with the management and utilization of natural resources for sustainable development. The discussion of conservation and utilization must focus on how the needs for conservation and utilization can be combined harmoniously to derive the maximum benefits for present and future generations.

Finally, the theme of worldwide linkages and expectations means that the way that wood is processed and used must be developed in a global context to achieve success in sustainable development. Local decisions on timber harvest and use have clear implications for other countries. In developed countries, with rising demand, local decisions not to harvest create a higher economic incentive to harvest elsewhere. In countries where natural forests are not managed for regeneration, short-term harvest decisions can affect the availability of all forest resources in the long term.

The Case for Forest Products Technology

Given this changing context, what roles will forest products play in relationship to forests and forestry? In our opinion, forest product technology will play a central role in meeting these challenges for the following reasons:

Management is and will continue to be necessary to achieve desired forest conditions.

Management that includes wood removal is a cost-effective way to achieve ecosystem health.

Wood technology will help provide choices for the management and use of the forest.

Sustainability must recognize the interdependence of the environment and the economy.

Management for wood fiber will maintain prominence but not dominance.

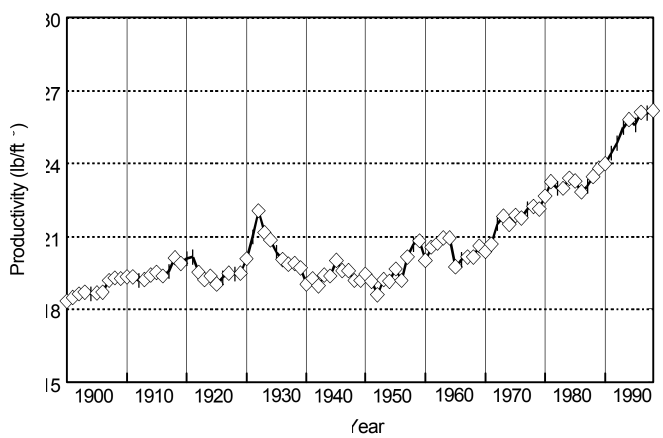
We need to understand and embrace the values the public is not willing to forego.

Forest products can help forest lands compete economically, thus making their conversion to nonforest uses a much less viable option.

Conservation of wood fiber, not competition of wood with other raw materials, must be the focus of wood products research.

A brief historical review is appropriate as one way of pointing out how a decline in wood resource availability can be at least partially offset by increasing efficiencies in the use of the wood resource. For example, in the United States, product output per unit of wood input has risen by about 40% during the past half century (Fig. 4) (Ince 2000).

Figure 4 – U.S. Product output per roundwood input (From Ince 2000)



Global Trends in Forest Products (FAO 1999)

To meet the needs for wood and nonwood products and, at the same time, fulfill demands for environmental and social services from forests is a challenge now facing the forest sector. Efforts to find an acceptable balance between production and protection and between use and conservation drive much of the debate surrounding the forest sector today.

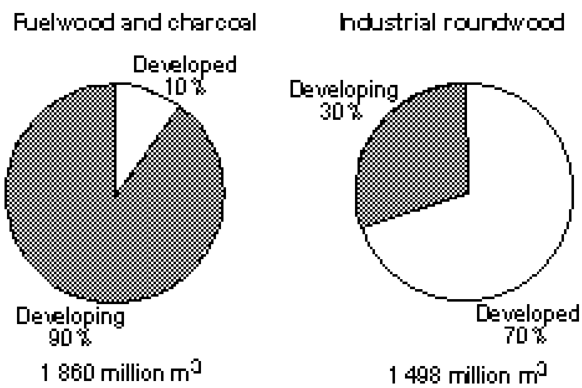
The overall patterns of production and consumption of wood products are very different between developed and developing countries. Developed countries account for 70% of the total world production and consumption of value-added industrial wood products. Developing countries, on the other hand, produce and consume about 90% of the world's fuelwood and charcoal, which are the major household energy sources in many of these nations (Fig. 5). More fuelwood and charcoal are consumed each year in the world than industrial roundwood. Demand for fuelwood is expected to continue to increase at a rate of about 1.1% per year between now and 2010, while demand for industrial roundwood is expected to increase at a rate of about 1.7% per year during the same period.

Factors that are expected to influence the ability to meet increasing demand include increased sources of wood (e.g., plantations and trees outside forests), technological improvements in wood processing, which will increase the efficiency of raw material use, and increased use of recovered and nonwood fiber. Trade will continue to help balance geographical wood deficits in one place with surpluses elsewhere.

While wood is the predominant commercial product from forests, increased attention is being paid to the actual and potential economic role of nonwood forest products (NWFPs). The importance of NWFPs to household and local economies, particularly among the poor in developing countries, is increasingly recognized, as is the need to consider them in forest management planning and in forest policy in many countries.

Wood energy is another area that is raising new interest. While fuelwood and charcoal remain significant sources of energy in developing countries, especially for domestic use, their potential to contribute to the modern energy sector as an alternative to fossil fuels is being investigated in several countries.

Figure 5- Production and consumption of wood products in 1996 (From FAO 1999).



Trade and Trends in Forest Products (FAO 1999)

According to the United Nations Food and Agricultural Organization, growth in the production of tropical forest products has slowed during the past 3 to 5 years. The export of most products has followed a similar trend; export volumes of tropical logs, sawn wood, and wood-based panels have decreased. Some of the trends reflect major structural changes that are unlikely to be reversed, while others are a response to normal short-term changes in market conditions. Factors influencing the changes include

- increasing domestic consumption in important developing producer countries;
- reduced harvest levels because of both environmental concerns and export market conditions;
- a shift in exports from logs, and to a lesser extent sawnwood, toward export of higher value products; and
- most recently, marked reductions in demand in Asia, especially in Japan.

Certification for sustainably produced forest products continues to be a high profile and often controversial subject in the forest sector. In addition, initial efforts are being made to extend certification to nonwood forest products, which will raise new issues. Certification systems are based on evaluating the standard of forest management being practiced.

Accurate statistics on the area of forests and volume of wood certified are difficult to obtain, and the figures are often difficult to interpret. The Forest Stewardship Council (FSC) reports that about 10.3 10^6 ha of forestland have been certified by FSC-accredited certifiers. It is significant that 90% of this area is in temperate developed countries, largely in Europe and North America. Sweden and Poland alone account for 58% of the total. Only a minor part is in tropical countries, where the problem of deforestation is greatest. The volume of certified wood involved and the volumes entering or about to enter the market are unknown but are still insignificant in global and regional terms. The area of forests certified is not a sound indicator of the volume of wood entering the market, since parts of the certified areas may not be of harvestable age, may not contain commercial species, or in extreme cases may not even have trees growing on them.

Certification efforts are being made at many levels. International efforts include those of FSC and the International Organization for Standardization (ISO). Regional initiatives include those of the African Timber Organization (ATO) and the European Union's Eco-Management and Auditing Scheme (EMAS) and Eco-Labeling Scheme. Countries with national programs include Brazil, Canada, Finland, Ghana, Indonesia, and Sweden. In the last 2 years, there have been many new initiatives and a number of additional forests have been certified or are in the process of being certified. Among importing countries, interest continues to be greatest in Europe, especially Germany, the Netherlands, and the United Kingdom. The exporting countries showing the most interest in certification are those whose main export markets share European countries and to a lesser extent the United States; hence the considerable effort Canada, Finland, Indonesia, Malaysia, and Sweden have put into developing national certification systems.

Future Supply and Demand for Industrial Roundwood and Wood Products (FAO 1999)

FAO has recently completed two new global supply and demand studies: the Global Fiber Supply Model (GFSM) (FAO 1998b) and the Global Forest Products Outlook Study (Whiteman 1999). A major and more detailed forestry sector study for the Asia and the Pacific region has also recently been produced (FAO 1998a). Rather than dwelling too intently on market forecasts, which are vulnerable to macroeconomic shifts (such as those recently experienced in Asia), these new studies focus more on the likely policy implications of forest product market developments. The following text briefly describes the main market developments that are expected in the future and discusses the implications of these developments within the context of sustainable forest management.

Future Forest Product Production and Consumption by Region

The current and projected level of wood production and consumption in 1996 and 2010 is shown by region in Figure 6. From 1996 to 2010, global industrial forest product production and consumption are projected to increase at an annual rate of about 1.7%, from 1,490 10^6 to 1,870 10^6 m^3. Thus in 2010, output will be about one-quarter higher than it is at present. It will, however, only be about 10% higher than the peak in production (1,700 10^6 m^3) around 1990. Growth will vary between regions, with Asia and Oceania likely to show the highest rates of expansion. Slow growth in consumption is expected for Africa and South America, and slow growth in both consumption and production is expected for North and Central America. North and Central America will, however, remain by far the largest producing and exporting region in the world. Europe, Asia, and North and Central America will account for about 85% of production and more than 90% of consumption in 2010 (roughly the same share as in 1996). However, within this group, it is expected that during this period of growth, a small share (about 5%) of global consumption will shift from North and Central America to Asia.

Future Forest Product Production and Consumption by Product Category

Current estimates and future forecasts of global forest product production and consumption by product category are shown in Table 1. As in the past, the market for paper and paperboard is expected to have the most rapid growth, at an annual rate of 2.4%. In contrast, production of pulp for paper is expected to grow by only 1.1% per year, reflecting an expected increase in the recycling of recovered paper in the total fiber furnish in the future. Moderate growth is expected in solid wood product consumption, at annual rates of 1.1% for sawn wood and 1.3% for wood-based panels. Most of the growth in the production and consumption of wood-based panels is expected in the reconstituted wood panels sector rather than the plywood sector.

Forecast Wood and Fiber Production Compared with Production Potential

A comparison of projected roundwood production levels in the Asia and the Pacific region with production (or estimated biological) potential shows that, in general, future wood demand could easily be met within the region. In certain countries and for certain types of wood (e.g., sawlogs), however, supplies are going to become increasingly scarce in the future.

FAO does not yet have sufficient data to make an accurate assessment of the production potential for the whole world. The Global Fiber Supply Model (GSFM), for example, covers a large part of the world but excludes the important contribution of trees outside forests. However, GFSM can be used to compare projected levels of production (Fig. 6) with supply potential from the forest and from recovered and nonwood fiber sources across some regions (Table 2).

As Table 2 shows, forecast production levels are well within the projected limits of production potential in South America and Oceania but approach the limit in Asia and exceed it in Africa. The results of the fifth European Timber Trends Study (Joint ECA/FAO Agriculture and Timber Division 1996) suggest that Europe should also have adequate wood supplies to meet production requirements in the near term. However, two points are worth noting. First, the GFSM projections should be considered as the absolute maximum amounts. The cost of accessing increasingly marginal areas, which are included in the GFSM analysis, may prevent the total potential supply presented in Table 2 from being realized in the near future. Second, it should be remembered that, while supplies may be plentiful at the broad regional or country level, there may continue to be local scarcity, which could put forestry policy makers under pressure to release natural forest resources for timber harvesting.

Figure 6— Forecast industrial roundwood production and product consumption in 1996 and 2010 (From FAO 1999).

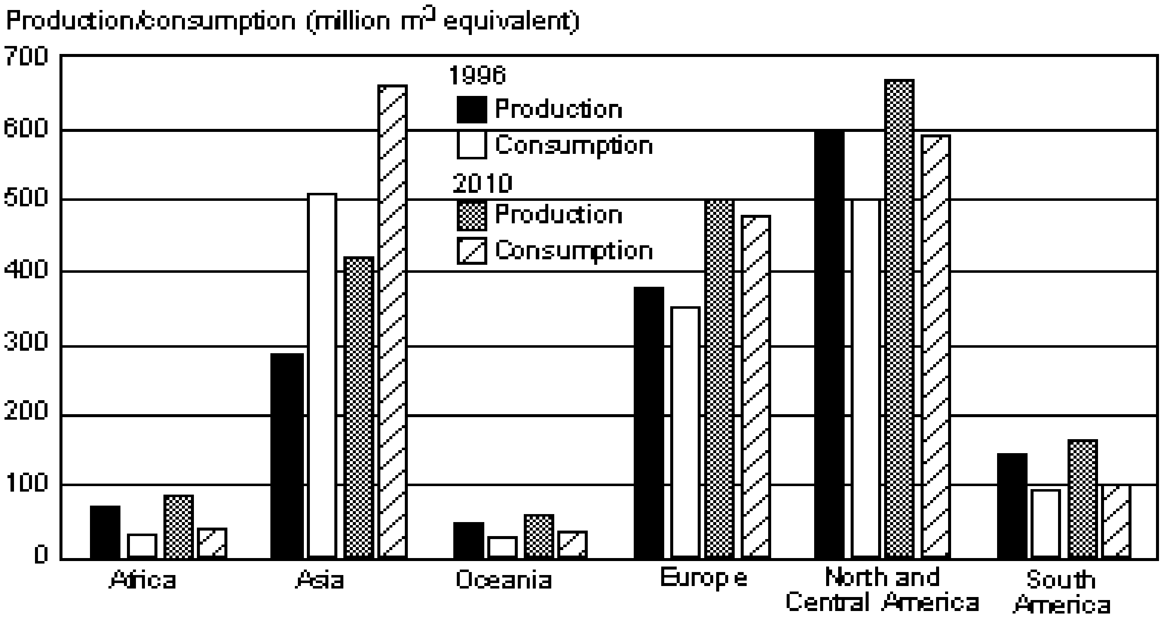


Table 1—Current and forecast global forest production/consumption by product category, 1996 and 2010[a]

Product	Production/consumption 1996	2010	Total growth 1996–2010 %	Annual growth 1996–2010 %
Industrial roundwood (million m^3)	1,490	1,872	26	1.7
Sawnwood (million m^3)	430	501	17	1.1
Wood-based panels (million m^3)	149	180	20	1.3
Pulp (million tones)	179	208	16	1.1
Paper and paperboard (million tones)	284	394	39	2.4

In regions such as Africa and Asia, where supplies (particularly of large logs) from forests are coming under pressure, consumers of wood and fiber will increasingly have to look to other sources to meet the demand (as they already do in Asia) if they do not wish to overexploit their forests. Another, perhaps more likely, alternative is that the markets for forest products will continue to move in the direction of substitution of other wood-based panels and engineered wood products for sawn wood and plywood. Wood-based panels and engineered products can be manufactured from small-sized wood or nonwood substitutes.

In summary, the supply and demand analysis carried out by FAO suggests that the capacity of the forest and other sources of fiber will be sufficient to meet demand for the near future. However, the situation will vary among countries and regions. Africa and South Asia will continue to need to use a wide range of nonforest supply sources to meet their consumption demands. The demand for higher quality sawlogs will also approach or even exceed the production capacity of forests and plantations in Africa, Southeast Asia, and the Pacific Islands.

Table 2— Forecast production potential from forests and recovered and nonwood fibre sources and forecast production of wood and fibre in 2010 (million m^3 equivalent)[a]

	Forecast production in 2010			
Region	Industrial roundwood	Recovered and nonwood fibre	Total	Total potential fibre availability in 2010[b]
Africa	84	2	86	81
Asia	421	222	643	729
Oceania	54	0	54	80
Europe	502	133	632	893
North and Central America	658	147	805	835
South America	153	2	155	225
World total	1,872	506	2,375	2,843

[a]From FAO 1999. [b]From GFSM (FAO, 1998a) or official government estimates.

However, it is expected that product prices will not rise significantly during the projection period. Many of the world's regions have ample or excess wood product manufacturing capacity. The current worldwide economic slowdown has further mitigated pressure on consumer prices for the time being. In selected cases, there may be upward pressure on the prices of certain types of roundwood (typically the higher grades), but price increases will be restrained by the availability of lower value wood and nonwood substitutes. Trading patterns are not expected to change significantly, apart from the continuing trend toward more in-country processing of wood raw materials. This should lead to less trade in semiprocessed and commodity-grade wood products and more trade in higher value products.

Possible Future Market Developments

Wood Supply

The sources of wood and other fibers used in production are likely to change in the future. It is expected that in most countries, there will be a move away from the use of forest resources for wood and fiber production and towards a greater reliance on other sources of supply. The greatest change by far will be the increased use of wood processing residues and recycled fibers in the product input mix. The use of such secondary sources is likely to continue to expand in the more developed parts of North America, Europe, and Asia, while trees outside forests are likely to have an increasingly important role as forest resources decline in some of the less developed regions of the world.

Within the forest, supply patterns are also likely to change in the future. The next decade or so will see large areas of commercial short-rotation plantations (for pulpwood) become available in the southern hemisphere. Greater areas of older plantations established for the production of sawlogs will also start to be harvested in countries such as Australia, Chile, New Zealand, South Africa, the United Kingdom, and the United States. These plantations will provide the greatest share of the expanded wood production potential expected in the future. In contrast, very few countries are likely to be able to expand production sustainably from the natural forest without considerable investment in silviculture.

Greater areas of natural forest are likely to be legally protected. Many of the areas that are likely to be chosen for preservation are not currently harvested and are considered unexploitable for economic reasons (physical constraints, transport limitations, low timber value). A decrease in harvesting intensities in the exploitable natural forest would have a greater impact on future supply potential than would an increase in the amount of legally protected forests.

Technological Change

Technological change has been incorporated in this supply and demand analysis only in the pulp and paper sector, where it has been assumed that current trends in the use of recovered paper in the total fiber furnish will continue in the future. For example, 1 ton of paper and paperboard in 1970 was made up of more than 80% wood pulp. By 1997, this figure had dropped to 56%, and by 2010, it is expected to fall to below 50%. This trend is partly a result of the increased use of recovered paper but is also a result of shifts in market shares, whereby the proportion of printing and writing papers (which have a lower fiber content) in the overall market has increased and is expected to continue to do so.

Other technological changes that are not included in the model may also occur in the future. First, improvements in harvesting practices could increase log recovery and reduce logging residues in many of the world's forests. Many developing countries have substantial room to increase their log recovery rates. Even a modest increase in log recovery rates in countries with high annual felling levels could increase production and contribute significantly to meeting the projected growth in industrial roundwood demand.

More efficient conversion and use of mill residues and better mill recovery rates have significant effects by reducing the amount of roundwood required to manufacture products. In addition, residues could be used more effectively to meet the demands of other wood processors. Not much is currently known about the utilization of mill residues outside a few of the large developed countries. However, it is suspected that large volumes of residues are wasted or left unused. As FAO (1998a) has shown, all of these sources could make a significant contribution to wood supply.

A third technological change that might occur is a move towards greater use of reconstituted panels because of two factors: upward price pressure resulting from the increasing scarcity of large-diameter logs and technological developments in construction and other wood-using industries, which would allow the use of such products where only plywood or sawn wood are currently used. This shift will also have the effect of extending the use of resources (recovery rates for reconstituted panels are typically higher than for sawn wood and plywood) as well as providing a ready market for residues from other industries.

Technological developments in wood processing continue to keep pace with market, environmental, and raw material resource trends. The increased production of reconstituted panels such as oriented strandboard and medium-density fiberboard and developments in the manufacturing of engineered wood products will continue to increase the efficiency of using more diverse raw materials. Engineered wood products increase opportunities for using small-diameter logs of lower quality and less-used species. The use of microprocessors in almost every step of the production cycle increases product quality and minimizes the amount of residues generated. Much of the technological development in wood processing is currently concentrated in industrialized countries, and the extent to which the technologies are used in nonindustrialized countries is not known. Wider adoption of current technologies and development of new ones that increase processing efficiency could help slow the increasing demand for raw materials to supply finished wood-based products.

Use of the Changing Wood Resource

Tomorrow's wood product manufacturers will face a distinctly different resource than that available today. The character of the wood supply varies with the forest management regime. Plantation-grown trees are likely to be single species, even age, even size class, relatively uniform, and genetically improved. Trees produced under sustainable forestry principles are likely to be more diverse—of mixed species, uneven aged, and mixed size classification. As the concepts of sustainable forestry and sustainable development move into practice, industry will most likely find itself needing to utilize a much more diverse raw material supply than it has in the past. In contrast, industrial processes and products usually benefit from a uniform, stable raw material supply because they can be optimized more readily. In addition, product variability is generally reduced and processes are more stable with a uniform supply. With a more diverse raw material supply, new technologies will be needed to overcome the problems of product and process variation. Today, technologies such as composite products, nondestructive evaluation, mechanical grading systems, and engineered wood products play an increasingly important role in adapting to a changing timber resource.

Composite technologies are generally more flexible in type and quality of material used than are solid lumber wood products. One composite experiencing remarkable growth is oriented strandboard (OSB), a product made from wood particles aligned to obtain the best engineered properties. OSB is being used as a replacement for plywood because of the difficulty of getting veneer-grade logs and because it can be made from a variety of tree species and size classes. OSB now represents more than 25% of the structural panel market, and the demand continues to grow. The raw materials for many OSB manufacturing plants in North America are underutilized species like aspen and yellow-poplar.

Another technology that has allowed the use of different tree species and size classes is nondestructive evaluation (NDE) technology. NDE can be used to determine the stiffness and strength of individual pieces of lumber, reducing dependence on visual grades (which are species dependent) in favor of mechanical grading (which is species independent). Mechanical grading can allow a wider range of species to be substituted for structural applications, as long as certain stiffness and strength requirements are achieved. Mechanical grading uses static bending techniques, vibration techniques, or stress waves to determine stiffness. Research has demonstrated a direct relationship between the bending stiffness of lumber and its bending strength. The only way to determine the actual bending strength of a board is to break it. Since that is not practical, the next best available method is to measure the board's stiffness, compute the modulus of elasticity, and then predict the bending strength. Such procedures produce a mechanically graded lumber that is accepted by regulatory agencies and all major building codes, provided that production follows approved grading agency certification and quality control procedures.

Meeting the Challenge

Forests are being squeezed between expanding needs and a shrinking resource base. The pressure being placed on the resource also pushes technological developments to help divert those pressures. Historically, technology has aided conservation by making more efficient use of resources. That trend will need to accelerate to meet the challenges of today and tomorrow. Key areas for research and development are use of the changing wood resource, extension of the resource, and environmentally friendly technologies.

Sustainable development must be based on the interdependence of the environment and the economy. Wood technology is essential to this integration. Some specific areas for research and development include

determining new, more efficient, and environmentally friendly ways to extract, reduce, and convert virgin wood raw materials to useful products,

developing technologies to allow the re-use of materials and products to the maximum extent possible,

making sure that the latest technologies for extracting, reducing, converting, using, and re-using wood raw materials are transferred to developing nations as quickly as possible,

developing methods to ensure that renewable resources of all kinds, e.g., wood and agricultural crop residues, are converted to value-added uses like advanced consumer and engineered wood products, and

developing technologies that do not produce harmful by-products during the manufacture of wood products.

This list represents just a few of the areas that hold promise for advancing wood utilization activities to meet the needs of society while keeping a well-tuned balance between the ecological, economic, and social aspects of sustainable forest management.

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Principles of Timber Harvest Planning

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Abstract

The purpose of timber harvest planning is to anticipate the future in a systematic way and threby reduce uncertainty. Numerous techniques have been proposed for ensuring sustainable timber yields and for evaluating alternative scenarios of forest development. Some of the techniques are limited to applications in simple forest production systems while others are suitable for any type of forest management, including selective harvesting systems. An important aspect of sustainable forest management is risk analysis which involves the evaluation of potential hazards for a given forest area and reference period.

Keywords: Risk analysis, Continuous cover forest.

Types of Forest Management

According to the statistics issued by FAO (1997) the world forest area in 1995 amounted to about 3.4 billion ha. The biggest share of this area is situated in South America and within the borders of the former Soviet Union, with over 800 mill. ha in each region. Forest areas of well above 500 mill. ha are found in each of the three important forestry regions Asia (including East South Asia), Northern and Central America and Africa. The forests in Europe, described in greater detail by Kuusela (1994), cover an area of about 146 mill. ha.

Comprehensive forest area statistics have been made available for some time, but very little is known about the distribution of forest management types. A traditional view of a managed forest is that its development follows a perpetual series of growth cycles which are defined by the rotation. A cycle begins with the establishment of the young trees and ends with the harvest of the mature ones. Intermediate thinnings may improve the value of the final crop. Productivity is measured in terms of the total volume produced, or the mean annual increment at rotation age (MAI_R). Sustained yield control is based on the model of the *Normal Forest*, and the present value of a specified silvicultural program is equal to the sum of the annual net incomes, discounted to the age of establishment[1]. The forest area is not continuously covered by trees and we may thus refer to such a forest as a *rotation management forest* (*RMF)*. Rotation systems with fast-growing timber species and intensive silviculture are found in the Southern hemisphere (Chile, South Africa, Australia, New Zealand), in the South-Eastern United States, in many parts of Asia and in some European regions. The management of plantation forests is comparable to that in agricultural production systems with short rotations, intensive pruning and thinning, fertilizer application, use of clonal seedlings, integrated timber processing plants and sophisticated information technology (Fig. 1).

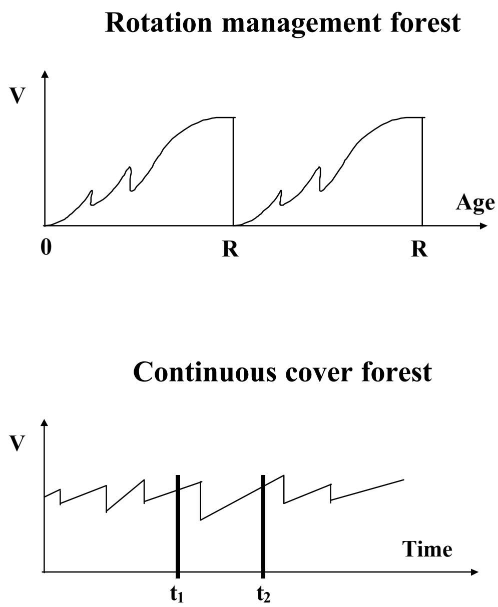
A second type of management which we may call *continuous cover forest* (*CCF*) is not uncommon in tropical regions and in Central Europe, where its importance and prevalence are currently increasing[2]. This type is characterized by selective harvesting of individual trees and for this reason the silviculture is appropriately known as *forest gardening*[3]. Forest development has no beginning or end. The forest remains in a state of undefined age, oscillating about a specified level of growing stock. Harvesting operations may take place at regular intervals and the distinction between thinnings and final harvests is not clearcut. Age-based measures of forest production and valuation, such as mean annual increment or age-based net present value, cannot be used and new simulation techniques for generating forest development

[1] for details concerning the economic criteria refer for example to Clutter *et al*. (1983) and Chang (1998).
[2] large areas which might be classified as *CCF* are not managed in a systematic way. Timber may be cut for construction or fuel, shifting cultivation and wildfires may be common and timber volumes are declining because no efforts are made to regenerate exploited forest areas.
[3] a translation of the French *jardinage*.

paths are required for evaluating future scenarios.

Examples of this type are the so-called *Plenter* forests found in France, Switzerland, Slowenia and Germany, some forests in the *Northern Hardwood* region of North America and the famous *Knysna* forests of South Africa. Low intensity systems of forest management are usually found in regions controlled by timber processing companies requiring more or less regular raw material supplies and large timber reservoirs are found in the coniferous forests of the boreal region and in the evergreen multi-species forests of the tropical and subtropical regions.

Figure 1. A rotation forest develops through a succession of growth cycles defined by a rotation (left). Age and rotation are undefined in a continuous cover forest and the growing stock oscillates about some desired level (right).



Sustainable Harvest Control

To sucessfully maintain an industry based on timber products, forest planning must ensure that there are always stands at the right stage of development and in sufficient number to yield the desired product mix coming from the forest. This problem has been addressed using a variety of methods. Some of the techniques are limited to the use in even-aged forests while others are suitable for any type of forest management.

Scenario Methods Suitable for Regional Resource Forecasting

Harvest planning is based on techniques which define a sustainable harvest on the basis of available growing stock volumes and growth rates. Quite useful, though not very sophisticated, are scenario methods based on age class simulation. The algorithm presented in Fig. 2, for example, may be used to simulate the effect of a given harvest level on the development of the age class distribution of a regional timber resource.

Obviously, the method involves considerable aggregation over growing sites, forest types and management regimes, and the predictions have to be interpreted with the necessary caution. However, an age-class simulation is often the only feasible way to predict the dynamic development of a forest resource for large timber growing regions.

Another highly aggregated approach involves the use of *area change models* which predict transitions of forest age class vectors through time. These methods have been used especially in Japan (Konohira and Amano 1986) and to a limited extent in Europe (Kurth *et al.* 1987; Kouba 1989). One of the most prominent applications is Suzuki's *Gentan* model which predicts the transition of a given age class vector through time (Suzuki 1971; Blandon 1985). The transition probabilities are not independent of the age class vector and this seems to be one of the problems associated with the use of area change models (Randall and Gadow 1990).

Planning Methods Suitable for CCF Systems

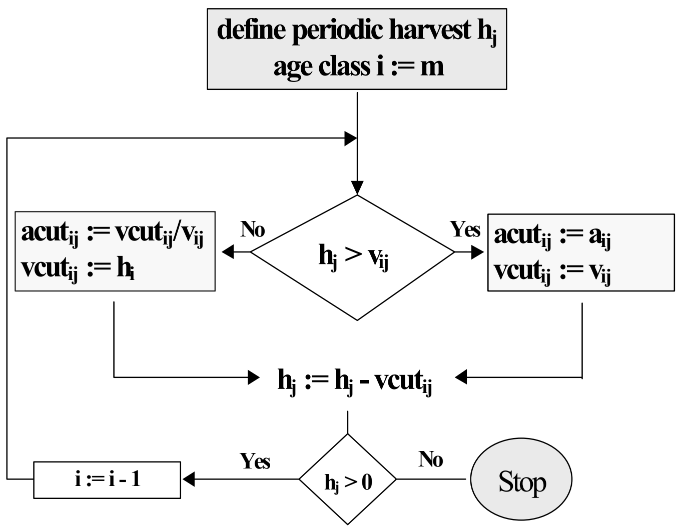
Various techniques have been devised for controlling sustainable harvests in continuous cover management systems. To ensure sustained production levels, a common method involves regular visits to a given area, recurring at discrete time intervals, and to harvest any accumulated surplus growing stock at each visit. Assuming a cycle of n years it is possible to map the progression of harvest locations and the change of the state-space distribution of forest states after each time step. The optimum state may be defined on the basis of a desirable diameter distribution after harvest (Susmel 1980, Virgilietti and Buorgiorno 1997) or a desirable basal area distribution after harvest (Hansen 1987; Gadow and Bredenkamp 1990, p. 111 et sqq, Seydack *et al*. 1995).

Sustainable management of a continuous cover forest may imply maximizing volume or value production while maintaining the forest in a steady state. The theoretical basis for this process is given by a linear transition matrix approach which assumes that each tree in a finite number of size classes has a known probability of moving to another class, which depends only upon its current size. During a given time step a tree may either remain in its class, grow into a higher class or die. The objective of an optimization model may be to maximize the total harvested volume, or timber value, during each cutting period while satisfying the equalities and inequalities derived from the transition matrix and specific steady state conditions (Buongiorno and Michie 1980; Rautiainen 1999).

Planning Methods Suitable for Any Management System

A managed forest typically consists of a discrete number of geographical units known as compartments. Each compartment develops over time in response to forestry operations such as plantings, prunings or removals of varying type and intensity. If appropriate tools are available, specific treatment schedules can be generated for a given compartment. A scenario of forest development represents a specific combination of treatment schedules for the different compartments within a specified forest area.

Figure 2. Algorithm for age-class simulation with flowchart (left) and abbreviated pseudocode (right). a_{ij}=forest area available in age class i (i=1..m) and period j (j=1..n); v_{ij}=timber volume available in age class i and period j; $vcut_{ij}$=timber volume harvested in age class i and period j (m^3); $acut_{ij}$=harvested area in age class i and period j (ha); h_j =specified harvest volume for period j (m^3).



For each harvest period *j*, do:
For each age class *i*, starting with the oldest one, and while h_j>0, do:

a) Calculate the available growing stock volume v_{ij} ;
b) if h_j v_{ij}, then harvest the entire growing stock available in age class *i*; else harvest only h_j m^3;
c) *subtract the volume harvested from* h_j

A scenario model thus embraces all the possible treatment schedules for all the compartments within the forest. The aim of forest management is to find the optimum combination of treatment schedules over all compartments. Various techniques have been developed to achieve this objective. The most popular method is constrained optimization which has been used for about three decades, after the basic structure was developed by Ware and Clutter (1971) which later became known as the Model I

In practice, the different silvicultural regimes are mutually exclusive. Only one regime per stand is possible. This limitation cannot be imposed in the Model I formulation, unless an integer solution is sought which would be prohibitive in terms of computer time. Various solutions have been offered to overcome the shortcomings of LP in timber harvest scheduling[4].

Risk Analysis

There is a wealth of harvest control techniques for calculating sustainable harvest levels, but a shortage of methods for evaluating sustainability under risk. *Risk* has been defined as the expected loss due to a particular hazard for a given area and reference period (United Nations 1992). An *expected loss* (*r)* is the product of the *damage* (*s)* expressed in monetary terms and its *probability* (*p*). *Risk assessment* is a formal procedure for quantifying risk with regard to the damage potential including all the possible threats within a given hazard domain. An example is the *hazard chain* in a spruce forest, presented in Fig. 3. A *risk evaluation* is concerned with the economic evaluation of potential threats and benefits while *risk management* includes specific strategies and actions for reducing risk (Hollenstein 1997).

A potential hazard presents a risk if it occurs with a probability greater than zero and if its occurrence will cause damage to a valuable object. The probability of occurrence of a given hazard factor may be defined by a probability distribution depicting the frequency of certain events on the basis of previous observations. Kouba (1989), for example, used the Weibull function for modelling spruce forest survival, assuming a variety of hazards and their cumulative effect.

$$\max Z = \sum_{i=1}^{I} \sum_{j=1}^{J_i} c_{ij} X_{ij}$$

subject to

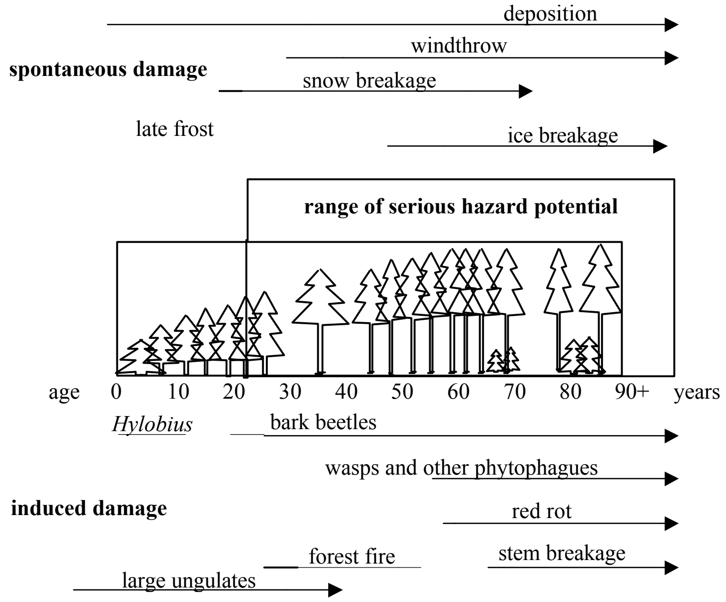
$$\sum_{i=1}^{I} \sum_{j=1}^{J_i} a_{ijpt} X_{ij} \le M_{pt}, \quad \forall p,t$$

$$\sum_{j=1}^{J_i} X_{ij} = A_i, \quad \forall i \text{ and } X_{ij} \ge 0$$

where

I=	number of compartments
J_i=	number of treatment schedules for compartment i (i=1..I)
X_{ij}=	area of compartment i managed according to treatment schedule j (ha; j=1..J_i)
a_{ijpt}=	amount of item p produced or consumed per ha in period t
M_{pt}=	total amount of item p produced or consumed in period t
A_i=	area of compartment i

Figure 3. Example of a hazard chain, - the potential hazards during the life of a spruce forest (Otto, 1994).



Discussion

The classical models of forest development are based on scenarios that evaluate alternative timber harvesting strategies and their effect on the future development of the resource. Harvest scheduling has always been a central issue in forest management, but harvest scenarios do not necessarily produce feasible plans. Felling volumes are often specified and, by some magic, assumed to be available at the prescribed time. To ensure that forest management scenarios are feasible, greater emphasis needs to be placed on models that predict potential hazards.

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Sustainable Production of Forest Products in the Humid Tropics of Southeast Asia: Latest Developments

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Abstract

A few Southeast Asian countries, particularly those from the everwet region like Indonesia and Malaysia that are endowed with timber-rich dipterocarp forests, dominate the international tropical timber trade. Many of these countries are quite dependent on the timber revenues, and so managing these natural resources on a sustainable basis is of high national importance. In this brief review, the state of forest management and product development in the region is given.

Attempts at sustainable management of natural forests have had a long but variable history in the region. The management systems were based on systems developed in European forests and subsequently tested in India and Burma. In the early part of the century the demand for timber was mainly domestic, and only the heavy and durable hardwoods were exploited. Management systems were developed to improve the poles, and subsequently the young regeneration of such species. With development of preservatives and mechanization of saw-milling, the number of species that can be utilized expanded, and the need to harvest large volumes in a unit area increased. A well renowned uniform tropical silvicultural system was developed to manage these timber-rich forests. Today, most of these forests have been exploited or converted to agricultural use. Forestry was relegated to the hills which are poorer in timber, and management problems more complex. Selective felling systems based on diameter limits became standard practice throughout the region. However, heavy logging damage to the residuals makes the system bicyclic instead of being sustainable. This, and concern for loss of these species rich ecosystems has brought about new ideas in management of tropical forests. There has been a departure from the concentration on yield management to practices that are holistic, and which encompass concern for biodiversity, socio-economic issues, environmental protection, etc. Today, foresters in the region are grappling with certification matters, "green timber" issues, carbon sequestration, minor forest products, and benefits to forest dwellers. The future of natural forest management would probably give less emphasis to timber production.

With the forecast that natural forests will play a lesser role in timber production, interest in plantations has grown in recent years. While there has been a long history of plantation trials, few successful models exist in the everwet region of Southeast Asia. Earlier attempts to produce fast growing exotic hardwoods for general utility timber saw massive failures. But small pockets of successes do exist and are now being expanded. There has been a swing in favor of planting indigenous species and mixtures of such species, out of consideration for biodiversity and pest problems in plantations. Research into high yielding clones, mass propagation using biotechnology, appropriate silvicultural practices, etc. are paving the way rapidly. All these spell a bright future for timber plantations in the region. In the next decade or so, the dream of capturing the high productivity in the everwet tropics may be fulfilled.

Product development is critical in furthering the effort towards achieving sustainability of resources. This area too has progressed with great strides and bounds since the beginning of the century. From utilizing a narrow group of highly durable heavy hardwoods, research in preservation techniques have made the majority of the big trees in the forests potentially usable. This saw the utilization swing from a handful of species at the beginning of the century to almost

300 species at the end of it. Other improvements in technology too have totally changed the processing and utilization of wood. Development of panel products, utilization of wood waste, developing technology with low environmental impact, laminating technology, etc. have resulted in better utilization of wood resources, leading to reduction in resource demands, and sustainability of the resource.

Keywords: Humid tropics, Sustainable production, Natural forest, Plantation forest, Forest products

Introduction

Sustainable production of tropical forests is no longer a subject of concern for foresters. The continued perpetuation of these forests has become an international issue, and is a much-debated subject these days. Well above that, sustaining the many benefits of tropical forests is a matter of survival for the millions of people in the tropics. In this respect, perhaps the issues and problems of management of the humid forests of Southeast Asia deserve a separate treatment of their own. This is because the tropical rain forests of the region are unique in several respects. Firstly, the timber-rich family Dipterocarpaceae dominates the region's humid forests. It therefore comes as no surprise that this region is the biggest player in the export of tropical timber in the world market. Easily 75% of the tropical hardwood logs traded in the world markets originate from the region (Nectoux et al. 1991). Next, the rate of deforestation is a shade higher in the region than that observed in the American and African tropics. Some of these forests are indeed among the richest in terms of biodiversity, and so their conservation is of a very high priority. Besides all the above, some important forest management practices were initiated in the region, and they hold a special place in the development of tropical forestry globally.

Which are the humid forests of Southeast Asia? The perhumid forests of the region are centered in the Malay archipelago, that include Sumatra, Peninsular Malaysia, Borneo Island, most of Sulawesi and the Philippines. The rain forests also penetrate into continental Asia, where they occur in the wetter and less seasonal parts of Myanmar, Thailand, Cambodia, Laos and Vietnam. All these areas enjoy a wet climate, with no regular dry season, or of only a few months' duration. In areas with longer annual dry season, tropical seasonal or monsoon forests occur.

Having recognized that many of the countries in the region are quite dependent of forest produce both as a source of foreign exchange as well as for survival, it is critical that the forest produce is managed on a sustainable basis. Besides management of natural forests, there is also the issue of plantations. For a long while, it has been argued that with such good growing climates, plantations would provide a superior means to supply timber for the overgrown timber industry. Their sustainable management is another equally important factor for the economic well being of this region. The same would also apply to the downstream industries, which provide considerable amount of employment opportunities for a large percentage of the people in the region.

Considering the above it is important to look at the issues of sustainable production of the natural forests, plantations and the industries in the region. However, treating a region as diverse as Southeast Asia may not be easily amenable for the present. With such enormous differences in the history of management, economic development, land-use patterns, and population demography, it will be no where possible to review all the issues thoroughly. What we have therefore adopted is to provide some of the important developments in the three areas, and use them as means to generalize for the development overall in the region. These models are applicable for many parts of the region, and they may be used for further developing the forest resources in each of the countries in Southeast Asia.

Sustainable Production in Natural Forests:

Certification

The byword in forest management these days is achieving Certification. This is a market movement whereby consumers are demanding that forests be managed on a sustainable basis before the products are sold. For attaining sustainable management, several international (e.g. ITTO Year 2000 Objective) and non-governmental agencies (e.g. Forest Stewardship Council's C&I) have promulgated a set of guiding rules, called Criteria and Indicators against which the forest management will be evaluated. These Criteria and Indicators represent a holistic approach, and takes into consideration aspects of forest management that include continuity of production, environmental protection, conservation of flora and fauna, and socio-economic benefits.

Reduced Impact Logging

To meet these stringent requirements for Certification, a number of forest management practices have to be improved. One of the first moves in the last decade in this direction was introduction of the practice now called Reduced Impact Logging. The issue to be addressed is logging damage. Heavy skidder-crawler tractor machines are used to harvest timbers. These machines, when used without supervision, cause enormous damage to the young regeneration, older residuals and the soils. Furthermore, many of the standing residuals become injured, and they succumb to the wounds and this mortality may persist for almost two decades following logging. Overall, as a consequence of using such damaging harvesting machinery, the negative impacts are numerous, and include:

- the second and future crops are heavily destroyed;
- soil damage is extensive and area for forest regrowth declines;
- erosion increases by many folds, waterways become silted, freshwater sources are destroyed;
- biodiversity, both flora and fauna decline.

Research in Kalimantan, Sabah and Peninsula Malaysia has come up with reduced impact logging techniques. Basically it involves logging guidelines for implementing good management practices, which include specifications for pre-harvest planning, vine cutting, felling, skidding, and post-harvest site closure. Pre-harvest planning entails preparation of 100% stock map of harvestable timber, including streams, road buzzer zones and sensitive areas. Roads and skid trails are located on ridges to avoid steep grades, facilitate uphill skidding, and minimize skidding distances. The positions of roads and skid trails are preplanned, so that only the least minimum is required for extracting timber. Directional felling of trees was employed to minimize damage to residuals. Further, the bulldozer skidding was limited to slopes of less than 35° only, blading of skid trails was restricted, and the practice of balding off of surface soil and sidecutting were controlled. As a result of all these strict guidelines, the damage to the forest was considerably reduced (Table 1).

The improvements to existing practices have resulted in considerable reduction in damage to the residuals and the environment. Today, for achieving forest management certification, RIL practices are obligatory. The additional costs for implementing RIL is calculated at US$ 4.50/m^3, about 10-15% increase over normal direct costs of harvesting and delivering logs to the log pond. But the indirect savings of lowered environmental impact, less loss of biodiversity, lower loss of soil nutrients, better future crops, etc. may far exceed the small additional costs incurred for practicing RIL.

Table 1. A comparison of damage resulting from conventional and reduced impact logging.

Effects	Conventional Logging	RIL
Proportion of area with soil damage	0.17	0.07
Skid trail density (m/ha)	199	67
% skid trails with subsoils exposed	87	38
Proportion of trees killed during logging	0.41	0.15
Density of undamaged seedlings (5-20 cm dbh)	49	104
Residual stand damage (%)		
Seedlings	33	18
Saplings	35	20
Poles and trees	40	19
Tree damage based on injury (%)		
Light	12	7
Heavy	29	12
Opened area (%)		
Caused by felling	11	8
Caused by skidding	9	5

Improved Harvesting Techniques

While the practice of RIL is a major development, it is merely an improvement and better implementation of existing practices. There are several researchers in the region who are looking at improving the harvesting techniques. Three improvements to the skidder-tractor systems are being tested. They are the helicopter system, mobile skyline yarder, and the long haulage ground cable system. Helicopter logging trials have been conducted in Sarawak. A heavy lift helicopter was used by Samling Sendirian Berhad to harvest dipterocarp forests (FAO 1999). The Boeing Chinook helicopter with a load carrying capacity of 12,700 kg was used. This translates into an annual extraction capacity of about 250,000 me, but in actual production it was about 100,000 m^3. The average payload for each trip to a landing was 5.8 m^3, and a typical tree produced a payload of about 7 m^3. It could yard up to 5 km, but the average extraction distance was 2 km. The damage to residual trees is limited to what occurs during felling, and soil damage is almost non-existent. The logging costs using helicopters ranged from US$60 – 70 per m^3, compared to about half using crawler-tractor systems. Besides this, the helicopter system has several other limitations:

i) because of its high costs, extraction of only a few valuable species is possible;

ii) maintenance and logistical problems are enormous to overcome under tropical conditions;

iii) the timbers cause too much torque, and spin a lot, resulting in their ejection often;

iv) the system allows free ranging, and theft outside the compartment cannot be controlled; and

v) the risk of accidents is too high, and it is becoming difficult to obtain insurance policies for such operations.

Similar conclusions were made from helicopter logging trial in Papua New Guinea (Blakeney 1994). Cheaper low impact logging systems are currently being investigated in Peninsular Malaysia. They include the Mobile Skyline Yarder (Sasaki et al. 1999) and the Long Haulage Ground Cable System (LHGCS) (Shamsudin et al. 1999). The LHCGS is a combination of a metal-fiber glass skidding cone attached to the front of a log, which is then hauled to the main road using a cable operated by a tractor. The system does not allow the tractor to free range in the forest. The cone allows logs to move over the ground unhindered by other logs, stumps, rock, or other obstructions. Practically no damage is caused to the soil, and damage to trees is only limited to a narrow corridor about 2 m wide from the valley to the main road. Both the low impact harvesting systems are being improved and their productivity is being improved. These systems are obviously much cheaper, and a small to medium-sized concessionaire can cheaply and easily operate the LHGCS. The technology is low-end and can be easily acquired as well. Overall, these systems offer the best promise as harvesting systems for tropical forests. If Certification is ever to be achieved, it seems like these systems have to be incorporated in all forest harvestings. Modifications of the systems can also be employed in plantations.

Nutrient Losses and Harvesting Cycles

The damage to the soil, in terms of soil erosion, water quality and nutrient dynamics has been extensively investigated (Zulkifli et al. 1998). Controlled selective logging experiments indicate 2-fold increases in the exports of Ca and Mg and 3-fold increase for K. The losses from timber extraction of 40 m^3/ha for Ca, Mg and K are 115, 13 and 44 kg/ha, respectively (Nykvist 1994). The recovery rates as a result of atmospheric and weathering inputs appear to be 35-90 years for Mg, 20-35 years for Ca, and 10-50 years for K. Under these circumstances, the estimate of a 30-35 year cutting cycle for dipterocarp forests appears rather too short. A more conservative one would be closer to 55 years for selective felling. However, if the improved harvesting systems become ubiquitous, then a 35-year cutting cycle may become a possibility.

Enrichment Planting

Enrichment planting has become a standard silvicultural practice to ensure regeneration poor sites are restocked with valuable timber species. Besides this, large tracts of logged forests are completely degraded – soils are compacted and/or highly eroded, with practically no tree vegetation able to colonize such sites. Such areas can measure up to 40-50% of a logged site. Fires have become frequent occurrences, and the areas that need rehabilitation planting are increasing. Vast sums of money are expended to restock the poorer forests, and rehabilitate the degraded sites. Enrichment planting has become the standard practice. However, in the majority of cases, the performance of enrichment plantings has been dismal to downright disasters. The problems are mainly due to the following:

i) the forest canopy closes too fast, and the plants stop growth, and eventually fade away;

ii) the sites are too compacted, and the root systems are not able to penetrate deep enough to receive adequate water and nutrients;

iii) heavily eroded sites are nutrient-poor, making growth difficult;

iv) the species chosen is unsuitable for such planting conditions; and

v) occasional drought spells wipe out the weakened seedlings.

New methods are being tested in Peninsular Malaysia, which appear quite promising (Raja Barizan *et al*. 1998). Tall seedlings/saplings of 1–2 m in height were used instead of the conventional seedlings which measure only about 10 cm in height. The tall seedlings, although more expensive both to raise and plant, have an advantage over the fast growing pioneer vegetation and climbers that proliferate in the forest immediately upon logging. The tall seedlings are able to out-compete the weeds, minimizing additional revisits and treatment costs. Where the soils are completed eroded or compacted, big planting holes, 1 x 1 x 1 m are made. This is done using a mechanical augur mounted on a small tractor. The soils are loosened before the planting is done, and fertilizer is added. First of all, the big holes allow deep root penetration, and this boosts the overall early growth of the plant. Such big holes contain a lot of moisture, which can sustain the plant during an unexpected drought. Finally, wild boars were a big nuisance to the seedlings, and many were bitten or pushed over. This was overcome by placing a barbed wire tower built around the base of the tree. All these measures have given meaning and success to the much-maligned enrichment-planting programme.

Village Model Forests

Forest dwelling communities are usually left out of the logging concessions, and the profits derived from such activities do not reach them.

Under these circumstances there was no compelling desire on the part of forest denizens to retain the forest, and quite often they converted them for agriculture. Realizing this, there have been moves in several Southeast Asian countries to introduce community forest management systems whereby the profits from logging accrue to the villagers. One such trial in Laos has developed a scheme to develop such a village forestry concept (Bonita 1997). Under the scheme a village forestry association was formed, and each village of about a hundred households is given about 2,000 ha to manage. They operate on a 5-year cutting cycle, removing only 1 – 2 trees/ha (Table 2). Heavy machinery are avoided, a lorry-winch system is used for extracting the trees along small tracks, and a lot of manual labor is employed in the harvesting operations. Under such systems the damage to biodiversity, soils, and waterways are minimized, and the minor forest produce is not compromised. The incentive to retain the forest stands is very high because of the labor opportunities and logging profits. Other countries like Vietnam and Cambodia are also looking into such schemes.

Forest Plantations

Forest plantations on the other hand is not new in concept and practice in the tropical region. However, interest in forest plantations in the past lacked the required impetus. It has vacillated quite a bit, influenced by only a few successful models in the tropics. Interest in forest plantation is now becoming more intense, being influenced by the fear of impending timber deficits in the future.

What Tree to Plant

The choice of species to plant depends initially on the end-use, or the environmental role of the plantations. Once the species has been chosen, it will dictate the silvicultural requirements, management and utilization of the crop. Switching to species halfway through its rotation incurs massive costs, that of cutting immature crop and planting the new ones. When choosing the species, the following basic questions must be answered: What is the purpose of the plantation? What species will readily grow in the available site? What relevant species are suitable and potentially available?

Table 2: Village timber management system compared with concession-based timber management system (Bonita 1997).

System elements	Village forestry	Concession-based forestry
Setting	50,000 ha, operated by 25 village forest associations; average 2,000 ha per association	50,000 ha, operated by a single concession
Cutting cycle	5 years	50 years
Compartment size	2,000/5=400 ha	50,000/50=1,000 ha
Cut per ha	5.8 m3	58 m3
Trees per ha	1-2	6-10
Openings in stand	Ca. 200 m2/ha	Ca. 2000 m2/ha
Logging methods	Labor intensive	Mechanized
Regeneration method	Natural regeneration	Natural regeneration augmented with enrichment planting
Forest protection	Easy	Difficult
Biodiversity conservation	Well conserved	Substantial loss
Soil and water conservation	Less erosion and sedimentation	More erosion and sedimentation

Once the end uses have been clearly defined, the specific choice of species for the plantations is narrowed down to select a number. Often foresters speak lyrical of the virtues of indigenous species, and otherwise of the exotics. Indigenous species are supposed to be more 'resistant' to local conditions. This may be a reaction to the predominance of a few species, mostly exotics that have dominated plantations throughout the tropics (e.g. tropical pines, eucalypts, acacias, yemane, teak and mahagony) to the neglect of some promising indigenous ones. The well-known exotics, on the other hand, have an accumulated knowledge of decades of research and should be exploited as well. The argument favouring indigenous species may also be spurious, because boundaries of a country are geopolitically determined and are not related to plant distribution. There are pros and cons about indigenous and exotics species. For example some of the tropical indigenous species like the merbau, chengal and balau produce excellent, highly durable, fine grained timbers with uniform colours. However, none will match the exotic cabinet quality species like teak, mahagony and khaya species as they fetch premium prices for special furniture and internal decorative work. Therefore restricting to only the indigenous species of the country limits the species choice for plantations.

Some important biological advantages are present with indigenous species, though. They therefore deserve more attention: It is possible to predict their performance in plantations based on their performance in natural stands; the species fills an existing ecological niche – it may therefore be less susceptible to disease and pests, since the natural enemies are already present; and the timber is well known to local industries. Major success with indigenous species are *Eucalyptus deglupta* in the Philippines and Papua New Guinea, *Pinus merkusii* in Indonesia, *Araucaria hunsteinii* and *A. caunninghamii* in Papua New Guinea and *Tectona grandis* in India, Thailand and Myanmar.

Exotics on the other hand provide a greater selection of species. The exotic, like *Hevea* is often free from disease and pest, for the early years at least. This could mean the natural predators and controlling agents are also present. The exotics in monoculture are often susceptible to massive uncontrolled attacks once a severe pest adapts to the exotic or natural disease and pests are unfortunately introduced (Tho 1979).

As a basic guideline species selection for plantation in the tropic should be classified into three classes. These categories would be:

Species for Pulp and Paper Production

Here species that have very fast growth habits and produce a large biomass within a short rotation of around 6-8 years should be considered. These would include exotic species like *Acacia mangium, Paraserianthes falcataria*, Pine spp and indigenous species like *Macaranga* spp.

General Utility Timbers

There is a huge demand for general utility timber for industrial purposes. They go into core of plywood, and make up the major constituents of fibreboard, particleboard, interior construction wood and other low-grade use. Several species have been identified for this purpose and include *Shorea* spp (light red meranti group), *Hopea* spp., *Dryobalanops* spp., *Endospermum malaccense*, *Hevea brasiliensis* etc. These species will have a rotation of around 30-35 years.

High Quality Timbers

High quality timbers will be grown for veneers, paneling, furniture etc. Suitable species will include *Tectona grandis, Azadirachta excelsa, Araucaria, Dyera costulata, Swietenia* spp., *Khaya* spp., etc. The rotations under full plantation conditions would be kept short, at around 20-25 years.

Production of High Quality Planting Materials for Plantation Programmes

Tree Improvement Programmes

A tree improvement programme involves all practices designed to produce genetically more desirable trees. It is important that any tree improvement programme is planned and coordinated in accordance with the purposes and priorities of national tree planting programmes in such a way that emphasis is placed on species for present or expected future importance and duplication of trials is avoided.

The objective of any tree improvement programme should be made clear and well defined before the programme is initiated.

The purpose of a tree-improvement programme is to optimize one or more of the following points

1. the quality of the end use as timber, fuelwood, fodder, shelter, etc
2. survival (adaptation to climate and environment)
3. resistance to pest and diseases
4. growth rate

Wrong selection as to growth rate will give less favourable results, while wrong selection as to adaptability, resistance and, possibly even more, end use may result in greater loss or even complete disaster.

A tree improvement programme is usually divided into different stages:

1. selection of desirable species
2. selection of desirable provenance within a species
3. selection of desirable families and individuals within a provenance
4. control breeding including recombination and hybridization.

Clonal Forestry

Marker Aided Selection

Conventional tree breeding for forest trees is a slow process when valuable traits are successfully improved. Traditional selection is based on phenotypic analysis, where efficient selection is possible only halfway through the rotation period. Methods to allow efficient selection at earlier age would allow increased gain per unit time.

An attractive alternative to expensive and time-consuming field trials is to take a small sample from each individual and look for the presence or absence of specific genes. This is especially important for traits that are not visible until the tree has reached maturity, for example wood quality. Most of the traits selected for in breeding programmes (so called quantitative traits) are regulated by several genes. The strategy is to use molecular markers for genomic sequences responsible for the expression of quantitative traits to make early selection.

Several approaches have been taken for identifying molecular markers linked to traits of interest. Molecular markers have for example been used to analyse the genetic basis for height growth and yield in eucalypt and pine (Sara von Arnold et al, 1998). Molecular marker maps are now available for several forest tree species and strategies are under development for using marker aided selection in the breeding of forest trees. It is expected that the incorporation of molecular markers in conventional breeding programmes will potentially result in significant genetic gains.

Vegetative Propagation through Macro and Micro Propagation Techniques

The possibility to propagate trees vegetatively creates significant advantages both for the deployment of selected genotypes through mass propagation and for capturing and enhancing the genetic gain in the breeding programmes. To ensure that maximum gain is achieved, of environmental factors on field performance of each genotype tested. Today the most common way to propagate plants vegetatively is through cuttings. However, large-scale cutting propagation is only possible for some tree species due to problems with rooting, ageing of mother trees, survival of cuttings and high costs. Tissue culture techniques and especially somatic embryogenesis can overcome some of these problems. From each seed an embryogenic callus is established. The callus consists of a high number of somatic embryos, which can proliferate very fast. Therefore within a short period of time it is possible to produce a large number of genetically identical plants.

Another advantage of somatic embryos is that they can be cryopreserved in liquid nitrogen. In conventional breeding programmes, with several forest species, by the time the superior genotypes have been identified in the field trials, they are too old to be successfully propagated vegetatively. Consequently, the identified elite genotypes are lost and they can only be used as parents for the next generation. However, if cryopreserved embryogenic calli from each genotype are available, the elite genotype identified during field trials, can be thawed and mass propagated for use in the plantation programmes

Genetic Engineering

Genetic engineering makes it possible to add new genes into selected elite genotypes without changing other properties. This gives the breeders the opportunity to improve economically important traits, which cannot be modified by conventional methods within a reasonable time frame. The full potential of genetic engineering will only be realized with the integration into conventional tree breeding programmes. Techniques are available for producing transgenic trees of many forest species. The scenario of traits to be improved using genetic engineering includes stress tolerance, growth rate, wood quality and resistance to insects, pathogens and herbicides. However more information about the genetics and the physiological and biochemical pathways involved in specific traits is still required, before commercial use can be made of this technology. Much research is currently underway to isolate genes of commercial interest, irrespective of organism or species.

Improved Silvicultural Techniques

Planting of improved and fast growing trees will definitely require higher input in terms of fertilizer etc. In a study conducted in Australia (Anon 1995) it was found that in a fast growing pine plantation, the uptake of nitrogen rises at an almost exponential rate from 7 kg per hectare in the first year to about 80 kg per hectare in the fifth year. Under these conditions demand for nitrogen is likely to be outstripped by supply after about 3 years growth indicating that fertilizer programmes which is not a norm in forestry will need to be seriously considered. In addition, other silvicultural operations like pruning, spacing etc need to be reviewed.

Changing Scenario of Timber Utilization

Traditionally, the largest group of timber obtained from the ASEAN countries – primarily Indonesia, Malaysia, Thailand and the Philippines belong to the Dipterocarp family such as meranti/luan. As a result of the depletion in supply of these traditional timbers, other species have been progressively introduced into the market. Due to the low concentration in any stand of natural forest of these newly introduced timber species, they are commonly marketed together as mixed species (or mixed hardwoods). Thus, there is a general change in the species of timber being marketed from the region. In addition to this changing scenario of supply, another compounding factor, which has greatly influenced utilization trends, is the 'anti tropical hardwood campaign' (ATHC) mounted by non-governmental organizations (NGO's), especially in the developed countries. Some local councils of developed countries have shown their support for ATHC by imposing a ban on the use of tropical hardwoods in house construction and other uses. Other related events like the call for 'eco-labelling' of tropical hardwoods and assurance of sustainable management of tropical forest followed. All these activities have affected the market for tropical timber and timber products. Following the call for sustainable forest management practices; there is now a drastic reduction in the logging intensity in the traditional tropical timber producing countries. It is projected that the local demand for round wood would not be met. It is projected that annual demand for round wood in the ASEAN countries would be about 57 million m^3 in the year 2000 (Hong & Razak 1996). The future supply of timber for the wood-based industries would be partially dependent on the success of forest plantations in addition to whatever is available from the natural forest. It is estimated that plantations will provide about 25% of the total demand. The demand for solid timber would continue to increase to satisfy the demand of the wood-based industry and for utility purposes. However, because of changing conditions of supply, environment and economy this demand for solid timber is being rationalized. This is evident in the increasing use of reconstituted panel products especially in the furniture and to some extend, the joinery and moulding industries. Therefore, given the situation that alternative timber species are required for substituting traditional timbers, there is the other alternative of using these timbers to produce reconstituted panel products. It is inevitable, judging by developments of the reconstituted panel product industry, products like particleboard, MDF, orientated strand boards and some others are becoming increasingly important.

Concluding Remarks

With the ever-increasing pressure to ensure sustainable management and biodiversity conservation of the natural forest, indiscriminate cutting of natural forest will become history. Today's forest managers are grappling with certification issues, carbon sequestration, minor forest products and benefits to forest dwellers. It therefore appears clear that the future of natural forest management would give less emphasis to timber production and more to conservation and recreational issues. Plantation forestry is poised to become the source of timber production for the future. There is a need to ensure high productivity per unit area from these plantations. To achieve this, tree improvement programmes employing the available new biotechnological tools have to be stepped up to ensure results in the shortest possible time. Traditional solid timber usage is now slowly giving way to reconstituted panel products as alternatives in line with the change to alternative fast growing timber species. More emphasis in the future will be placed in panel products and MDF.

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Sustainability of Raw Material Supply- Research Perspectives of an International Forestry Corporation

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Abstract

Consumption of paper products will increase along with worldwide population growth and economic development. This will inevitably lead to increased use of raw materials within the industry. In the foreseeable future wood fibre (primary or recycled) will remain the main raw material source for the expanding paper and board industry. Stora Enso is one of the largest forest products companies in the world. Stora Enso's target is to grow and expand its production particularly in the paper and board industry, and the sustainable supply of raw material is therefore a major concern for the company. Stora Enso conducts various research and development (R&D) activities at its research centres, mills, forest departments and plantation projects. Most of the R&D resources are assigned to the development of industrial processes and new products. The efficient use of raw materials and the reduction of environmental effects are also important subjects. The contents of actual forestry R&D programmes are assessed separately for each country of operation and are based, among other things, on the existing scientific knowledge, magnitude of the company's forestry operations, forest conditions, forest ownership, and social, economic and natural environment. In Europe and North America national forest research is highly advanced and therefore Stora Enso mainly seeks low-cost collaborative arrangements for its specific forestry R&D needs. Consequently only modest R&D resources are assigned for forestry issues, and most efforts are focused on improving harvesting, storage and transport logistics. Stora Enso is presently involved in forest plantation projects in Brazil, Indonesia, Portugal and Thailand. Practically oriented R&D programmes are substantial parts of these projects. The main justifications for high research inputs are prospects for great productivity and quality improvements through genetic tree improvement, genotype-site matching and appropriate silviculture. Securing sustainable site productivity and control of pests and diseases over successive rotations are also fundamental R&D topics. Social and environmental issues are important in each project and require appropriate R&D activities. Collaborative research between companies and institutions in these countries is often difficult to practise, and therefore efficient, individual R&D programmes are necessary.

Keywords: Stora Enso, Pulp raw material, Research, Fast-growing plantations.

Raw Material Supply for Stora Enso - Present Situation

Stora Enso is one of the largest forest products companies in the world, producing annually some 14 million tonnes of various papers and close to 5 million m^3 of sawn timber. Stora Enso's target is to grow and expand its production particularly in the paper and board industry (Stora Enso 1999b).

Wood is the most important raw material for Stora Enso. The Group's total annual wood consumption is about 40 million m^3. The company owns 2.7 million hectares of forest, of which 1.9 million hectares are located in Sweden, 0.6 million hectares in Finland and 0.14 million hectares in Brazil (smaller areas are owned in Canada, Portugal, Thailand and Estonia). In addition, the company has leased altogether about 0.8 million hectares of forests in Canada, Russia and Portugal. Own and leased forests provide only about 15-20% of Stora Enso's total raw material requirements and the remaining 80-85% are purchased from various sources (Stora Enso 1999a). The raw material supply, however, varies greatly between countries and between individual mills in each country. Stora Enso's current wood consumption and domestic raw material supply is presented in Table 1.
The annual wood import to the company's mills in Finland and Sweden is at the level of

some 8 million m^3. Most of the imported wood comes from Russia and Eastern Europe. Stora Enso has its roots in Finland and Sweden, but as a result of its rapid expansion over the past couple of decades, it has emerged as a truly international company. The growth and internationalisation have increased production in regions with abundant secondary fibre (recovered paper) supplies. Recovered paper is mainly available in areas with relatively high population density and paper consumption. The use of recycled material is therefore, common in Stora Enso's Central European mills. The Nordic mills continue to use predominantly primary fibre and export most of their products to densely populated market areas such as South and Central Europe. In 1998 the company utilised 1.9 million tonnes of recovered paper in its mills.

Stora Enso Celbi's eucalypt plantation programme in Portugal commenced in the 1960s to meet its fibre requirements. In addition, Stora Enso is now also involved in three plantation projects in the tropics in Asia and South America. These projects are being developed in co-operation with local partners, and their raw material supply strategies are tailored for local conditions. The development of economically, ecologically and socially sustainable raw material resources requires quite different research and development inputs in these hardwood plantation projects than in the Nordic, North American and Central European operations. Thus, even though the company is global, the practical research and development arrangements must always be local.

Research and Development Units Within Stora Enso

Most of Stora Enso's research and development (R&D) work is focused on the development of industrial processes and new products. This R&D work is conducted using joint resources at the four research centres of the corporation (one in Finland, one in Germany and two in Sweden) and within the business units. Some R&D services are also purchased from outside the Group. Stora Enso employs close to 400 researchers and engineers in the research centres and about the same number of R&D staff at the mills. Research work at mills is focused largely on day-to-day problem solving, whereas at the corporate level R&D is conducted in accordance with long-term corporate strategies. In addition, the role of R&D is being expanded in the planning of new investment projects; R&D experts are expected to provide the corporation and its divisions with reliable information for the assessment of each project.

Although most of the company's R&D activities are focused on product and process development, many of these research topics have links to the sustainability of raw material supply. For instance improvements in processes or development of new products may result in reduction of fibre need, decreased pollution, more efficient use of energy or enhancement of recycling. Replacing wood fibres with other raw materials would diversify raw material supply and could improve the sustainability of the fibre supply by reducing the need for primary fibres.

The R&D work carried out at Stora Enso's research centres and mills does not include forestry research. However, Stora Enso does have expertise in forestry R&D in the countries it operates in.

Contents of forestry R&D programmes (including tree breeding and silviculture) are assessed separately for each country of operation and are based, among other things, on the existing scientific knowledge, magnitude of the company's forestry operations, forest conditions, forest ownership, and social, economic and natural environment.

Table 1. Wood consumption of Stora Enso by countries (1999 estimate)

Country/Region	Consumption, mill. m3	Domestic supply, mill. m3
Finland	20.6	15.6
Sweden	14.8	12.3
Central and South Europe	4.6	4.6
Canada	1.4	1.4

Forestry Research within Stora Enso in Northern and Central Europe and in North America

In Europe and North America forest legislation ensures stable wood supply through the use of sustainable forest management practices. In addition, national forestry research is well established and exchange of scientific information occurs freely. Forestry is mainly based on management of natural forests or on planted indigenous trees with relatively slow growth rates, which means that prospects for remarkable growth increases are low even under intensive forest management practices. In these areas most of the wood for corporate mills is purchased from other forest owners. Stora Enso therefore mainly seeks low-cost collaborative arrangements for forestry R&D needs and consequently only modest R&D resources are assigned for forestry issues in these regions. However, the collaborative R&D is rather extensive. For instance, during the last year Stora Enso's forest department in Finland co-financed more than 20 wood harvesting technology projects and was involved in a dozen research consortia with various institutions.

On the other hand, the corporation has very extensive industrial operations in this region. A continuous flow of raw material has to be guaranteed to each mill daily, weekly, annually and year after year. Wood for each individual mill is procured from various sources the Group's own forests, private forests or from publicly owned forests in different parts of the country. Part of the raw material may also be imported from various sources in neighbouring countries, or it may be grown in plantations in another country or even on another continent. Forest departments of the corporation must be able to purchase, harvest and transport the needed wood without unnecessary storage and cross-transportation. Legal, political, social, environmental and economic constraints of wood procurement must be solved in a sustainable way.

The wood procurement operations are costly and therefore have a direct effect on company profitability. Thus one of the main interests in forestry R&D is the development of cost-efficient harvesting, measurement, transport and storage systems to ensure optimal distribution of wood between various mills. These issues are largely about logistics and it is therefore impossible to draw a clear line between R&D and daily management. Information systems are playing an increasingly important role in decision-making and problem solving. For instance, in Finland the planning of forestry activities in the company's own forests is assisted by geographical information systems, where all data concerning these forests are stored. Information about the other forest resources is obtained from a remote sensing based system developed in co-operation with the Finnish Forest Research Institute. Forwarders, harvesters and trucks working for Stora Enso are equipped with computers and Geographical Positioning Systems (GPS), and the transportation optimisation system designed in-house is used to give daily work instructions to each vehicle, including necessary maps.

Stora Enso's forest departments in Finland and in Sweden, as well as Stora Enso Forest Consulting have staff for the co-ordination and execution of various R&D projects. However, most of the work is carried out through collaborative work with external agencies. The development and testing of working methods and harvesting machinery are carried out mainly through the joint research organisations of the forest industry. Information systems are developed and updated as a joint effort between company specialists and external agencies. National research institutes carry out basic silvicultural and productivity research. Issues of special interest to Stora Enso are, however, studied through collaborative arrangements. Tree improvement in Finland and Sweden is carried out in close co-operation with all major forest owner groups and national research institutes. In recent years more research, both in-house projects and joint assignments with external agencies, has been focused on issues that are closely linked with the environmental and social responsibility policy of the company. This research includes biodiversity and conservation studies, and surveys on the acceptability of products and operations.

Forestry Research in Plantation Projects

Stora Enso is presently involved in forest plantation projects in Brazil, Indonesia, Portugal and Thailand. Forestry R&D inputs in these projects are relatively much higher than in operations in the European-North American conifer region. There are several reasons for this. First of all, these projects are based on exotic plantation species, and their domestication is still in process. These species have relatively short breeding cycles and rotation periods, and therefore prospects for greater productivity (growth and yield) and quality improvements through genetic tree improvement (conventional tree breeding and biotechnology), clonal forestry, species/genotype-site matching and improved silviculture are very good. These improvements and gains can be achieved in relatively short time frames. Secondly, the land available for forest plantations comprises degraded, marginal soils where tailored fertilisation regimes are required for satisfactory growth. Thus a competitive advantage can be achieved by developing in-house R&D programmes with well-focused objectives. Another factor driving in-house R&D in these countries is that collaborative research between companies and institutions is often difficult to practise and slow due to long distances, poor communication facilities and administrational obstacles. In addition, within large countries like Brazil and Indonesia environmental conditions vary greatly and therefore local species and clone testing and site improvement research are absolutely necessary.

Stora Enso Celbi, a pulp company in Portugal, has been developing *Eucalyptus globulus* plantations since the mid-1960s. The company's land base is partly owned and partly leased. Presently Stora Enso Celbi's own eucalypt plantations cover over 45,000 ha, plantations with other species 4,000 ha and 8,000 ha are designated for conservation and other uses. Intensive tree breeding and genetic selection (between 1987 and 1995) have increased the productivity (tonnes pulp/ha/a) of the latest *E. globulus* plantations by up to 60%. Improved silvicultural practices will further increase the productivity. Modern molecular genetic technology (molecular markers) has been applied in the selection of parent material. In addition to growth, wood properties have been successfully used as breeding criteria, and this has contributed to the significant reduction of wood consumption per tonne of pulp.

In Bahia, Brazil (16.5 degrees South), Stora Enso is engaged in a joint venture company Veracel. The aim is to establish eucalypt plantations large enough to supply a pulp mill. By the end of 1998, the land ownership comprised 138,000 ha, of which 43,000 ha hectares were already planted with eucalypts, 24,000 ha were designated for planting and 21,000 ha were considered non-productive and designated for reafforestation with indigenous tree species. The land was formerly used for low-intensity agriculture, such as cattle grazing. About 50,000 ha of the property are still covered with rainforest and will be preserved and restored as a nature conservation area.

Almost all Veracel's plantations are grown from clonal cuttings of *Eucalyptus grandis x E. urophylla* hybrids. Existing plantations are producing on average 40 m^3/ha/a. Intensive tree improvement and other R&D activities are expected to improve the current growth rate by about 40% in plantations established from year 2006 onwards. Basic wood density and pulp yield per kg of wood will also be increased. The productivity of these plantations (tonnes of pulp/ha/a) should therefore increase by

50%. In addition, the genetic diversity of plantations will be increased. Such improvements will greatly add to the profitability of the project. In tree improvement modern molecular techniques are applied, but no genetic engineering is practised.

In West Kalimantan, Indonesia (at the Equator), Stora Enso is a shareholder in a joint venture engaged in reforesting large areas of grassland and bushland. These vegetation types are results of shifting cultivation or forest fires, and are considered to have only minor ecological or social importance. So far, over 20,000 ha have been planted mainly with *Acacia mangium* - *A. crassicarpa, A. aulacocarpa* and *E. pellita* are planted on a small scale. R&D has mainly been focused on nutritional issues and tree improvement. Unimproved acacia plantations in the region yield an average of 20-25 m^3/ha/a. This productivity could double with intensive tree improvement, careful site selection and appropriate silvicultural practices (fertilisation and weeding). Local species are being tested as alternative plantation species. The project has also extensive community development and environmental components. As one part of that work, seedlings of local timber and multipurpose species are produced and supplied to rural people within the company's operating area.

In Thailand, Stora Enso owns a small trial plantation area for developing and testing improved eucalypts (mainly *E. camaldulensis, E. tereticornis* and their hybrids) and for silvicultural research and development. This operation is close to Advance Agro's pulp and paper mills where Stora Enso is a minority shareholder. Advance Agro wood requirements are met in part from own plantations. The rest is produced in plantations established by local farmers under a special out-growing scheme. The opportunities for remarkable growth and yield improvements of plantations through the application of R&D findings are good.

The R&D activities in these projects are managed through individual R&D departments in each project/company. Technical and scientific support for these departments is provided through Stora Enso Pulp and Stora Enso Forest Consulting. However, as Stora Enso's operations become more global and more complex, there will be an increasing need to coordinate, monitor and support the R&D activities at the corporate level. Cooperation between various projects would enable them to achieve quick progress through the implementation of best research practices. Such arrangements would ensure that the possible substantial returns from R&D are achieved in all fast-growing plantation projects of the corporation. In some cases, these returns may exceed 30% through reduced raw material costs.

Future Trends

It has been estimated that consumption of paper products will grow globally by 2.8% per year to 2010. Thus consumption will total 420 million tonnes in 2010, up from present 300 million tonnes (Jaakko Pöyry 1999). This development will inevitably lead to increased use of raw material within the industry. At the same time demand of logs for sawn timber or plywood will also grow, but at the slower rate of about 0.8% (Jaakko Pöyry 1994). As Stora Enso aims to be the leading paper products company in the world, the sustainable supply of pulpwood and other raw materials for paper making will be a major objective for the Group.

Primary Wood

Recycling, new raw materials and development of processes are expected to slow down the increase in pulpwood demand. However, pulpwood demand is forecast to grow by some 1.5% each year until 2015 (Jaakko Pöyry 1994). Forest resources are increasing in Europe and North America. On the other hand there is strong competition for this wood and prices are high. It is also likely that a considerable part of the increment may not be available at the wood markets as forest owners may not be willing to sell it or large forest areas may be reserved for conservation or recreation. At the corporate level this calls for increasing co-ordination of the limited R&D resources, and focusing them on issues where major savings or improvements in wood supply can be made. Russia has huge forest resources, about one fifth of the world's forests and 50% of the world's softwood, and these resources are considered underutilised (Saastamoinen 1999). Accurate forest inventory, functional legislation and improved logistics are key issues in enhancing the utilisation of this resource. R&D on economical and environmentally sound harvesting and transportation is needed, too.

Fast-growing plantations in the tropics are emerging major raw material sources for the pulp and paper industry, and global forestry corporations are getting increasingly involved in such plantations. Presently industrial fast-growing plantations cover some 17 million hectares worldwide. This is about 13% of all forest plantations and less than 1% of the closed forest area in the world. Growth rates of well-managed plantations are high, and the uniform wood is an excellent raw material for certain paper and paperboard products. The consumption of tropical wood for pulping is expected to double within the next 15 years to about 120-140 million m^3 per year (Brown *et al*. 1997, Jaakko Pöyry 1994). If sufficient plantations are not developed, pressure on indigenous tropical forests will increase and be severe.

Stora Enso does not use wood from natural forests in the tropics, but wood from plantations established on open, degraded sites is accepted. The afforestation efforts on degraded, often marginal sites require specialised knowledge in genetic improvement of trees (conventional and modern genetic technologies), clonal forestry, silvicultural practices and plantation management. Biodiversity and environmental aspects must always be carefully considered. The maintenance of soil productivity over successive rotations is a fundamental requirement for sustainable forestry operations. Harvesting and transport systems for the extreme climates and sensitive soils must be developed, too. Such plantation operations also require efficient management information systems, which are based on computerised mapping tools and database systems, which can be adapted to varying education levels of local staff. Local people must be involved in and benefit from the activities, and their rights and cultures must be respected. Thus, development of large-scale plantations will require major R&D inputs.

More Efficient Use of Wood Raw Material

Development of new products, use of alternative raw materials and more efficient and environmentally friendly pulp and paper making processes will reduce average wood fibre needs per unit of output in the future. More efficient use of wood raw material may still be possible by further integration of mills, better allocation of various wood components between mills, reducing losses during harvesting and processing, and by using wood presently wasted.

Recycling

More efficient recycling will be one essential source of raw material. Presently about 80% of paper worldwide is made from primary fibre, but according to some estimates by 2010 nearly half of the world's paper will be made from recycled fibres (Brown *et al*. 1997, Jaakko Pöyry 1999). For instance European Union countries aim to increase the recovery rates by up to 75% for paper by the year 2005. Such high levels of recovery will generate huge volumes, and for proper utilisation sorting procedures must be developed. Presently, impurities of collected paper and inadequate collection systems cause severe problems in repulping, and the resulting pulp does not allow mills to produce high quality paper grades at a reasonable cost (Brooks 1999). Exports of recovered paper from Europe and North America to Asian paper producers may increase substantially in the near future (PPI Asia News, 1999).

New Raw Materials

New raw materials   new tree species, use of waste wood, non-wood fibres and/or other potential raw materials   will be a major field of research and development. Theoretically the worldwide availability of non-wood fibres (e.g. straw, grasses, hemp, linen, bamboo, bagasse, components of oil palm, etc.) could be 3–4 times higher than that of wood fibres. Furthermore, the properties of non-wood pulps may allow replacement of wood pulp in many board and paper grades. Genetic breeding of several plant species to meet this demand for non-wood fibres is likely to yield quick results due to their short rotations. In addition, advances in biotechnology may also play a key role in the utilisation of new raw material sources. Commercial applications of new raw materials will depend on feasible solving of necessary logistics arrangements as competitive operations may require bigger mills than present ones. According to recent estimates, the share of non-wood fibres as paper raw materials will remain at about 5% (Jaakko Pöyry 1999). Replacing renewable plant fibres with inorganic materials must be critically considered and special attention must be paid on the environmental effects. Matching the properties of the raw material with the proposed end-use is essential, regardless of the raw material source. This calls for an open, fresh, collaborative research approach to explore all options for the diversification of raw material sources.

Conclusion

In the foreseeable future wood fibre primary or recycled will remain the main raw material for the expanding paper and board industry. This will require responsible management of the world's forests. Information generated through research will be of critical importance in achieving this goal. Research resources should be carefully focused to support the sustainable management of existing forests and the establishment of new forests on marginal lands. Long-term performance and sustainability of the wood processing industry is closely linked to the research advances and the application of the results in practical forest management.

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Current Timber Supply and Demand in Taiwan Compared to that in Major Asian Countries

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Abstract

With the ever-increasing concern for environmental protection, it has become necessary for governments, resource managers, and forest industry to implement a reasonable forest establishment and utilization policy to ensure that environmental goals are met. This "Eco-management" has strongly influenced the supply of forest products in Asia, where people experienced a very fast economic growth from 1992 to 1996. The forest area in Asia in 1995 was about 565 million ha. There was a net loss of 16.6 million ha. between 1990 and 1995 due to the conversion of land to non-forest uses, representing an annual decrease of 3.3 million ha. Annual decrease was slightly less than one half of that rate from 1980 to 1990. While the area of the Asian forest has been steadily decreasing, the FAO data indicate that the consumption of roundwood in this region increased by 6.6% between 1992 and 1996. At the same time, the production of roundwood increased 6.1%. Exports of industrial roundwood from Asia decreased dramatically in 1993, resulting in an average annual decrease of 9.2% from 1992 to 1996, while world exports maintained an average increase of 1%. The unit value of the exports from Asia was one third higher than the world average, while those from Myanmar, Cambodia and Singapore were even three times the world average. Although world sawnwood exports increased 17.7% from 1992 to 1996, the amount from Asia decreased steadily from 9.6% to 5.9% of the world total. The unit value of the goods exported from Asia was nearly 70% higher than the world average ($US 223 thousands). Sawnwood products from Indonesia were valued almost three times the world mean value. Timber production has, for many decades, played an important role in support of economic development in Taiwan. Recent forest policy has emphasized conservation, sustainable management and multiple uses of forest resources. Imported sawnwood, on a log basis, totaled 5.02 million m^3 . Recycling of wastepaper provides 3.1 million tons of the fiber needs of the paper industry. The promotion of wastepaper recycling has increased domestic recovery from 2.30 to 2.79 million tons from 1992 to 1997. The total use of wastepaper in 1997 was 4.1 million tons. Four major factors--- more efficient processing, diversifying raw material sources, increased recycling and expanding the use of residues have enabled the forest industry in Taiwan to reach her goals for value-added processed products.

Keywords: Timber supply, Demand in Taiwan

Current Forest Status in Asia and Taiwan

Approximately 565 million hectares of forest, or about 16 percent of the world's total is located in Asia where one half of the world population resides. Due to the extremely rapid social and economic changes in recent years, expanding population has resulted in the highest annual deforestation rate (1.1 percent) in the tropical countries of Asia.

The fast depletion of traditional timber species from the tropical forests has resulted in more plantation species to be marketed. Recognizing that plantation wood will become an increasingly important lignocellulosic resource in the future with the anticipated reduced production of logs from the remaining natural forests, more than 22 million hectares of tropical plantation, about three-quarters of the world's total, have been established. While greater efforts have been made to bring timber harvest within sustainable levels, forest conservation and biodiversity have also increased at the same time.

Asia and North America dominate the world forest products economy. Asia has been gradually recovering from the monetary crisis of 1997. With its history of fast growing, this most populated area certainly will expect a dramatic growth in the coming years. Wood consumption is no exception. To satisfy this growing demand, we must create and use regional forest resources with increased effort and efficiency.

With a total area of 35,570Km^2, Taiwan lies between latitudes of 21°42'25" – 25°56'21" North and longitudes of 119°18'03" – 124°34'09" East. Nearly 2.1 million hectares, or 58.5 % of the land, is covered by forest (Tsou 1997). This is 6.5% more than 20 years ago when the 2nd forest resource inventory was conducted. Mountainous topography forms a wide range of environments and supports a diverse flora and a rich fauna. The number of plant species is about the same as in Australia, which is 200 times greater in area. About 25 % of the 4021 documented vascular plant species (Lin 1999) are endemic. Taiwan is also known for its rugged terrain, with 75 percent of hilly land and half of the land above 1,000 meters. Overall, 200 peaks are above 3,000 meters. Six types of forest can thus be recognized on this small territory.

The steep topography in most areas of the island has contributed to the limitation of large scale exploitation of forest resources since the late eighties. Table 1 shows the decreasing annual cut of timber, while Table 2 indicates that 34.3 percent of the area of forest reserves in Taiwan is on land steeper than 35 degree. These areas contain nearly 40 percent of the 360 million m^3 total timber volume. With a net growth rate of 2.3 percent, the forest produces 8.5 million cubic meters of wood annually. According to the 3rd survey of forest resources and land utilization 72.2% of the total forest is natural forest, the other 422,600 hectares is 51% coniferous plantation and the rest is hardwoods and mixture of both. The total volume in plantations is about 47 million m^3 which implies a usable volume of 1.1 to 1.5 million m^3. Changes of forest growing stock in the past three decades are shown in Fig 1.

Timber Demand and Supply in Major Asian Countries

Asia, Europe and North America dominate world forest products production. They account for 80 percent of roundwood and sawnwood production and more than 90 percent of wood based panels and pulp and paper products. Asia's consumption of forest products is rapidly approaching that of North America and exceeds that of Europe in total demand. The growth in demand is projected to outstrip supply for almost all products, leading to rapid increases in imports.

To compensate for the expanding gap between demand and supply from natural forests, serious consideration has long been given to the adequate management of the plantation resources in Asia. Forest plantation establishment in Asia was about 67 million hectares in 1995, up from 33 million hectares in 1980 (FAO 1997). Most of these plantations were intended for the production of industrial roundwood and/or fuelwood, though many were established for environmental protection or carbon sequestration. Annual increase in plantation establishment reached 70 million hectares in 1998 (Lai 1998), almost equaled the total of the developing counties.

Figures from FAO indicated that the consumption of roundwood in Asia increased by 6.6 percent between 1992 and 1996. At the same time, the production of roundwood increased 6.1 percent (Ho 1997). Strong social and economic ties existing among the Asian countries create intensive trade of forest products. When one government decides to reduce forest harvesting, the decision impacts neighboring countries in the form of increased harvesting and export.

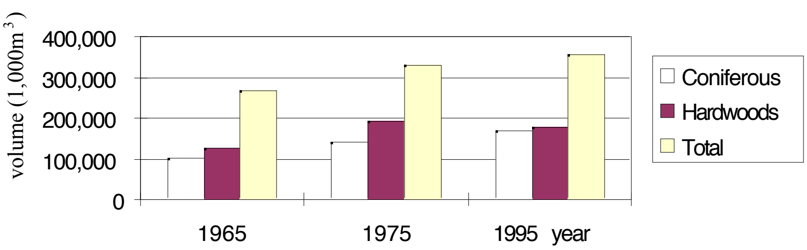
Table1. Annual timber harvest and consumption in Taiwan (Ho, 1997; Jan 1999).

Year	Area(ha)	Volume cut (m^3)	Volume(%)	Wood consumption(m^3)
1987	5,546	670,410	100.0	7,866,551
1988	5,208	426,483	63.6	7,816,847
1989	2,493	264,492	39.5	7,308,823
1990	1,917	203,213	30.3	6,917,574
1991	1,046	126,059	18.8	7,973,353
1992	1,036	118,323	17.6	8,367,903
1993	575	71,735	10.7	7,191,878
1994	439	56,128	8.4	6,625,296
1995	625	63,176	9.4	6,527,707
1996	500	56,374	8.4	5,691,196
1997	--	--	--	6,020,926
1998	--	--	--	4,963,074

Table 2. Forest reserves distribution by slope class (Taiwan Forest Bureau, 1995).

Slope class	Area %	Growing stock %	Growing stock m^3/ha
<5°	2.19	0.98	76
5-15°	8.68	5.45	107
15-25°	20.72	19.15	158
25-30°	34.15	35.61	178
35-45°	26.52	31.75	204
>45°	7.77	7.05	155
Total	100	100	171

Fig. 1 Changes of forest resources in Taiwan (Taiwan Forest Bureaus, 1995)



Among the ten countries contributing to 90 percent of roundwood production, Mainland China, India, Indonesia and Malaysia were the top four which produced three quarters out of the approximately 1,185 million m^3. Japan and Taiwan were the only two countries where roundwood consumption exceeded production. Japan, Korea and Mainland China were the top three importing countries and accounted for 90.4 percent of the total 72 million m^3 imported roundwood. Exports of industrial roundwood in Asia decreased dramatically in 1993, with an average annual decrease of 9.2 percent while world exports decreased an average of one percent from 1992 to 1996. Among the top ten exporting countries, exports from Malaysia in 1996 were only 40 percent those of 1992, as was also the case for Myanmar. Exports from China, decreased an average of one percent from 1992 to 1996. Among the top ten exporting countries, exports from Malaysia in 1996 were only 40 percent those of 1992, as was also the case for Myanmar. Exports from China, Indonesia, Viet Nam, North Korea and Laos have increased greatly on a percentage basis, however, the total amount of their exports accounted for only one third of the reduction from Malaysia.

As world sawnwood exports increased 17.7 percent from 1992 to 1996, the amount from Asia decreased steadily from 9.6 to 5.9 percent of the world total. Tropical hardwood production of veneer, plywood, particleboard, cement-bonded panels and medium density fiberboard, as well as furniture have registered very healthy growth in this region except in the recent monetary crisis beginning in 1997.

Forest Products Industry in Taiwan

The forest products industry in Taiwan encompasses sawnwood, furniture, plywood, composites as well as pulp and paper. The total market value of the industry in 1996 was 5,210 million US dollars which was 1.9 percent the figure of national GDP in that year and was 0.4 percent less than that of 1995 (Table 3).

Taiwan exported 3,345 million US dollars worth of forest products, contributing 2.9 percent to the grand total export, in the year 1996. This was significantly lower than the 3.5 percent in 1994 (Table 4). The reduction could be attributed to 1) the rocketing rise in price of imported logs, 2) the leaping increase in labor costs, and 3) the vigorous competition from the neighboring countries.

According to the employment statistics (Table 5), nearly 120 thousand workers were employed in the forest products industry in 1996, contributing 5 percent to the national manufacturing labor force. The percentage decreased from 5.2 and 5.1 percent in 1995 and 1994 respectively, indicating that the labor population in the industry was declining.

The sawnwood industry has been declining since the historical peak of economic development in 1976, due to the log export ban and the implementation of a policy favoring domestic wood processing exerted in the neighboring forest-rich countries. The import of sawnwood, in the meantime, significantly increased. The record in 1988 was 1,060,847m^3, with a value of about 320 million US dollars. The figures in 1997 increased to 1,512,075m_3 and 473 millions dollars. Fig.2 shows the total values of imported and exported forest products form 1984 to 1998 (Li *et al*. 1979).

Wood consumption in Taiwan reached its first peak in 1979 at 7.92 million m^3 then fluctuated between 6 and 8 million cubic meters (Fig 3). The second utilization summit occurred in 1992, when 8.36 million cubic meters were consumed, though the percentage used for lumber decreased from 88.2 to 78.4. The substantial reduction in consumption resulted from a dramatic decrease in plywood export. Only one sixth of the previous quantity was shipped out, which resulted in a great drop in log consumption. Wood imports have shifted from log to lumber and wood products in Taiwan. This trend has become more clear with the decreasing export of plywood. The recent surge of importing composite boards could mainly be attributed to the increasing demand of MDF in the furniture industry.

The continuous out-moving of the factories can be attributed to two major elements: lack of raw materials and higher labor cost. Forest products industry has experienced a serious decline since 1993. In contrast to the gradual recession of the plywood industry, the furniture industry had its first big boom during the past two decades in 1987□Fig 4□. Many plywood processors shifted their investment to furniture manufacturing. The recession of the latter industry has been much slower due to its higher requirement in manufacturing techniques. The historical success of Taiwan furniture industry could be attributed to the factors listed in Table 6. A competence survey of the furniture industry in Taiwan completed in 1995 showed that Taiwan was inferior to Malaysia, Indonesia, Mainland China and even Mexico only in labor costs and raw material supply while the world renowned furniture countries--Italy and Germany-- surpassed Taiwan in seven out of eight factors studied (Table 7).

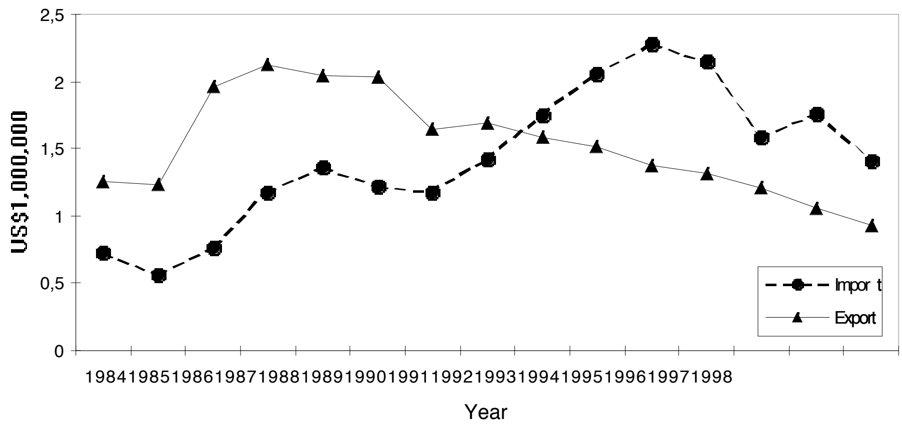
Table 3. Production value of Taiwan forest products (Million US $; Source: Lai, 1998).

Industry	**1994**	**1995**	**1996**
Lumber	198.5	150.4	159.4
Plywood	449.6	430.1	399.6
Furniture	912.1	753.6	710.4
Pulp and paper	3,806.4	4,505.4	3,931.6
Sub-total	5,366.6	5,839.6	5,200.9
GDP	241,077.5	251,808.5	271,464.8
Percent on GDP	2.2	2.3	1.9

Table 4. Export value of the forest products in Taiwan (Million US $; Source: Monthly report on salary and productivity statistics; Lai, 1998)

Industy	**1994**	**1995**	**1996**
Cork and Wood manufacture (excluding furniture)	728.5	696.5	664.8
Furniture parts	1,782.2	1,690.5	1,713.0
Pulp and paper	772.4	930.6	966.4
Sub-total	3,283.1	3,317.6	3,344.2
Total export	92,854.8	107,766.8	115,324.9
Percent on total export	3.5	3.1	2.9

Fig 2. Total value of imported and exported forest products in Taiwan (Source: Jen, 1999).



The pulp and paper industry in Taiwan accounted for 78 percent of the turnover value of the forest products industry in 1996. There has been downsizing within the sector due to increasingly stringent environmental regulations and difficulty in procuring skilled labor. Nearly thirty-five factories were closed or moved out of the State in the past ten years. There are currently 129 paper mills in the country, two of which are integrated pulp and paper mills. The products range from printing and writing, packaging, newsprint, household and joss paper to specialty products such as insoles and handmade Chinese calligraphy paper.

Table 5. Employment statistics in the forest products industries (Source: Monthly report on salary and productivity statistics; Lai, 1998.

Industries	1994	1995	1996
Wood and Bamboo products	33,900	31,102	29,165
Furniture	28,192	25,118	25,671
Pulp and paper	64,573	65,663	63,481
Sub-total	126,665	121,883	118,317
Total in the manufacturing (A)	2,438,632	2,399,659	2,348,946
Percent on (A)	5.2	5.1	5.0
Total national labor (B)	9,081,000	9,210,000	9,310,000
Percent on (B)	1.4	1.3	1.3

Fig 3. Wood consumption and production in Taiwan.

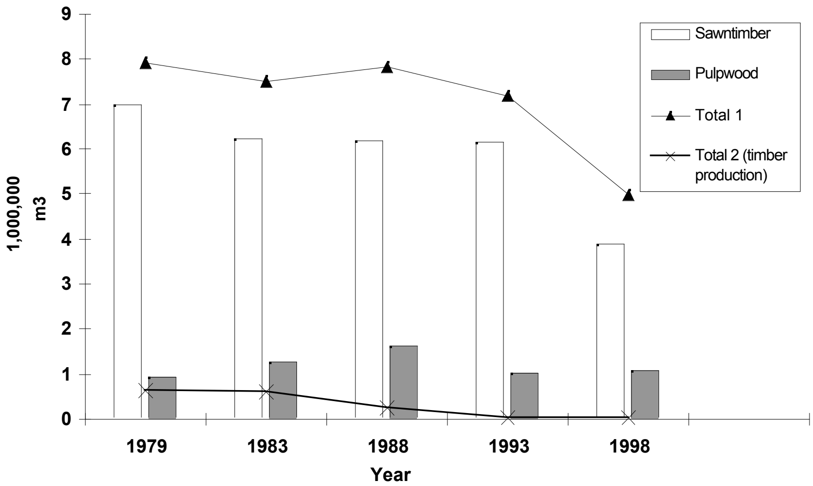


Fig 4. The export value of plywood and wood furniture in Taiwan.

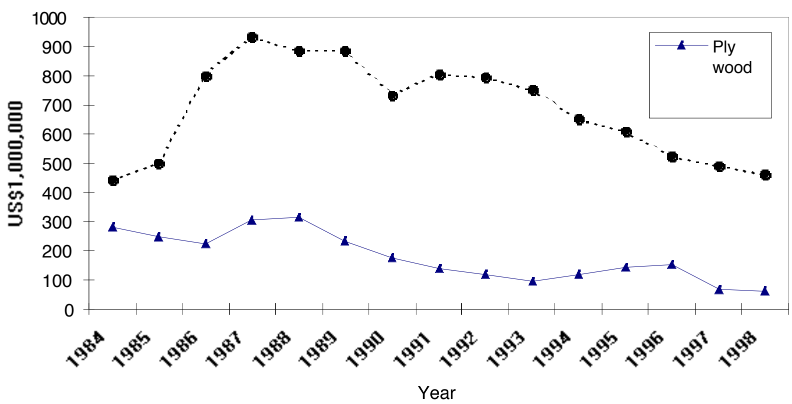


Table 6. Analysis on the factors contributing to the previous success of Taiwan furniture industry (Source : Investigation made by Information Division, Chemical Engineering Dept, Industrial Technology Research Institute; Tsou, 1997). The larger the figures the higher significance the factor exerted.

Factors	Furniture industry	Wooden furniture
Mill owner's diligence and creativity	1.63	1.65
Skillful technician	1.43	1.55
Raw material supply	1.39	1.57
Labor cost	1.32	1.33
Design and development capability	1.32	1.37
Potentiality in new techniques	1.30	1.28
Market accessing	1.23	1.23
Cooperation within the industries	0.69	0.72
Policy assistance	0.68	0.47
Technical assistance from abroad	0.25	0.35

Table 7. Competence analysis on the furniture industries of Taiwan with several other States (Source: Investigation made by Information Division, Chemical Engineering Dept, Industry Technology Research Institute; Tsou, 1997)

Country / Factor of Competition	Italy	Germany	Mexico	China	Indonesia	Malaysia
Labor cost	0.55	0.57	-0.90	-1.58	-1.62	-1.28
Effectiveness of the facility	-1.00	-1.07	0.37	0.76	0.79	0.61
Skillfulness of workers	-0.50	-0.33	0.60	1.16	1.29	0.92
Mill scale	-0.79	-0.67	0.16	0.57	0.48	0.27
Capability in designing and development	-1.19	-0.39	0.39	1.23	1.15	1.05
Supply of raw materials	-1.05	-1.11	-1.00	-0.50	-1.29	-1.18
Products quality	-1.15	-1.05	0.70	1.08	0.96	0.70
Marketing	-1.10	-1.00	-0.85	0.00	0.00	-0.12

Note 1. Negative figures indicate the inferiority in Taiwan's competence, zero implies equal capability.
Note 2. The smaller the figure the greater the discrepancy between Taiwan and the denoted country.

Most of the mills are of small to medium size compared to those in North America, Scandinavia and Japan. The production of the 13 largest companies (with annual business volume exceeding US $ 50 millions) accounts for 60% of the total production which is 4.50 million tons, ranking the 13th in the world. Increase in production fluctuated from -1.8 to 7.5 percents during the past five years, with an average increase of 2.6 percent per year. Fig.7 shows production and per capita GNP and paper consumption in the past decade.

The raw materials used for pulp production are wood chips and wastepaper exclusively. Bagasse and bamboo have been abandoned because of environment and economic considerations. Wastepaper contributes about 74 percent of total raw materials required (Taiwan Paper Industry Association, 1998). More than 4.1 million tons of wastepaper was consumed in 1997 with 2.8 million tons domestically collected and 1.3 million tons imported .The rest 26 percent materials came mostly from exotic pulps.

Timber Supply Strategy in Taiwan

The Taiwan forest industry has been heavily relying upon imported timber (Table 8). This dependence has been strained by exporting countries trying to promote their own manufacturing development. In order to support a prosperous forest industry, Taiwan needs not only to diversify its timber purchasing but also to maintain its own sustainable supply.

It is obvious that local timber production in Taiwan has never met consumption needs and large-scale import of wood has been increasing to meet domestic requirements. It is estimated that the annual timber consumption per person in Taiwan will reach 0.265m^3 in the year 2020 (Lin, 1999). The total timber required for Taiwan will be 6.6 million m^3 assuming population growth to 24,928 thousand in 2020.

Timber harvest has been the major source of government revenue since the late forties. Prominent forestry experts were consulted in 1957 and the main objective of Taiwan forest to perpetually produce renewable resource on a sustainable basis was established. In recognizing the importance of sound living environment and preserving natural resources, people in Taiwan have strongly requested a new guideline for forest management. " Program for Reform of Forest Management in Taiwan” was promulgated in 1976. The prospects for timber production have been changing as a result of strong calls for more balanced environment after long term exploitation. However, the meaning of "sustainability" has changed through time. To enhance conservation of forest resources in Taiwan, the annual allowable cut from natural forest has been lowered from 1.5 million m^3 to 500 thousands m^3 since 1987. At the same time, multiple use of Taiwan forests has been practiced through establishing conservation and recreation areas and enhancing watershed and wildlife management. Since 1987, 640 thousand hectares of plantations in the national forests have been established.

Fig 5. Paper and board consumption, per capita GNP in the past decade.

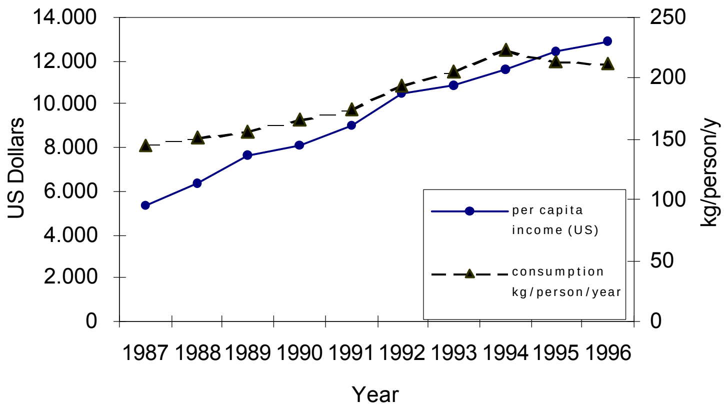


Table 8. Local timber supply and consumption in the past 20 years

Year	Local supply 1,000m^3	Total consumption 1000m^3	Percent of local supply
1975	1,027	5,323	19.3
1980	680	6,734	10.1
1985	574	6,105	9.4
1990	145	6,918	2.1
1995	40	6,528	0.6

We have relied not only on plantations to adequately increase the domestic supply of timber. Silvicultural systems developed abroad were also implemented in the late seventies. Through collaboration with a pulp and paper corporation owned by overseas Chinese in Parawan, Indonesia, Chung Hwa Pulp Cooperation and YFY paper company have successfully planted 110 thousand hectares of pulpwood. In Viet Nam, 40 thousand hectares of *Eucalyptus* for pulpwood were planted in 1993 with an investment of Taiwan capital. Another 500 thousand hectares is projected to be planted in the northern or central part of Viet Nam.

With the recognition of a resource crisis, sustained yield management has become one of the three significant guiding principles of Taiwan forestry. The long established “Timber Production Center in Taiwan" project was seriously promoted by the Council of Agriculture in 1995. Three guidelines were postulated in the plan (Lin, 1996):

1) At least two plantation centers, each of 10 thousands hectares, must be selected from the eight forest management districts on the island, with a goal of 20 centers in total.
2) The least average annual growth per hectare in each center is set to be 5 cubic meters.
3) After the establishment, 200-300 hectares could be harvested annually in each center. A total of 6,000 thousand hectares forest land could be felled and reforested, resulting in an annual timber production of 2 million m^3 and a total of 400 thousand hectares plantation forest within 20 years.

Many forestry programs have been lagging sharply since 1987 as a result of a significant financial crisis in the Taiwan Forest Bureau, which played a key role in forest management in the past. The deficit came partially from the sixfold increase of average wage costs and partially from lack of adaption to the quick change of forest management direction. As of 1996, nearly 80 thousand hectares have been planted in the 25 established plantation centers, 75 thousand hectares were found to be too rugged and inaccessible to be reforested. Some 82 thousands programmed hectares were suspended by the ban of natural forest cutting.

Conclusions

The area of the Asian forest has been steadily decreasing, while consumption of roundwood has increased by 6.6 percent between 1992 and 1996. Exports of industrial roundwood from Asia decreased at an average annual rate of 9.2 percent from 1992 to 1996 while world exports increased an average of one percent. Management of plantation forests has long gained attention throughout Asian countries due to the large-scale depletion of forest resources. Taiwan has been under tremendous pressure from environmental groups to reduce the extraction of timber from natural forests. Actions to maximize the utilization of plantation forests in Taiwan have been emphasized. The most important change in Taiwan forestry is that timber production is becoming less important. Forests have become a source of recreation, soil and water and biodiversity conservation and wildlife habitat.

With the ever growing enjoyment and appreciation of wood products, including paper and board, coupled with the restriction of log and lumber exports, the assurance of timber supply in Taiwan in the future is a very significant challenge that government and industry people will be facing. It is suggested that the non-cutting policy in natural forests should be reviewed as soon as possible and revised every five years by government and wood industries from the standpoints of international wood supply and the global village concept.

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Sustainable Roundwood Supply in the Republic of Korea

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Abstract

The timber market of the Republic of Korea can be characterized as being 1) import-oriented supply and 2) domestic-oriented demand. Recently, import patterns have also been changing as follows: 3) from hardwood to softwood, 4) from high to low quality, and 5) from roundwood to wood products. These 5 characteristics indicate that the Republic of Korea is a typical country importing wood-based raw materials, and today faces difficulties in securing a sustainable supply of roundwood through both domestic production and imports. As a method meeting the needs of environmental protection while securing a stable supply of wood based materials, the establishment of overseas plantations of fast-growing tree species has been decided upon by Korean companies and government. It is primarily aimed at ensuring a sustainable supply of wood materials. The Korean Government also aims to avoid disadvantages as a log consumer country and to gain a good reputation as a country that contributes to preserve the global environment. In establishing plantations, there are basic principles proposed by the Government. Fast-growing tree species would be favoured and countries which are geographically close would be preferred to other countries farther afield. In any case, the political and economic safety of investments should be secured. To ensure the security of investment, a series of security pacts with partner countries have been concluded. For investment safety from the economic viewpoint, reports detailing the investment environments of various countries such as Malaysia, Vietnam, Myanmar, New Zealand, Australia, Solomon, PNG, Chile and China have been issued. The Government also finances corporations or personal investors who plan to establish plantations overseas. 90-100% of the cost of establishing plantations is financed with a low interest rate of 3%. The financing period is 10-20 years for fast-growing tree species and 28 years for tree species of long rotation.

Keywords: Timber market of Republic of Korea, Environment protection, Export restriction, Sustainable supply of roundwood, Establishment of fast-growing plantations, Support policies.

Introduction

The Republic of Korea has relatively poor forest resources compared with other Asian countries. As of 1997, in the Republic of Korea about 65 % of the total land area is covered with forest land, of which about 80% was newly afforested during the last 30 years and today represents a relatively young stage of forest. The average timber growing stock per ha is consequently very low at about 56 cubic meter as of 1998. This young forest is not expected to supply sufficient timber products to meet the national demand.

The Republic of Korea is inevitably a consumer of wood-based materials. At present about 90% of all roundwood used in the Republic of Korea is being imported. In recent years, the Republic of Korea has, however, experienced increasing difficulties in importing the roundwood, due to increases in log export restrictions in producer countries and world-wide concerns about environmental protection.

The objective of this paper is to review the import trends of roundwood and to examine various strategies for ensuring a long-term sustainable supply to the Republic of Korea.

Demand and Supply of Roundwood in Republic of Korea

Roundwood Demand

The total roundwood demand in the Republic of Korea increased dramatically in the early 1970s, peaked in 1978 and decreased rapidly towards 1982. Since then the total demand for roundwood has tended to increase slightly, showing fairly similar trends to the domestic demand, as can be seen in Fig 1a.

The roundwood demand for export had increased until 1977, exceeding the demand for domestic use. In the mid 1970s, about 60-70% of the total roundwood consumption occurred in wood-based industries producing wood products, especially plywood for export. After reaching the maximum in 1977, the demand for roundwood in the export sector began to decrease and dropped to 300 thousand cubic meters in 1990. Since then the demand of roundwood for export has remained fairly constant at low levels.

In contrast, the demand for roundwood for domestic use has been steadily increasing. It had drastically increased during 1976-1979, reaching the maximum in 1979, and dropped again towards 1981 during the oil shock period in 1979-1981. Since 1981, the domestic demand of roundwood has tended on the whole to increase slightly, determining the trend of total demand of roundwood, though there were slight fluctuations in this trend. The demand for roundwood for domestic use in 1997 has increased about 104% of its value in 1977, while the demand for export in 1997 has decreased about 94% over the same period.

The economic crisis which began in 1997 caused a dramatic decline in domestic and total demand of roundwood in 1998, while the demand of roundwood in export-oriented industries increased a little, perhaps due to the devaluation of the Korean currency and the resulting price competitiveness of wood products made in Korea.

Demand for Domestic Use

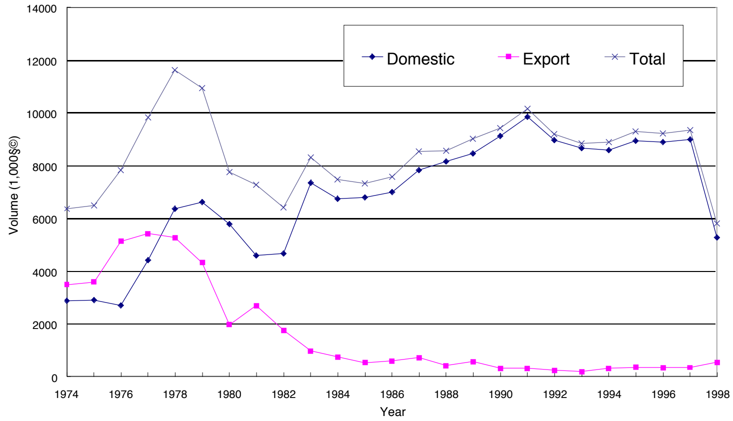
The demand of roundwood for domestic use shows a generally increasing trend, being very sensitive to the demand for sawnwood, which is mainly used by the domestic construction industry (Fig 1b). The yearly fluctuation of the domestic demand is very similar to the demand for sawnwood. The roundwood demand for producing pit props, plywood and pulp has stayed almost constant, not influencing the trend of the domestic demand. Here we can see that the roundwood market in the Republic of Korea is heavily dependent on the domestic construction industry. It appears that the construction industry would determine the demand for sawnwood which would again determine the domestic and total demand of roundwood.

Demand for Export Use

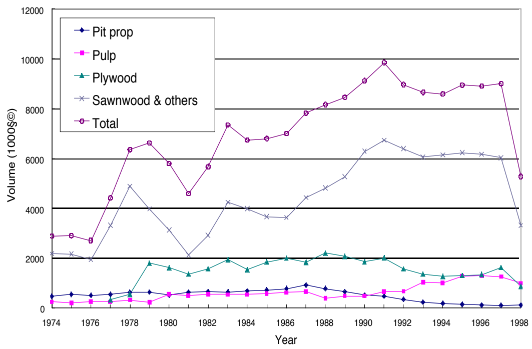
The tendency of the demand of roundwood for export use had followed a pattern similar to the demand for producing plywood to be re-exported to the middle of 1980s and since then has shown a rather similar pattern to the demand for producing sawnwood which has remained almost unchanged, though perhaps decreasing slightly (Fig 1c). Up to the mid 1980s, most of the roundwood in the export sector had been used for producing plywood. During the 1970s, the wood based market in the Republic of Korea was very dependent on the plywood processing industry, in which roundwood imported from southeast Asia was processed to plywood to be re-exported (FRI 1997b).

The demand for roundwood in the export-oriented plywood industry declined markedly after 1977, causing the decreasing tendency of roundwood demand in the export sector. It had been combined with the non-export policy of roundwood in producer countries since the late 1970s. Various policies prohibiting log exports in producer countries caused an increase in the price of roundwood on the international log market and accompanied difficulties in the availability of overseas roundwood to the Republic of Korea. In the long run, the competitive power of plywood made by Republic of Korea had been weakened in the international plywood market, the plywood industry in Korea had been on the decline, and the demand for roundwood for plywood also declined.

Fig 1. Total demand of roundwood (a), the demand of roundwood for domestic (b) and export (c) use (Source: Forest Administration 1999)



(a)



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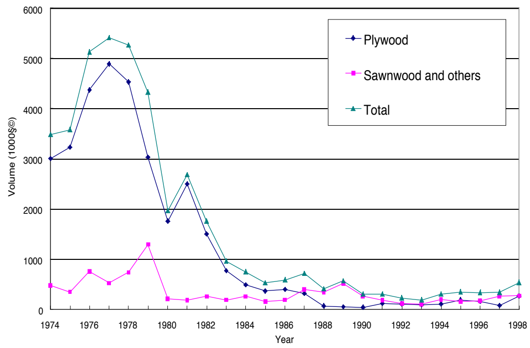


(c)

Supply of Roundwood

Fig. 2a represents the trend of roundwood supply in the Republic of Korea since the 1970s. As a whole, import of roundwood shows an increasing trend, fluctuating between 6,000 and 8,000 thousand cubic meters. In contrast, the domestic supply of roundwood remains almost constant at round 1,000 thousand cubic meters. The increasing rate of roundwood imported from 1980 to 1997 amounts to around 35%, while roundwood supplied domestically increased only 5% over the same period. Most of the roundwood demand in the Republic of Korea has been met by imported roundwood and only about 12-15% has been supplied domestically.

Domestic Supply of Roundwood

The domestic supply of roundwood shows a similar trend to the pit prop use until 1990 (Fig 2b), indicating that most of roundwood supplied domestically had been used for pit props over the period. Production of roundwood showed a minor increase due to increasing demand of pit props until 1987. Since then consumption of domestic roundwood for pit props had drastically decreased and today marks only about 100 thousand cubic meters. In contrast, use of domestic roundwood for sawnwood has increased since 1989, offsetting the decreasing use for pit props. Consumption of domestic roundwood for pulp had increased slightly from about 200 to 400 thousand cubic meters from 1974 to 1998. The domestic supply of roundwood as a whole shows little decrease

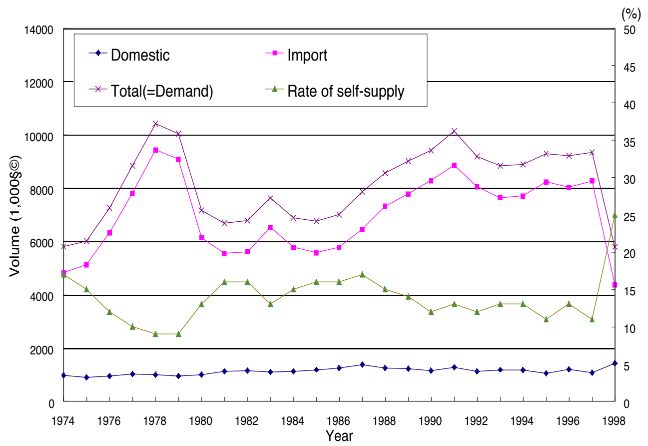
Roundwood Supply by Import

Fig. 2c shows the roundwood supply from overseas and it's uses. The import of roundwood had followed a similar trend to the export use in 1970s and the domestic use during 1980-1990s. Up to 1978, most imported roundwood had been used for producing plywood to be re-exported. But the use of imported roundwood in the export sector had decreased markedly from about 5,000 to 500 thousand cubic meters from 1978 to 1985, and remained at 500-600 thousand cubic meters until 1989 and since then at 300 thousand cubic meters. In contrast, the domestic use of imported roundwood has increased steadily since 1981. The volume of domestically imported roundwood use in 1997 increased about 175% of its value in 1981, while the volume for export use decreased about 87 % over the same period. Today, most imported roundwood is used for domestic wood based industry, especially for producing sawnwood - mainly used for construction purposes.

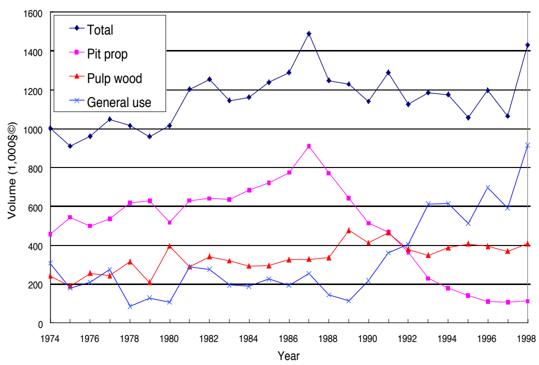
Roundwood Import by Region

Importing hardwood from South East Asian countries such as the Philippines, Malaysia, and Indonesia has decreased steadily, while importing softwood from other nations such as New Zealand, Chile, U.S.A., and Russia has increased. Since 1989 the imported log volume from temperate or boreal regions has exceeded that from South East Asian (Fig 3a).

Fig 2. Total supply of roundwood (a), domestic supply (b) and import supply (c) (Source: Forest Administration 1999)



(a)



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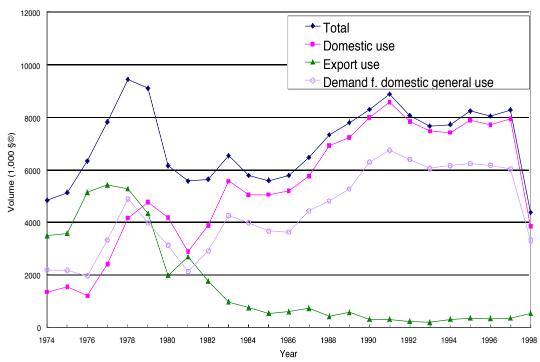


(c)

Tropical hardwood had been imported mainly from Indonesia, Malaysia and the Philippines up to the mid 1980s (Fig 3b). However, imports of roundwood from Indonesia had drastically decreased from 1978 to 1982 and there have been no roundwood imports from Indonesia since 1985. A small quantity of roundwood were imported from the Philippines up to 1986, since then there has also been no more roundwood trade with the Philippines. Yearly around 2,000 - 3,000 thousand cubic meters of roundwood had been imported from Malaysia from 1977 to 1992, representing the highest ranking in volume of roundwood imported from tropical lands. But it dropped to about 1,000 thousand cubic meters in 1993 and has continued to decrease so that today only 300 thousand cubic meters of roundwood are imported from Malaysia. Over the past 20 years, import of roundwood from PNG including the Solomons has increased to a small extent and was composed of about 60% of roundwood imported from tropical forest in 1997.

The partner countries for importing softwood have changed from USA to New Zealand, Chile and Russia (Fig 3c). Up until the early 1990s, most softwood logs had been imported from the USA. Import of softwood logs from the USA had increased to 1989 and then began to decrease, drastically while import from New Zealand, Chile and Russia went up since the early 1990s. Today most softwood logs are imported mainly from New Zealand (46%) and Chile (24%). From USA and Russia, about 11% of softwood logs are imported respectively, showing a decreasing trend from the USA and an increasing trend from Russia.

Roundwood Import by Tree Species

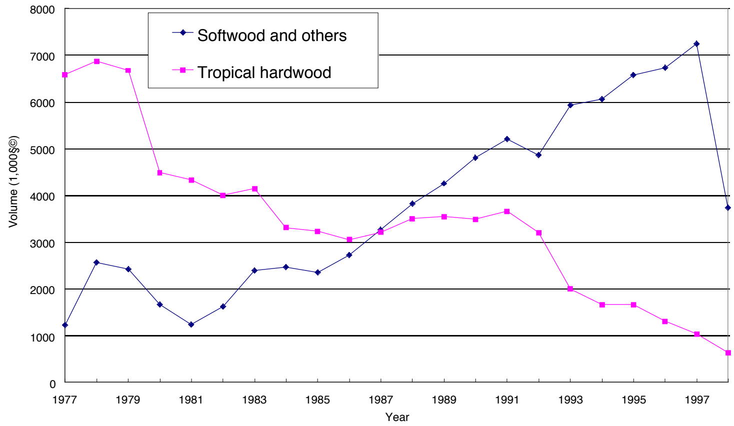
The main tree species of imported roundwood changed from tropical hardwood to temperate and boreal softwood. The ratio of tropical hardwood in imported logs has declined sharply, whereas the volume of softwood has increased. Of the roundwood volume imported in 1980, 73% was tropical hardwood and 27% temperate softwood. But it changed in 1997, so that tropical hardwood amounted to only 16% and temperate and boreal softwood occupied about 84% of imported roundwood (Fig 3a). Correspondingly, there have also been changes in tree species and quality, changing from high to low quality. In the case of hardwoods, Lauan of high quality has been substituted with Keruing and finally MLH (Mixed Light Hardwoods) of relatively low quality. In softwoods, Douglas fir of high quality, mainly imported from the USA, has been substituted with low quality radiata pine from New Zealand and spruce from Russia (Table 1).

Flow of Roundwood in Republic of Korea in 1997

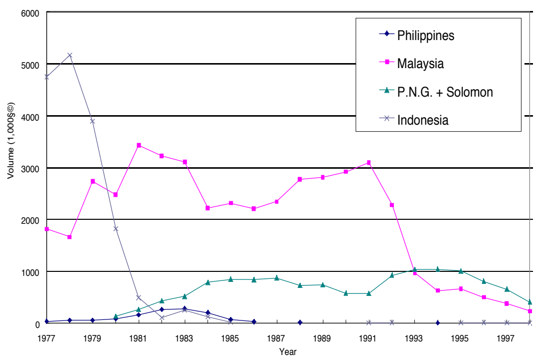
Fig. 4 represents the marketing flow of roundwood in the Republic of Korea in 1997. Roundwoods supplied domestically were all consumed domestically. For the year 1997, roundwoods produced domestically totalled 1,062 thousand cubic meters of which 55% were used for sawnwood and other wood products, 35% for pulpwood, and 10% for pit props.

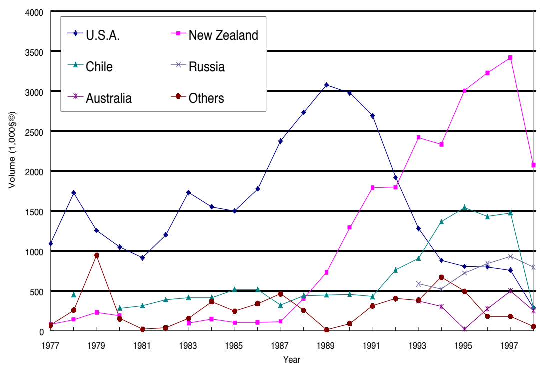
Of the imported roundwoods, amounting to 9,328 thousand cubic meters, about 96% were consumed domestically and only 4% were used for sawn- and plywood to be re-exported. All roundwoods demanded for export were imported. About 68% of the domestic consumption of imported roundwoods occurred for sawnwood and other wood products, 20% for plywood, and 12% for pulp respectively. All the roundwood required for pit props was domestically supplied, while all roundwood required for plywood was imported. Of the roundwood for producing pulp used domestically, 71% was imported and 29% was supplied domestically. About 90% of the roundwood used for producing sawnwood and other wood products consumed domestically was imported and only 10% was supplied domestically. As a whole it can be seen that producing sawnwood and other wood products for domestic use led the roundwoods market in Republic of Korea.

Fig 3. Roundwood import of soft- and hardwood(a), roundwood import of hardwood (b), roundwood import of softwood (c) (Source: Forest Administration 1999)



(a)

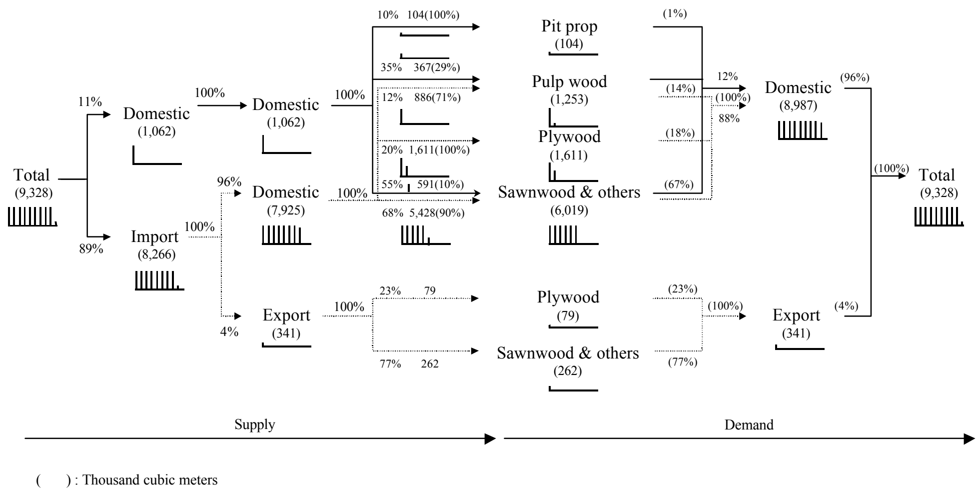




(b) (c)

Of the imported roundwoods, amounting to 9,328 thousand cubic meters, about 96% were consumed domestically and only 4% were used for sawn- and plywood to be re-exported. All roundwoods demanded for export were imported. About 68% of the domestic consumption of imported roundwoods occurred for sawnwood and other wood products, 20% for plywood, and 12% for pulp respectively. All the roundwood required for pit props was domestically supplied, while all roundwood required for plywood was imported. Of the roundwood for producing pulp used domestically, 71% was imported and 29% was supplied domestically. About 90% of the roundwood used for producing sawnwood and other wood products consumed domestically was imported and only 10% was supplied domestically. As a whole it can be seen that producing sawnwood and other wood products for domestic use led the roundwoods market in Republic of Korea.

Fig. 4: Market flow of roundwood in Republic of Korea in 1997(unit: 1,000 cubic meter)



Import of Wood Products

In Fig. 5, an obvious shift in imports from roundwoods towards high-priced wood products can be clearly seen. Starting from 1991, the increasing trend of roundwood import turned to a slightly decreasing trend. In contrast, the import of wood products such as ply- and sawnwood tended to increase steadily since the mid 1980s and its volume exceeded the volume of roundwood imported since 1988. While imported log volumes by 1997 were almost the same as those of 1990, the imported wood products increased by about 39% over 1990-1997. These increasing imports of wood products were accompanied by log export prohibition in producer countries (FRI 1997b).

Characteristics of the roundwood market in Korea

The timber market of the Republic of Korea can be characterized by 1) import-oriented supply and 2) domestic-oriented demand. Recently, the import pattern has changed as follows: 3) from hardwood to softwood, 4) from high to low quality, and 5) from roundwood to wood products. These 5 characteristics indicate that the Republic of Korea is a country importing wood based raw materials and today faces difficulties in sustaining a supply of roundwood through both domestic production and import. As one of the consumer countries of wood materials, the Republic of Korea would not like to have a reputation as being a country causing the deforestation of tropical forests with associated harmful effects on the global environment. It would thus be very important for the Republic of Korea to stabilize the supply of wood based materials, especially roundwood, without any destruction of both domestic and foreign forests

Strategies for Sustainable Timber Supply in Industry

The view that exports of roundwood are being curbed by producer countries motivates wood-based companies in Republic of Korea to invest directly in tropical and sub-tropical countries. Plantations of fast-growing hardwood species are being established by several wood-based companies to meet the anticipated increases in the demand for wood-based materials, as a long-term means of coping with a shortage of raw material (KFS 1999). Up to date, about 270 thousand forest concessions from 7 countries were acquired and a total plantation area of about 32 thousand ha has been established with such fast-growing species as *Acacia mangium* (Vietnam), *Eucalyptus* (Australia, Solomon), and radiata pine (New Zealand) by several companies (Table 2).

Table 2: Establishment of plantation in tropical and sub tropical countries by several companies (KFS 1999). Unit: ha

Year	Australia	New Zealand	Solomon	Vietnam	Indonesia	China	Sum
1993	508	-	-	-	-	-	508
1994	1,000	-	-	498	-	-	1,498
1995	854	-	413	1,124	-	-	2,391
1996	2,248	504	1,796	956	1,150	-	6,654
1997	2,035	1,515	2,016	1,000	510	-	7,076
1998	1,400	1,300	2,010	1,786	1,100	150	7,746
1999	2,013	1,000	1,513	-	577	1,250	6,353
Sum	10,058	4,319	7,748	5,364	3,337	1,400	32,226

In the economic view, roundwood production from plantations in tropical and subtropical countries is considered more profitable in relation to cost, price and yield. For example, the planting cost of radiata pine in a plantation would be only one third of the planting cost for *Pinus koraiensis* in the Republic of Korea while 5 times the volume could be yielded with the same rotation period of 30 years (KFS 1999). The price of roundwood from plantations established by Korean companies in tropical and subtropical countries would be 40-60% of the price of roundwood imported (KFS 1999).

Various projects to promote the establishment of plantations have been carried out by the Korean government. According to the Korea Forest Service (KFS, 1999), about 1 million ha of plantation is planned to be established by 2050, and about 50% of the roundwood demand in the Republic of Korea will be met by wood materials produced in the plantations (Table 3).

Support system

In establishing plantations, there are basic principles proposed by the government. Fast-growing tree species would be favoured and countries located geographically nearby would be preferred to more distant countries. In any case, political safety of investments should be secured, therefore the political stability of the partner countries plays an important role in the decision-making process prior to investment. To ensure the security of investments, a series of security pacts with partner countries have been concluded. Forestry pacts with Indonesia, Russia, New Zealand, Australia, China, Vietnam and Myanmar have already been concluded, and forestry pacts with other countries will be set in process (KFS, 1999).

Investment security in the economic view is also a very important principle in decision-making. It is important for successful investments in foreign countries to have accurate information on partner countries. False information or lack of good information would hinder the success of investments. Thus political, economic, social and cultural information on partner countries has been compiled by the Forestry Research Institute and distributed to investor companies. In recent years, reports on the investment environment of several countries such as Malaysia, Vietnam, Myanmar, New Zealand, Australia, Solomon, PNG, Chile and China have been issued (Forest Administration, 1996; FRI, 1994,1996,1997a,1998a,1998b). In these reports, the political and economic situations, information on forest resources and forestry, infrastructure, laws and institutions related to forest, and incentives for investment were detailed.

Various projects to promote the establishment of plantations have been carried out by the Korean government. According to the Korea Forest Service (KFS, 1999), about 1 million ha of plantation is planned to be established by 2050, and about 50% of the roundwood demand in the Republic of Korea will be met by wood materials produced in the plantations (Table 3).

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The Government also finances companies or personal investors who plan to establish plantations overseas. 90-100% of the cost of establishing plantations is financed with a low interest rate of 3%. The financing period is 10-20 years for fast-growing tree species and 28 years for tree species with a long rotation.

Conclusion

It is not anticipated that the domestic supply of roundwood in the Republic of Korea will improve sufficiently to meet the roundwood needs in the near future. The current demand for roundwood will inevitably rely upon imports for some time. In view of environmental concerns, importing wood materials in the form of roundwood will be more difficult in any case. Accordingly, in the long run, the Korean government needs to make efforts to improve its own forest resources and to diversify its log imports from overseas. As a method meeting the needs of environmental protection while stabilising a supply of wood-based materials, the establishment of plantations of fast-growing tree species overseas has been decided upon by Korean companies and government.

Table 3: Long term plan for log supply in Republic of Korea (KFS, 1999) 1) Plantation area in overseas

	1997	2010	2020	2030	2040	2050	Unit
Plant. Area [1)]	32	334	534	734	936	1,000	1,000ha
Log supply	9,328(100)	30,746(100)	35,348(100)	38,559(100)	40,531(100)	42,043(100)	1,000m^3
Domestic	1,062 (11)	3,234 (10)	4,635 (13)	6,844 (18)	9,486 (23)	12,574 (30)	1,000m^3
Import	8,266 (89)	23,312 (76)	22,295 (63)	19,315 (50)	14,645 (37)	8,669 (21)	1,000m^3
Plantation	-	4,200 (14)	8,400 (24)	12,400 (32)	16,400 (40)	20,800 (49)	1,000m^3

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Criteria and Indicators For Sustainable Forest Management at The U.S.A. National and Regional Level

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Abstract

At a variety of scales, and in a number of arenas, efforts are underway to define "sustainable forest management" and to measure it (or progress toward it) using criteria and indicators. The purpose of this paper is to use readily available information to describe several broad scale measures that can be used both to describe the state of ecological and social conditions and in a discussion of joint consequences of various management actions. Here we develop an index of timberland integrity that is a combination of six measures of various indicators of forest condition and status. We used growing stock value as a measure of the various economic and social criteria, i.e., a broad proxy for timberland wealth. These broad-scale composite measures helped us to look at the notion of tradeoffs, compatible production, and the integrative nature of ecosystems. Our experience suggests that scientists can contribute to both developing individual broad scale measures and composite indexes and the process for aggregation to higher spatial scales and thus make the discussion about sustainable forest management more productive.

Keywords: Sustainable forest management, Criteria and indicators

Introduction

At a variety of scales, and in a number of arenas, efforts are underway to define "sustainable forest management" and to measure it (or progress toward it) using criteria and indicators. Efforts like the Montreal Process share: a desire to provide a factual basis for increasingly contentious policy debates; recognition that some information is more important in the sense of being policy relevant; and knowledge of the fact that success in condensing a large quantity of complex information will "add-value" and help focus policy debates on critical issues. In the United States (which is attempting to use the Montreal Process) we are just seeing "first approximation"[1] types of reports that focus on developing measures of the criteria and indicators.

Measurement of criteria and indicators for sustainable forest management poses two challenges for the science community. First there is the empirical challenge that focuses on the process of developing broad scale measures of ecosystem condition from highly disparate data often at different spatial scales. The second challenge is to develop judgments relative to sustainable forest management based on broad scale measures developed from various combinations of indicator variables. The purpose of this paper is to use readily available information to describe several broad scale measures that can be used both to describe the state of ecological and social conditions and in a discussion of joint consequences of various management actions.

This exercise is entered into acknowledging that the Santiago Declaration stated that "(t)he C & I should be used as a complete set and when applied as such, provides an implicit definition of the sustainable management of forest ecosystems. No single Indicator implies sustainability when isolated and should be considered within the context of the other C & I." At the same time the Declaration recognized that "(t)he C & I contain some Indicators that may not be quantifiable at this time for any or all of the signatory countries." In fact 79% of the indicators in Criteria 1-6 are described as data availability being a problem. We feel that to meet our objective of focusing the discussion on broad scale measures, it is not feasible or necessary to wait for agreed upon measures of all criteria.

Background

[1]See the report for the state of Oregon (Oregon's Forests at the Millennium. First Approximation Report 1999 http://www.odf.state.or.us/FAR/FARdefault.html).

In this paper, we focus on developing two broad scale measures that allow us to link together the concepts of sustainable interactions between humans and ecosystems to maintain ecosystem integrity. We have been influenced by work done for large-scale ecoregion assessments that attempted to develop explicit measures for broad scale goals of ecological integrity and some socioeconomic counterparts such as resiliency (Quigley *et al*. 1996, Haynes *et al*. 1996). In this context, ecological integrity refers to the presence and functioning of ecological components and processes. The social and economic counterpart to ecological integrity is resiliency, which in the context of ecosystem sustainability reflects the abilities of people to maintain well-being through personal and community transitions. In practice, both of these are composite measures of ecosystem condition and function that are derived from more specific ratings for individual processes or functions. Often these individual ratings for individual indicators are based on proxies that represent relative conditions. We acknowledge that much of this effort will involve value judgments.

Development of Two Broad Scale Measures

Our two broad scale measures are timberland integrity and timberland wealth. Both of these are narrower measures than those defined above but our purpose is to assess the prospects for forest management rather than the broader concerns about complete ecosystems. We will develop these measures for both the United States and for four major regions within the United States. Our discussion includes the basis for and the construction of the two measures, hierarchical concerns, and policy inferences. Much of the data comes from the periodic Timber Assessments required in the United States as part of the Resources Planning Act (Haynes *et al*. 1995). On the biophysical side we develop what we call an index of timberland integrity (mostly based on indicators found in the first two criteria from the Montreal Process, see Appendix). For the socioeconomic criterion we use a very broad proxy — gross value of U.S. growing stock inventory or timberland wealth.

The timberland integrity index was developed in an exploratory fashion to illustrate the usefulness of a broad scale composite measure for U.S. timberlands. Some of the current broad scale assessments of either ecological conditions (Committee of Scientists, 1999) or those concerned about the conservation of biological diversity of forests assume the premise that ecological conditions of U.S. forests are in decline. These inferences are generally based on a collection of various anecdotes rather than a more systematic consideration of data.

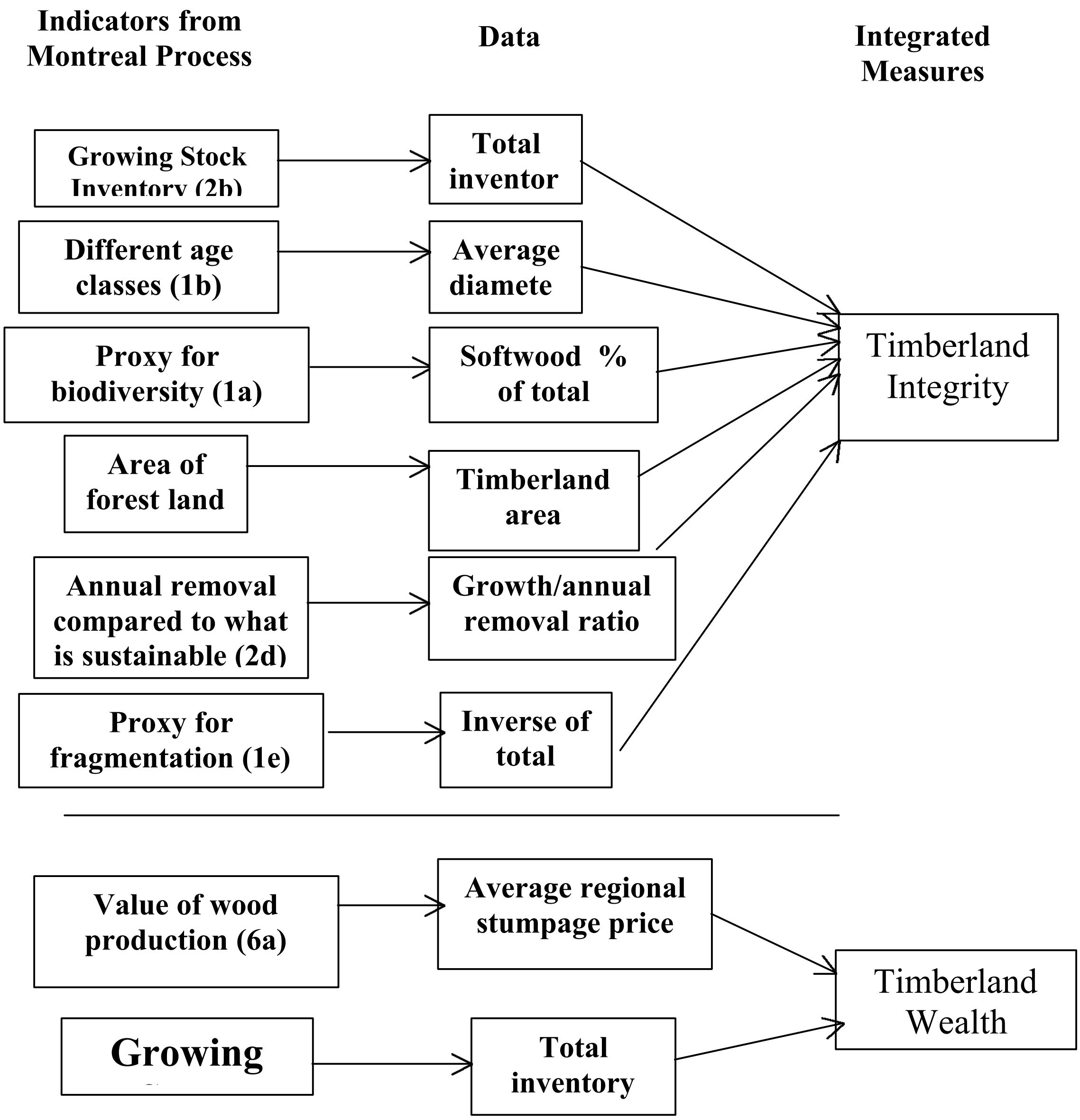
Here we develop an index of timberland integrity that is a linear combination of six measures of various indicators of forest condition and status. These indicators are growing stock inventory[2], area of timberland, annual growth to removal ratio, and proxies for fragmentation (inverse of total harvest), age class structure (average diameter), and biodiversity (softwood percentage of total inventory). Figure 1 shows the general representation and the cross walk of the selected variables with those from the Montreal Process. The data is shown in table 1 and is taken from the 1993 RPA Timber Assessment Update. The data is for the national level but later we will discuss the implications for different regional representations. The actual index was constructed by converting each data series into indices where 1952 equals 100, than summing the indices where each indicator has equal weight (different weights will be discussed), and finally dividing by the number of variables in the index.

The results (equal weight line shown in figure 2) illustrate that there has been a general decline in timberland integrity since 1952 but the decline has slowed in the 1990s and is expected to stabilize in the future. Several interesting trends are hidden in the index. First, increases in overall growing stock inventory offset increased fragmentation and slow the shift from softwood to hardwoods. Second, these changes take place against a 250 percent increase in harvest during the nearly

[2]All inventory definitions follow U.S. Forest Inventory and Monitoring definitions. See Powell and others (1992) for specific definitions.

90-year period (1952 to 2040). In terms of magnitude of change the greatest change took place between 1976 and 1986. Changes both before and since involve smaller magnitudes.

Figure 1–Schematic for integration at the broad scale[1]



The proxies for the Indicators from the Montreal Process shown in Table 1 and plotted in Figure 2 provide a starting point for discussions about how to quantify the concept of sustainability at the broad scale. Using this process it is possible to discuss, and hopefully reach some consensus about, the relative importance or weights of the different Criteria and Indicators for evaluating sustainability. For example, some might argue that Average Diameter is relatively more important than some of the other indicators because it measures the ability of forested landscapes to provide multiple values such as habitat for cavity nesting species, hibernacula for large over-wintering animals, coarse woody debris, and high value clear timber. Others might counter that Total Inventory is relatively more

[1] See Appendix for Montreal Process Criteria and Indicators

important than the other indicators because it measures the suitability of forested areas to provide a different range of values. The methods described here may facilitate such debates by providing a way to quantify and illustrate differences that are not possible through discussion alone. This process is illustrated in Figure 2 where the base case, all indicators given equal weight, is contrasted with the two scenarios proposed here. In the first, Average Diameter is given a 5X weight (Dia 5X) and all other indicators given equal weight. If this indicator is considered relatively more important than the others, under this projection timberland integrity decreases at a faster rate. In the other, Total Inventory is given a 5X weight (Inv 5X) and all other indicators are given equal weight. In this scenario, the weighting of timber inventory increases timberland integrity above historical levels. We can see that depending on what consensus is reached about the relative importance of the various indicators, the magnitude if not the shape of the curve could change markedly and with it our perception of the broad scale sustainability of a region.

Broad scale measures covering socioeconomic indicators, societal benefits, and institutional criterion that make up 58 percent (39) of the indicators in the Montreal Process, have been especially elusive. In recent Forest Service ecoregion planning efforts broad scale socioeconomic measures were developed using the concepts of social and economic resiliency (Horne and Haynes 1999). In this sense resiliency is a measure of the extent that human systems are adaptable to change, that "sense of place" is recognized in management actions, and that the mix of goods, functions, and services that society wants from ecosystems is maintained. This approach is difficult to apply at the national level where recent related discussions have been more in the context of expanding the National Income and Product Accounts to include the environment. The first attempt to add forests used gross forest value[1].

We used the gross variable of the growing stock value (Figure 3) as a relatively parsimonious measure of the various economic and social criteria, i.e., a broad proxy for ecosystem wealth. The essential data is summarized in Tables 2 and 3 where the data sources are again the 1993 RPA Timber Assessment. The construction of the index is much the same as for timberland integrity except the national index is a weighted index where the weights are the regional proportions of total inventory (this follows the convention in the U.S. of using volume weighted average prices for regional proxies).

Our intention is to contribute to the emerging discussion of Sustainable Forest Management as well as the general interest in understanding how broad conditions have changed. In the next section we will look at one policy context where we use this index and a measure for timber wealth to discuss the extent that changes in timberland integrity have resulted in reductions in timberland wealth. Or as some in the environmental movement would like to believe that the forest landscape is unraveling because landowners do not act in the forest's best interest to preserve biodiversity and ecosystem wealth.

Discussion

The choice of measures and proxies used in this analysis was in part dictated by the ability to project changes in these measures based on accepted forecasts. There are other broad-based measures suggested in the Montreal Process that would lend themselves to historical analysis, especially under Criteria 6, including forest products percentage of GDP, employment in the forest sector, and others. The addition of these measures would add richness to the discussion of where we have been but the lack of useful projections of these indicators does not allow analysis of where we are headed.

[1]Nordhaus and Kokkelenberg (1999) review this effort and offer a number of suggestions for an improved measured of the economic contribution of forests.

Table 1. Indexes of timberland integrity

Year	Inventory	Diameter	Softwood Inventory	Area	Growth/ Harvest	Harvest	Total
1952	100		100	100	100	100	100
1962	108		96	101	126	105	107
1970	114		94	99	128	90	105
1976	119	100	87	97	134	85	104
1986	124	76	84	95	98	62	90
1991	128	75	82	96	96	61	90
2000	131	68	80	94	90	56	86
2010	138	68	81	93	89	52	87
2020	145	67	84	92	83	48	87
2030	150	67	86	91	80	46	87
2040	154	66	87	91	75	43	86

Figure 2. U.S. Timberland Integrity

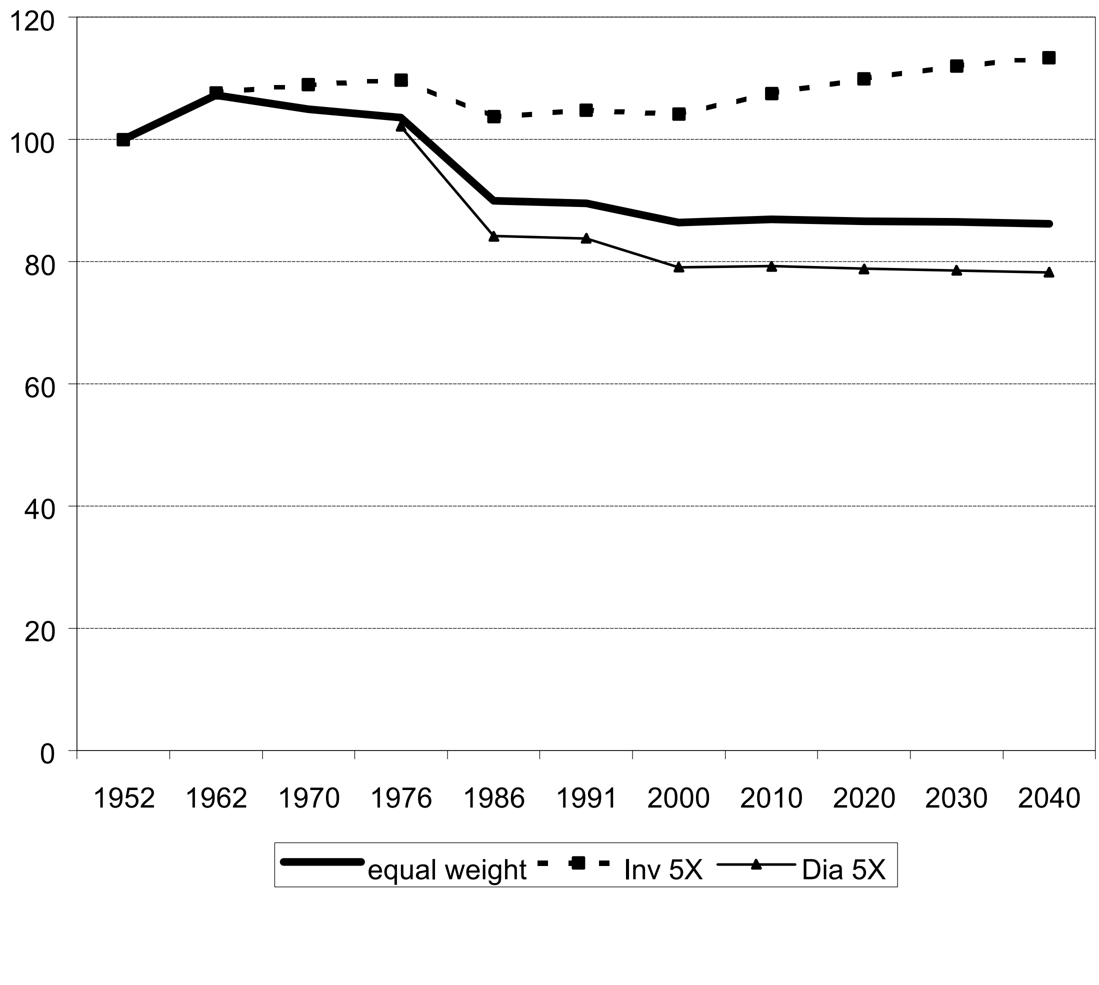


Figure 3. U.S. Timberland Wealth

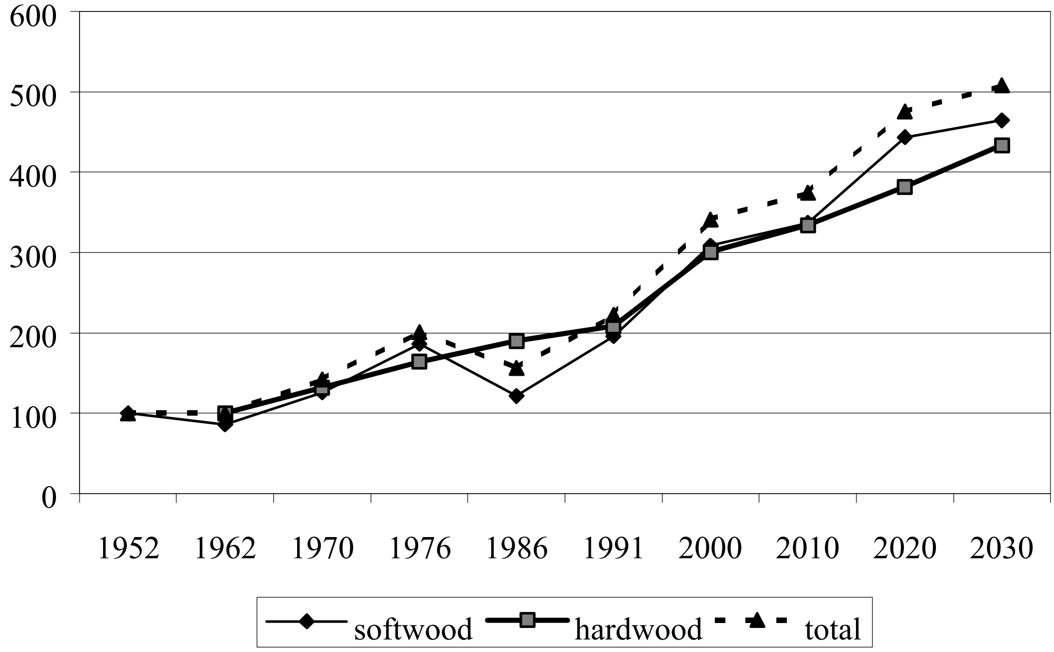


Table 2. Softwood inventory price, billion 1982 dollars

Year	Total	North	South	Rocky Mtns.	Pacific Coast
1952	137	12	39	12	74
1962	118	10	41	9	58
1970	173	10	53	17	92
1976	256	11	71	32	142
1986	167	6	54	15	91
1991	269	12	62	28	166
2000	423	22	116	73	212
2010	462	38	141	79	205
2020	608	47	164	108	288
2030	637	58	162	118	300

Table 3. Hardwood inventory price, billion 1982 dollars

Year	Total	North	South	West
1962	51	34	15	1
1970	67	41	25	2
1976	83	46	35	2
1986	97	65	29	3
1991	106	73	30	3
2000	153	102	49	2
2010	170	109	58	2
2020	194	123	68	3
2030	220	142	75	3

National indices can mask differences that only become apparent in less aggregate analysis. Figure 4 shows the timberland integrity measure for the four U.S. regions. The national historical trend shown in Figure 2 was clearly being driven by the eastern region (North and South). Projections 2000 and beyond are based on the 1993 RPA estimates and may change with the next revision due later this year.

Similarly the regional timberland wealth index (Figure 5) shows that the projections for the western region have a much different trajectory than the rest of the country. An even more disaggregated analysis could further refine regional influences.

These estimates are based on broad proxies for various processes. Some of the proxies for ecological measures, for example, reflect structure rather than the underlying process. We did not presume to have measured nor revealed the absolute levels of ecosystem integrity or resiliency. Rather, these ratings represent a first attempt at estimating integrity and resiliency at this spatial level. Given more time and information, integrity indices might include direct consideration for elements such as recovery cycles, synergistic interactions between environmental components and biophysical linkages, and feedback mechanisms operating on different spatial and temporal scales within the area.

Figure 4. Regional Timberland Integrity

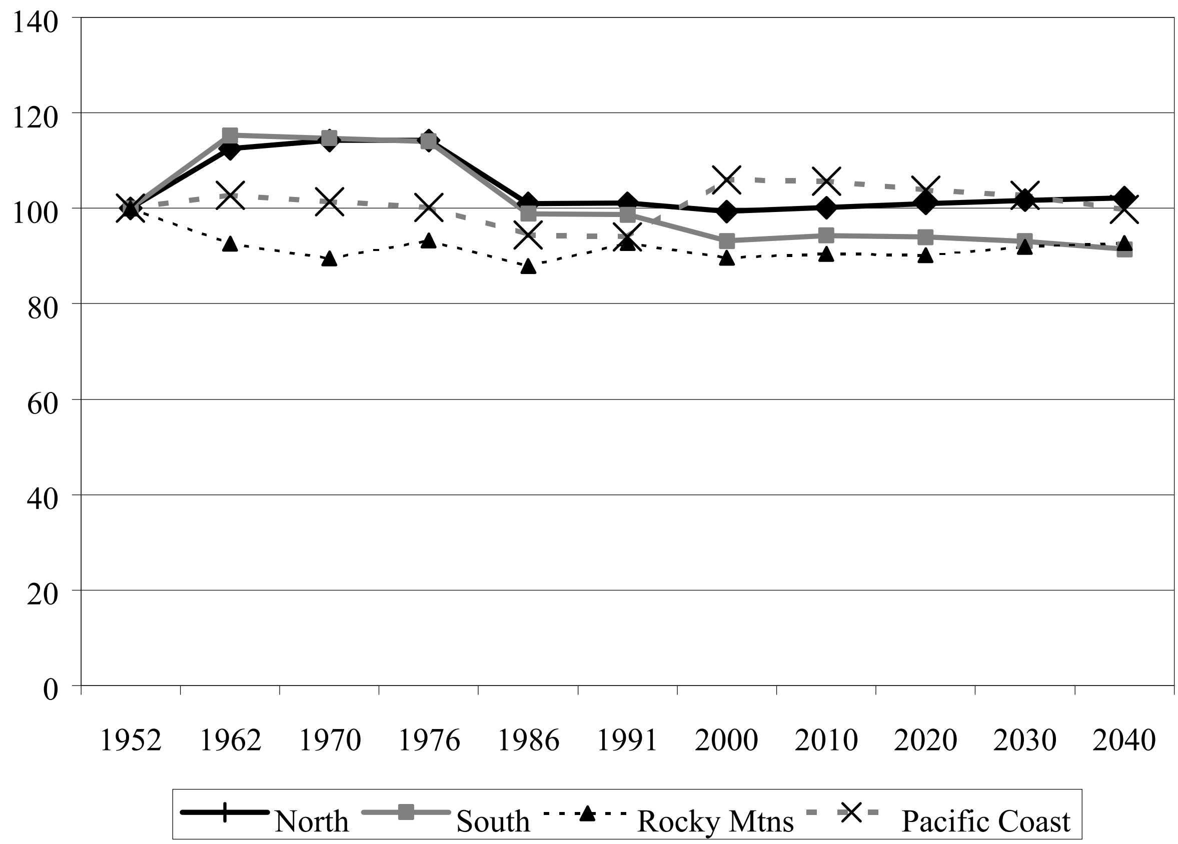
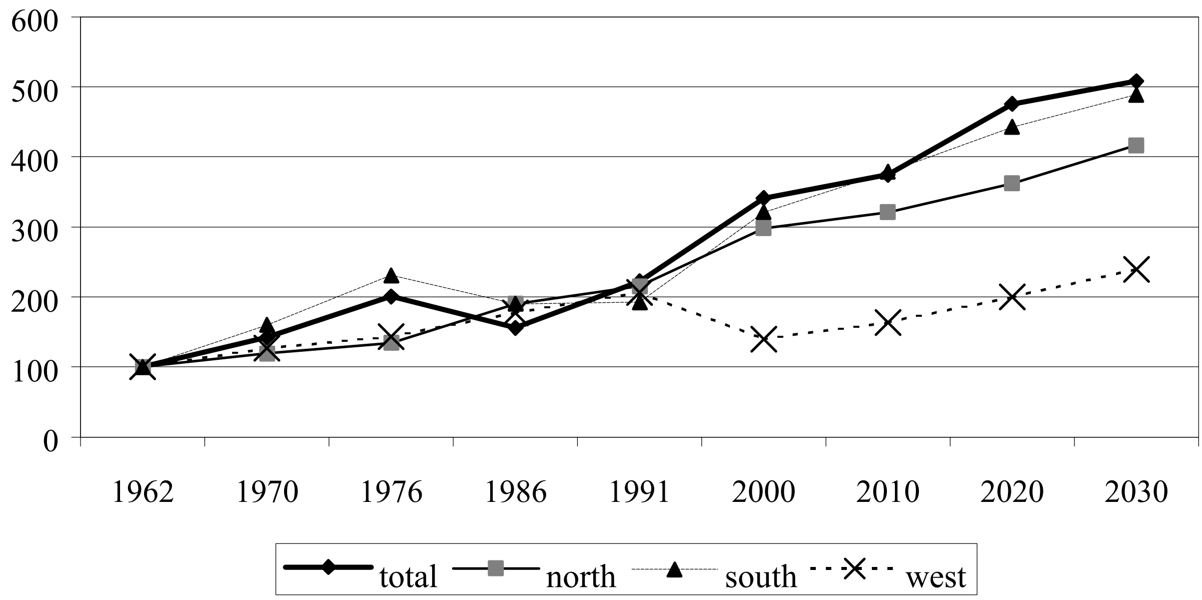


Figure 5. Regional Timberland Wealth



Summary

The challenge of measurable goals moved us beyond describing goals using platitudes. No longer can we conduct an assessment around vague and often misunderstood goals such as sustainability, healthy forests or community stability. At the same time there is a great interest on the part of scientists to avoid the "owl vs. jobs" nature of the spotted owl debate in the U.S. Pacific Northwest. In that debate all concerns for ecological conditions were reduced to habitat conditions for the northern spotted owl while all concerns about social well-being centered on employment in the lumber and wood products industries. These broad scale composite measures (like criteria based on selected indicators) do help us to look more broadly at the notion of tradeoffs, compatible production, and the integrative nature of ecosystems.

One measure of success for protocols like the Montreal Process will be the extent to which they shift the debate about Sustainable Forest Management away from two-dimensional arguments about tradeoffs to one that addresses strategic questions about the compatibility of wood production with ecological and socioeconomic goals. Scientists can contribute to both; developing individual broad scale measures as well as composite indexes and the process for aggregation to higher spatial scales.

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Appendix

Montreal Process Criteria and Indicators (adapted from US Forest Service Report to Facilitate Discussion of Indicators of Sustainable Forest Management, http://www.fs.fed.us/land/sustain_dev/sd/welcome.htm)
Those in italics are included in this analysis with the specific measure in parentheses

Criterion 1: Conservation of biological diversity
Biological diversity includes the elements of the diversity of ecosystems, the diversity between species, and genetic diversity in species.

Indicators:

Ecosystem Diversity

a) Extent of area by forest type relative to total forest area; (a)[1] (softwood)
b) Extent of area by forest type and by age class or successional stage;(b) (average dbh)
c) Extent of area by forest type in protected area categories;(a)
d) Extent of areas by forest type in protected areas defined by age class or successional stage;(b)
e) Fragmentation of forest types;(b) (total harvest)

Species Diversity

f) The number of forest dependent species;(b)
g) The status (rare, threatened, endangered, or extinct) of forest dependent species at risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment;(a)

[1] Indicators followed by an "a" are those for which most data are available. Indicators followed by a "b" are those which may require the gathering of new or additional data and/or a new program of systematic sampling or basic research. No priority is implied in the "a" and "b" designations.

Genetic Diversity

h) Number of forest dependent species that occupy a small portion of their former range;(b)
i) Population levels of representative species from diverse habitats monitored across their range.(b)

Criterion 2: Maintenance of productive capacity of forest ecosystems:

a) Area of forest land and net area of forest land available for timber production;(a) (timberland area)
b) Total growing stock of both merchantable and nonmerchantable tree species on forest land available for timber production;(a) (growing stock)
c) The area and growing stock of plantations of native and exotic species;(a)
d) Annual removal of wood products compared to the volume determined to be sustainable;(b) (Growth/drain ratio)
e) Annual removal of non-timber forest products (e.g. fur bearers, berries, mushrooms, game), compared to the level determined to be sustainable;(b)

Criterion 3: Maintenance of forest ecosystem health and vitality:
Indicators:

a) Area and percent of forest affected by processes or agents beyond the range of historic variation, e.g. by insects, disease, competition from exotic species, fire, storm, land clearance, permanent flooding, salinisation, and domestic animals;(b)
b) Area and percent of forest land subjected to levels of specific air pollutants (e.g. sulfates, nitrate, ozone) or ultra violet B that may cause negative impacts on the forest ecosystem;(b)
c) Area and percent of forest land with diminished biological components indicative of changes in fundamental ecological processes (e.g. soil, nutrient cycling, seed dispersion, pollination) and/or ecological continuity (monitoring of functionally important species such as

nematodes, arboreal epiphytes, beetles, fungi, wasps, etc.);(b)

Criterion 4: Conservation and maintenance of soil and water

This criterion encompasses the conservation of soil and water resources and the protective and productive functions of forests.

Indicators:

a) Area and percent of forest land with significant soil erosion;(b)

b) Area and percent of forest land managed primarily for protective functions. e.g. watersheds, flood protection, avalanche protection, riparian zones;(a)

c) Percent of stream kilometers in forested catchments in which stream flow and timing has significantly deviated from the historic range of variation;(b)

d) Area and percent of forest land with significantly diminished soil organic matter and/or changes in other soil chemical properties;(b)

e) Area and percent of forest land with significant compaction or change in soil physical properties resulting from human activities;(b)

f) Percent of water bodies in forest areas (e.g. stream kilometers, lake hectares) with significant variance of biological diversity from the historic range of variability;(b)

g) Percent of water bodies in forest areas (e.g. stream kilometers, lake hectares) with significant variation from the historic range of variability in pH, dissolved oxygen, levels of chemicals (electrical conductivity), sedimentation or temperature change; (b)

h) Area and percent of forest land experiencing an accumulation of persistent toxic substances.(b)

Criterion 5: Maintenance of forest contribution to global carbon cycles
Indicators:

a) Total forest ecosystem biomass and carbon pool, and if appropriate, by forest type, age class, and successional stages;(b)

b) Contribution of forest ecosystems to the total global carbon budget, including absorption and release of carbon (standing biomass, coarse woody debris, peat and soil carbon);(a or b)

c) Contribution of forest products to the global carbon budget;(b)

Criterion 6: Maintenance and enhancement of long-term multiple socioeconomic benefits to meet the needs of societies

Indicators:
Production and consumption

a) Value and volume of wood and wood products production, including value added through downstream processing;(a) (wood value)

b) Value and quantities of production of non-wood forest products;(b)

c) Supply and consumption of wood and wood products, including consumption per capita;(a)

d) Value of wood and non-wood products production as percentage of GDP;(a or b)

e) Degree of recycling of forest products;(a or b)

f) Supply and consumption/use of non-wood products;(a or b)

Recreation and tourism

g) Area and percent of forest land managed for general recreation and tourism, in relation to the total area of forestland (a or b)

h) Number and type of facilities available for general recreation and tourism, in relation to population and forest area;(a or b)

i) Number of visitor days attributed to recreation and tourism, in relation to population and forest area; (b)

Investment in the forest sector

j) Value of investment, including investment in forest growing, forest health and management, planted forests, wood processing, recreation and tourism;(a)

k) Level of expenditure on research and development, and education;(b)

l) Extension and use of new and improved technology;(b)

m) Rates of return on investment;(b)

Cultural, social and spiritual needs and values

n) Area and percent of forest land managed in relation to the total area of forest land to protect the range of cultural, social and spiritual needs and values;(a or b)

o) Non-consumptive use forest values;(b)

Employment and community needs

p) Direct and indirect employment in the forest sector and the forest sector employment as a proportion of total employment;(a or b)

q) Average wage rates and injury rates in major employment categories within the forest sector; (a or b)

r) Viability and adaptability to changing economic conditions, of forest dependent communities, including indigenous communities;(b)

s) Area and percent of forest land used for subsistence purposes;(b)

Criterion 7: Legal, institutional and economic framework for forest conservation and sustainable management[2]

Indicators:

Extent to which the legal framework (laws, regulations, guidelines) supports the conservation and sustainable management of forests, including the extent to which it:

a) Clarifies property rights, provides for appropriate land tenure arrangements, recognizes customary and traditional rights of indigenous people, and provides means of resolving property disputes by due process;

b) Provides for periodic forest related planning, assessment, and policy review that recognizes the range of forest values, including coordination with relevant sectors;

c) Provides opportunities for public participation in public policy and decision making related to forests and public access to information;

d) Encourages best practice codes for forest management;

e) Provides for the management of forests to conserve special environmental, cultural, social and/or scientific values.

Extent to which the institutional framework supports the conservation and sustainable management of forests, including the capacity to:

f) Provide for public involvement activities and public education, awareness and extension programs, and make available forest related information;

g) Undertake and implement periodic forest related planning, assessment, and policy review including cross-sectoral planning and coordination;

h) Develop and maintain human resource skills across relevant disciplines;

i) Develop and maintain efficient physical infrastructure to facilitate the supply of forest products and services and support forest management;

j) Enforce laws, regulations and guidelines;

Extent to which the economic framework (economic policies and measures) supports the conservation and sustainable management of forests through:

k) Investment and taxation policies and a regulatory environment which recognize the long-term nature of investments and permit the flow of capital in and out of the forest sector in response to market signals, non-

[2] Criterion 7 and associated indicators relate to the overall policy framework of a country that can facilitate the conservation and sustainable management of forests. Included are the broader societal conditions and processes often external to the forest itself but which may support efforts to conserve, maintain or enhance one or more of the conditions, attributes, functions and benefits captured in criteria 1-6. No priority or order is implied in the listing of the indicators.

market economic valuations, and public policy decisions in order to meet long-term demands for forest products and services;

l) Nondiscriminatory trade policies for forest products;

Capacity to measure and monitor changes in the conservation and sustainable management of forests, including:

m) Availability and extent of up-to-date data, statistics and other information important to measuring or describing indicators associated with criteria 1-7;
n) Scope, frequency and statistical reliability of forest inventories, assessments, monitoring and other relevant information:
o) Compatibility with other countries in measuring, monitoring and reporting on indicators.

Capacity to conduct and apply research and development aimed at improving forest management and delivery of forest goods and services, including:

p) Development of scientific understanding of forest ecosystem characteristics and functions;

q) Development of methodologies to measure and integrate environmental and social costs and benefits into markets and public policies, and to reflect forest related resource depletion or replenishment in national accounting systems;

r) New technologies and the capacity to assess the socioeconomic consequences associated with the introduction of new technologies;

s) Enhancement of ability to predict impacts of human intervention on forests;

t) Ability to predict impacts on forests of possible climate change.

Assessing State and Change in Global Forest Cover: 2000 and Beyond

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Abstract

The United National Food and Agriculture Organisation (FAO), at the request of the member nations and the world community, regularly reports on status and trends in the world's forest resources. This paper briefly describes the methods used in past surveys, describes the data and methods to be used to complete the 2000 Forest Resource Assessments, and proposes a follow-on continuous world forest survey system to enable FAO to provide the necessary information on a permanent basis. This paper is based on a background document and on the results of an Expert Advisory Meeting on FRA 2000 held in Rome, Italy on March 6-10, 2000.

Keywords: Inventory, Assessment, Monitoring, Global, Satellite, Tropical

Introduction

The United National Food and Agriculture Organisation (FAO), at the request of the member nations and the world community, regularly reports on the world's forest resources through its Forest Resources Assessment Programme (FRA). FRA is now executing the Global Forest Resources Assessment 2000 (FRA 2000). Reliable information on forest change (both negative and positive changes) and its trends has been widely recognised as indispensable for ensuring the sustainable management of the world's forests.

The purpose of this paper is to (a) describe the data and methods used to complete past and current Forest Resource Assessments, and (b) to propose a follow-on continuous world forest survey system to provide FRA products in future years. This paper is based on a background document (Paivinen and Gillespie 2000) and on the results of an Expert Advisory Meeting on FRA 2000 held in Rome, Italy on March 6-10, 2000.

FAO Forest Resource Assessment in 1980-90

The 1980 FRA was essentially an expert assessment based on existing inventory information for each of 76 tropical countries. A small team of experts in FAO headquarters gathered and synthesised whatever information they could find regarding the status of forests in each of 76 tropical countries. The diversity of the information was seen in three different angles: subject, scale and reliability. The FRA 1980 study 'consisted mainly in the selection, organisation, compilation and interpretation of this abundant and diverse mass of information using a single framework of classifications and concepts for the 76 tropical countries' (Lanly 1982). Although it was clearly the best available global synthesis of its time, the 1980 FRA was criticised for over reliance on country-reported data, which was feared to be biased in favour of underreporting rates of forest loss. Another criticism was that the methods used to synthesise and update data were not fully documented and made available to potential users of the data.

Partly due to this, as well as to the increased staff capacity and access to technology, the 1990 FRA incorporated a statistical sample of satellite imagery to produce regional levels of forest cover change, as a validation of the aggregated country level results produced by country data and models. This survey covered, with 10 percent intensity, all tropical forests in wet, moist and dry conditions. The survey was based on a statistical sample composed by multi-temporal satellite images over 117 sampling units. For each unit the study included the analysis of one entire Landsat image close to year 1990 and one (or more) close to year 1980.

The 1990 FRA also used a set of models to predict forest change as a function of population, based on the assumption that "the growth of human population, independently in the absence of economic development, and jointly with poorly planned and uncontrolled economic development, are the driving forces behind human activities that initiate deforestation" (Scotti 1990, Palo 1986). It was assumed that forest area reduction increases slowly at initial stages, faster in intermediate stages and slows down at final stages, following principles of biological growth processes, often described with well-known Chapman-Richards function. The mathematical connection between population density and non-forest area was created using forest cover data in a number of sub-country regions in Tropical countries. Finally, the deforestation rate was estimated assuming that the increase in the population will determine the decrease in the change of forest cover.

Forest Resource Assessment 2000 Data Available

The FRA 2000 continues the use of satellite image assessment for estimating rates of forest cover and change at the regional level. However, resources do not provide for extension of this approach to the country level, nor has FAO been given the mandate to conduct this level of work. Since estimates at the country level are still needed, such estimates will have to be based on other types of data. Sources of information available for completing FRA 2000 include the following:

1. Update of the 2000 Remote Sensing survey of tropical countries. The strategy for the Tropical 2000 Update approach is to revisit the topical FRA 1990 sampling units, and update them with a third date of TM imagery for the reference year 2000. Such a survey will provide up-to-date information on change processes, as well as new and unprecedented insights on deforestation trends over the periods 1980-1990 and 1990-2000.

   The key strength of the TM change assessment approach is that it utilises advanced satellite technology in a way that provides consistent, reliable results. This approach also helps reduce program costs by allowing use of the photographic image archive already maintained by FAO. Although the method of manual interpretation does not take full advantage of current image processing technology, the method is simple to replicate, relatively inexpensive, and is readily familiar to foresters all over the world. The primary weakness of the TM change assessment as implemented by FRA is that, due to financial and time constraints, the sample intensity is designed for regional results only; few countries will have sufficient samples to support estimates at the country level. Thus, some subtle forms of forest degradation or deforestation may be missed in the stratification process, which may lead to false estimates of rates of forest loss.

2. AVHRR (Advanced Very High Resolution Radiometer) forest map. FRA 2000 will feature a global forest cover map produced at 1-km spatial resolution, produced at the U.S. Geological Survey (USGS) EROS Data Centre (EDC) in cooperation with FAO. This map is a complete global coverage produced with a consistent methodology and a flexible database philosophy, using AVHRR Normalized Difference Vegetation Index (NDVI) as the primary input data. Two levels of land cover are available from the database: the full classification based on seasonal definitions and the aggregated 17-category International Geosphere and Biosphere Programme (IGBP) classification. The FAO forest cover mapping effort builds on the full USGS

seasonal database, refining forest classes to reflect forest density classification.

The primary advantage of AVHRR imagery is that the imagery is acquired for all lands (wall to wall) on a daily basis. This presents a low cost alternative to TM imagery, and the frequent availability makes it more likely that cloud free imagery will be available for any given target area close to any given target date. The primary weakness of AVHRR imagery is the lower resolution (1 km pixel size vs. 30m for TM), which leads to much coarser interpretability and less precision than interpretation TM imagery. The wider angle and interference of atmospheric effects cause problems with interpretation near to the edge of images. Thus, while AVHR may be very suited for change assessment in large (e.g. regional) areas, it may not be so useful for assessment at the national level, particularly for small or medium sized land areas

3. <u>Existing country level inventory data.</u> Many countries have in place systems for monitoring their forests on a periodic or occasional basis. Other countries have conducted studies of subsets of their forests, or complete or partial forest inventories sponsored by a variety of donor organisations. The result is a huge set of information regarding status and trends in forest statistics at the national and sub national level. FRA 2000 professional staff have been working for years to make and keep current a metadata base describing what data exist, by country, throughout the tropical world, as well as archiving the actual data in the FORIS (Forest Resources Information System) database. Regional specialists travel to the countries in their region, gleaning available information and assembling it for potential incorporation into the FRA 2000 and future studies. FRA will make these data available, along with appropriate metadata, via the World Wide Web.

   The strength of using data reported by countries is that results tend to be of higher precision than results from studies conducted at the regional scale. National forest statistics would be harmonised with other reports and analyses produced by and used in the target country, increasing consistency between FAO and National reports. Presumably, forest statistics gathered at the National level would be overseen by experts with more familiarity with the target country and with more time to spend on a single country, which should lead to improved data quality. The primary weakness with the aggregation of country level is that there is tremendous inconsistency and incompleteness in country inventory data, both within countries over time as well as between countries. Assessments are conducted with different objectives and populations of interest, using different definitions, standards, sample designs, and field methods from those used by FAO or by neighbouring countries. The results can be difficult to interpret and harmonise for comparison across countries, as FRA must do. Additionally, many countries particularly in Africa simply lack the resources to conduct forest assessments, so that data are lacking.

4. <u>Models to derive forest change as a function of other attributes.</u> The strength of the modelling approach used already in FRA1990 is that it provides a platform for generating estimates for all countries regardless of availability of country level data. Data gaps would simply be modelled by more generalised functions. Generation of models is a useful exercise in that it forces study of cause and effect relationships and can lead to insights regarding true mechanisms or drivers of forest cover change, which in turn could lead to better investment decisions by national governments seeking to manage their forests. The results of existing models are probably reasonable at the global level. However, the greatest weakness of the modelling approach continues to be inadequacy of existing models when applied to specific countries. The process of deforestation is such a complex process, involving physical, climatalogical, political, and socio-economic forces which are themselves very complex, that simple generalised models of forest change have so far not been developed. Current models are

oversimplified and yield similar predictions of forest cover change rates for countries which are known to be very different. More complex models are yet to be developed and tested.

New Methods

Remote Sensing

The most straightforward way to intensify Remote Sensing based approach is to maximise the coverage of TM figures to cover up to 100% of the tropical belt. This, however, would require plenty of resources for purchasing the data and staff for working on it using present visual interpretation approach.

There are other potential useful sources of remote sensing imagery which may be incorporated into the final analysis. In 1999 FRA commissioned a global forest cover map to be produced by the Eros Data Center (EDC) of the US Geologic Survey (USGS). This map, based on AVHRR coverage, provides a global snapshot of forest cover at a relatively coarse scale. There are also other AVHRR – based forest cover mapping projects ongoing (see for instance http://fellini.gvm.sai.jrc.it/trees/ or http://www.geog.umd.edu/tropical/main.html.

The primary advantage of increased use of satellite imagery is that it provides a tool for objectively filling in existing data gaps by use of an information source which is universally available. Linking TM and AVHRR data - using multi-stage or multi-phase sampling or ratio estimates - would be objective and simple to implement once the data and methods were available. The primary weakness of this approach is the lack of existing strong relationships between TM and AVHRR. Significant amounts of research have sought such correlations, with mixed results. Correlations may not be universally strong enough to act as a reliable source for filling in data gaps.

Formalizing Expert Opinions

Given the lack of globally consistent forest inventory data, some kind of synthesis based on partial data plus expert opinion is not an unreasonable way to arrive at answers. Certainly expert opinion can be subject to bias and imprecision; yet it will generally be better than no information at all. Two of these methods are the Delphi Technique and Convergence of Evidence.

Delphi Technique

The Delphi Technique applies elementary statistics to a sample of expert opinions in an iterative fashion, with the intention of eliminating outliers, providing feedback, and converging to a level of consensus. The technique was originally developed for making forecasts of socio-economic trends and has since been generalized for use in a variety of estimation or problem solving situations (Sackman 1975).

The original Delphi Technique had several distinguishing characteristics. A pool of experts was chosen to make predictions on some topic. However, rather than assembling the group together, each group member was asked to submit their estimates anonymously, to avoid the chance that more prestigious or dominant group members would unduly influence the estimates made by other group members. The set of estimates was then averaged, and individual estimates which were outside some range of standard error were returned to the expert who had submitted it along with a request for justification or for a new estimate. The process would iterate several times until all there were no further changes in individual estimates, at which time a consensus estimated would be adopted. Advantages of the Delphi Technique are that it will always provide an answer in the time available, and that it takes advantage of expertise and experience which may be relevant but non quantitative. Disadvantages are that the method may lack repeatability, and that the quality of the answers depends heavily on the quality of the experts. In our case, it may be difficult to find a qualified pool of experts for each of the many countries for which we wish to derive estimates.

Convergence of Evidence

A second qualitative technique called Convergence of Evidence is currently used by the Foreign Agriculture Service of the US to produce annual assessments of agriculture crops in major producing or consuming countries of the world. Whereas the Delphi Technique relies on a group of experts arriving at consensus based on their (somewhat different) experience, Convergence of Evidence instead relies on a single expert who has at their disposal a variety of independent or quasi-independent information sources regarding the parameter of interest (Roke 1999, www.fas.usda.gov/pecad/who_what.htm).

For example, for estimating future wheat harvest in country X, an analyst has at their disposal historical records of past crop yields, recent weather data affecting the current year's crop, short term future weather forecasts, historical land ownership and farming data, agricultural statistics and forecasts produced by country X, and satellite data at different points over the current growing season showing potential areas and biomass accumulation of the target crop. The analyst synthesizes this information internally, using their experience and knowledge for assigning more weight to information that they feel is more reliable and arriving at a final answer. Ideally, over time, the expert has a chance to validate their estimate against a future measurement, allowing for learning over time.

This technique most closely resembles the methods used in the 1980 Assessment, where a small group of individuals immersed themselves in various available data sources. This trend continues to some extent in the current FRA 2000 where a small group of regional analysts are compiling, interpreting, and preparing to analyse regional and country level data. Clearly, the quality of the estimates for each country relies heavily upon the expertise and experience of the analyst. One advantage of this method is flexibility in that estimates can be derived when the data sources vary in availability and quality from country to country. Like the Delphi Technique, an estimate can be generated for every country and can be completed within a finite time window, recognizing that lack of time can limit the depth of the analysis. Disadvantages of this approach are dependence upon the skill of a single expert which can readily lead to bias, imprecision, and lack of repeatability.

Recommended Methodology for FRA 2000

An international panel of experts in forest assessment met in March 2000 to review progress and plans for completing FRA 2000, and to make recommendations for how the final results could be completed by the deadline of December 31 2000. The group reviewed the available sources of data and the proposed methods for combining the data, proposed additional data sources and analysis methods, and evaluated several alternatives for both scientific rigor and for practicality within the time and resource constraints. Criteria used to evaluate the alternatives included (1) statistical accuracy and precision of estimates, (2) ability to be used within available time, resource, and data availability constraints, (3) degree of general scientific acceptance of methods, (4) degree of transparency in methods, (5) ability to yield estimates for all countries of interest regardless of data constraints, and (6) simplicity.

After significant debate, the Panel recommended a combination of the Delphi Technique (an interative process using blind expert opinion to refine estimates) and a Convergence of Evidence (a method for weighing and combining different sources of information to arrive at a single country level estimate). The recommended approach uses a small group of experts to weigh the different available data sources for each country and attempt to arrive at final estimates. The experts are led in each region by the FRA Regional Coordinator. The Coordinator summarizes all available information (from TM image analysis, country reports, relevant models, other satellite imagery, etc.) and derives an initial estimate or range of estimates for each country, explaining their decision process and documenting the weight that they assigned to the various available sources of information. They then share the results with the small set of regional or country level experts to validate the results, asking the other experts to critique the reasoning or assignation of weights in the production of country level estimates and attempting to seek some consensus on final estimates. The process is illustrated schematically in Figure 1.

All available data will be used in the process. However, there were some observations and recommendations regarding the reliability of data sources. The use of AVHRR data was to be carefully considered, since the observed low correlation between FRA TM data and AVHRR map, especially on dry and semi-dry lands in the Tropics. Therefore, the panel recommended FRA 2000 to consider an additional sample of TM images to complete FRA 2000 change assessmentin Africa where other sources of data are very limited. The change model based on population, due to its limitations mentioned earlier, was recommended to use only as ancillary data in cased of very poor quality data from other sources.

The primary strength of this combined approach is that it allows the flexibility to include a variety of information sources assessed by people familiar with the situations in the countries, while mitigating some of the disadvantages inherent in relying on a single expert to integrate the data sources. This approach makes maximal use of available information, which varies from country to country. It allows incorporation of experience and qualitative information which is relevant but is normally not considered by more objective, purely quantitative analyses. The validation procedure adds a second set of information useful for comparative purposes or for calibration.

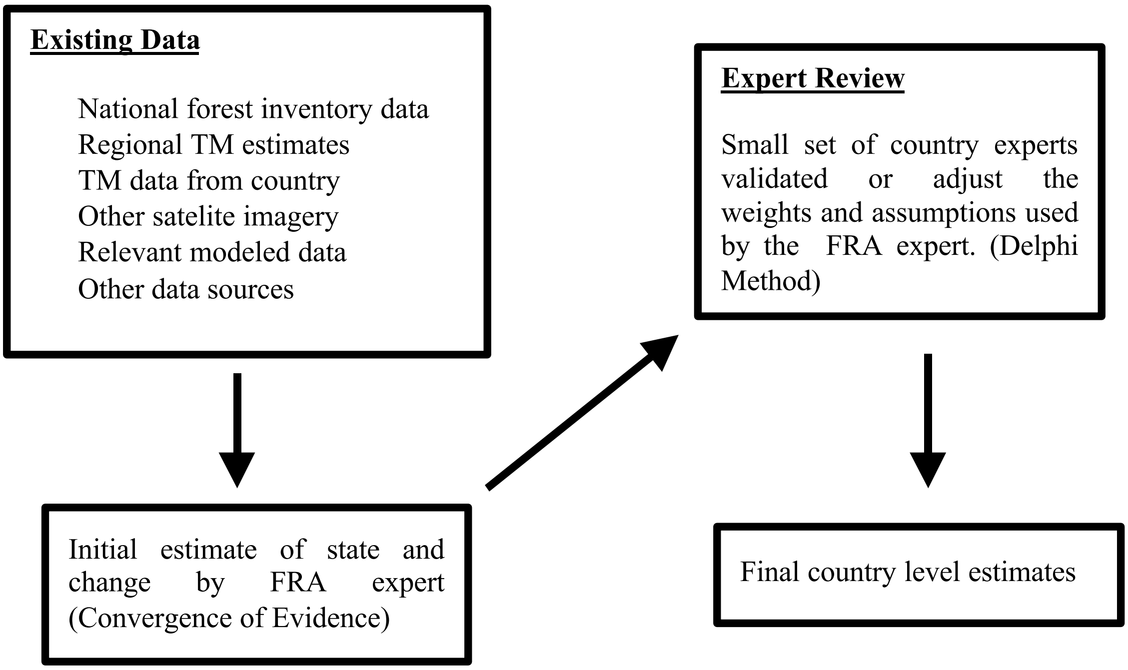
The primary weakness of this approach is the reliance on sufficiently diverse group of experts to add value in each country, and the unavoidable reliance on the availability of expertise and data. Time and resource constraints may limit the ability of FRA staff to seek sufficient input for each country. This difficulty could be partly mitigated by conducting a triage, whereby certain countries with known strong data were given less discussion, and countries with weaker data had more attention. Triage might also include stratifying countries by amount of forest cover to ensure that countries with the most forest are examined more closely, in order to minimise the chances of making relatively larger estimation errors.

FRA Beyond 2000: Towards a World Forest Survey

Since 1996, FAO has worked toward the development of a continuous monitoring programme of forests at the global level, or **World Forest Survey (WFS).** This programme is intended to extend a statistical sample over the entire world following new stratification criteria to improve its efficiency. At present, due to several technical and financial considerations, a phase-in of the new long-term Global Continuous Monitoring Programme is being envisioned along with the implementation of the 2000 Update for the year 2000 assessment. Ultimately, the WFS will provide continuously updated country level data, with global reports and analyses published at 5 year intervals. In this document, we concentrate on the tropical FRA2000, but keeping the development of a global monitoring programme in mind for after the year 2000.

The participants in the Expert Advisory meeting reviewed the current state of FAO thinking on the WFS concept and agreed that the FRA program of the FAO should take the lead in developing a proposal for a World Forest Survey. The proposal should identify the potential customers, costs and benefits of such a system. A logical first step in such a process should be to further identify potential WFS customers and their needs. It was further agreed that the FRA team should prepare a technical document on the WFS concept, to be shared with the global forest monitoring community and that a future Expert Advisory meeting should be called to help move the concept towards implementation.

Figure 1. Schematic diagram showing the steps used to take available data and arrive at a final country level estimate.



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Sub-Plenary Session: A5 - Posters

Sustainable Management of Forest Resources:

Sustainable Forest Management and Productivity

Coordinators:

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The Determinants of Silvicultural Investment in British Columbia: An Economic and Policy Perspective

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Abstract

Being a key link in the chain of sustainable forest management practices, silviculture occupies an important place in British Columbia's forest policy considerations. This poster aims at providing an economic and policy analysis of the silvicultural investment in BC's public forestlands. First, a brief historical overview of the Province's silviculture programs is presented to outline the institutional context in which the silviculture sector has evolved. Next, silvicultural activities and expenditures are reviewed statistically. Then, a regression analysis is undertaken in an attempt to reveal the effects of several explanatory variables such as harvest areas, timber prices, non-timber values and government stumpage revenues on the levels of silvicultural investment. Finally, the policy implications of the research findings are discussed from the perspective of sustainable forestry. The paper ends with a comment on the emerging trends of BC's forest policy regarding silvicultural operations in the Province.

Keywords: British Colombia, Silvicultural investment, Economic and policy perspective.

Détermination de la Productivité des Jachères dans Cinq Régions du Mali

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Abstract

La filière bois-énergie au Mali permet de couvrir 91 % des besoins énergétiques natinaux. Le bois est issu des formations naturelles et des formations "hors forêt" ou diffuses des espaces agro-sylvo-pastoraux. Pour mettre en place une gestion durable et raisonnée de la ressource ligneuse, le Mali s'est doté d'une politique énergétique : la Stratégie Energie Domestique. La production de la biomasse ligneuse des formations forestières est connue, alors que celles des jachères (formations forestières diffuses) sont tout à fait empiriques.

Pour mieux appréhender sa production, la Cellule Combustibles Ligneux (volet offre de la Stratégie Energie Domestique) en liaison avec l'Institut Polytechnique Rural de Katibougou, a installé des sites d'étude dans cinq régions du Mali d'Ouest en Est : Négala, Ouéllésebougou, Fana, Cinzana et Koutiala. Les sites choisis doivent permettre une meilleure connaissance des formations "hors forêt" du pays.

'inventaire des arbres (de jachères et de parc), de la régénération, le cubage par classes (0- 5 ans, 6-10 ans, 11-15 ans, 16-20 ans et plus de vingt ans) ont été réalisés dans ces sites. La répartition par classes d'âge a été obtenue par enquêtes auprès des paysans exploitants de ces jachères.

La productivité annuelle de ces formations est fortement liée à l'anthropisation, elle varie de 0,06 m3/ha/an à Koutiala (fortes occupations des terres pour la production du coton) à plus de 0,25 m3/ha/an dans les régions de Fana et Négala. Ces résultats n'incluent pas les arbres dits de "parc" tel que Vitellaria paradoxa, Parkia biglosa, et Lannea spp..

Les essences caractéristiques de ces formations "hors forêt" sont pour l'étage dominant les arbres de parcs cités au pargraphe précédent, pour l'étage dominé : Combretum nigricans, Acacia macrostachya, Combretum glutinosum ; la régénération est caractérisée par des espèces pionnières : Piliostigma reticulatum, Acacia macrostachya, Guiera senegalensis.

Ces données partielles seront utilisées pour la réactualisation des Schémas Directeurs d'Approvisionnement des principales villes du Mali (Bamako, Ségou, Mopti et Koutiala).

Keywords: Mali, productivité des jachéres

Under-Canopy and Preliminary Forest Cultures as A System of Forest Growing in Conditions of Smooth Natural Generation Change in The Boreal Forests of Russia

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Abstract

Natural spruce forests of the boreal taiga are usually presented by multiple-aged forest stands. Spruce reforestation under the canopy of such crops is a natural process, corresponding to the natural peculiarities of the zonal (area) forests. However, in the considerable area of the exploitable crops of the European part of Russian boreal forests it is quite difficult to run a forestry, orientated to the conservation and further utilization of the young growth during the cutting of the mature forest stand. During the last 35 years in the north-western and central parts of Russia there were probated new methods of planting and conditions of artificial growing of spruce and other shade-requiring species under the canopy. Depending on their purpose these cultures are subdivided into preliminary and under-canopy.

Common to both types is the fact they are planted under already existing (growing) canopy; while the difference is that preliminary cultures are planted under the canopy of maturing and mature crops (approximately 10-12 years before cutting), but under-canopy cultures- under the canopy of open undergrowth(I-II age class). The technological system of preliminary cultures provides for preventing unfavorable succession of spruce species and gradual(progressive) replacement of old generations by young, ecologically stable forests. Planting and growing of preliminary cultures, unlike the clear cutting forestry management and further reforestation, has a number of technological, ecologically-silvicultural and economic advantages.

The purpose of under-canopy cultures is slightly different and consists in planting structurally and compositionally complex forest crops on the basis of open unsuccessful or damaged forest stands. Young spruce growth in the open cutting usually suffers greatly because of the late frosts and sun burns. Besides, its growth is greatly restrained by grassy vegetation and broad-leaved sprouting. Microclimatic conditions are much softer and more favorable for survival and growth of young plants under the parent canopy. In particular, there is no competitive pressure on the crops from grassy vegetation and broad-leaved sprouting, the fact that greatly decreases care costs.

Moreover, under the canopy of forest crops the processes of bogging are weakened as here, in contrast to clear cuttings, water regime(condition) is regulated by growing forest crops. We can't help mentioning a most important ecological effect of the under-canopy reforestation system, that is reduction of the amount of open forests peculiar to clear cutting forestry. Nowadays, when forests suffer immensely from air emissions and other technogenic(industrial) pollutions, under-canopy "covered" system of forest growing considerably reduces the probability and degree of salvage. The under-canopy system of forest growing essentially reduces and prevents CO_2 release into atmosphere owing to unproductive temporal interval (10-15 years), until the territory of cutting is planted by new crops. The long-tem researches of the stationary plots showed that during the processes of planting and growing of preliminary cultures. The latter accelerate their growth abruptly when the upper canopy is cut or thinned. Their biometric parameters and productivity become similar to those of the cultures planted earlier in the open areas. In all its technological and forestry components the under-canopy system of reforestation and forest growing will favor ecologolization of the forestry management system in the boreal forests.

Keywords: Russia, Boreal forests, Natural regeneration.

The Application of Growth and Yield Models for Yield Regulation And to Assess Indicators of Sustainable Forest Management for Mixed Tropical Forests.

by

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Abstract

Yield regulation has been identified as a key constraint to sustainable management of natural tropical forests. Growth and yield simulation models are being developed as tools for growth prediction and yield regulation using data from permanent sample plots and forest inventory. This paper illustrates the application of an individual-based (single-tree spatial) model for simulation of the growth and yield of moist tropical forest systems. SYMFOR is a modelling framework that has been principally designed to study and predict the effects of different silvicultural treatments for sustainable yield management of natural Dipterocarp forests in Indonesia.

The current version of SYMFOR has been applied to illustrate the utility of both empirical and process-based growth and yield models for three applications: (1) growth and yield prediction, (2) evaluation of alternative silvicultural systems and (3) evaluation of indicators of sustainable forest management. Predictions of growth and yield are presented for an area of lowland dipterocarp forest in East Kalimantan (Indonesian Borneo). These predictions are used to describe and predict the recovery of the forest following logging compared to its pre-logging condition. This analysis is then extended for the same dataset to determine the effect of altering the silvicultural system applied to the forest through alterations in either diameter cutting limits or length of cutting cycle. These results are then further analysed to illustrate simple indicators of sustainable forest management. The analysis of these simulation runs demonstrated the importance of appropriate statistical analysis of model simulations.

The paper concludes that growth and yield models will become an increasingly important tool for the management for sustained yield of tropical forests and can be further applied to develop and implement effective criteria and indicators for sustainable forest management. These applications will require the development of appropriate analytical procedures to utilise output from simulation models and to make their results readily available for application by forest managers.

Keywords: Mixed tropical forest, Growth yield models, Sustainable forest management.

Tropical Forests Management Based on Tree Populations Dynamics:The Example of Moabi in The Dja Forest (Cameroon)

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Abstract

Though Central African rain forests contain a wide diversity of tree species, present logging practices are extensive and mining, and focus on a relatively restricted range of valuable timber species Considering the complexity of management practices aimed at controlling global stand dynamics, we propose an approach based on ecological characteristics and demography of particular timber species and we assume that forest management mainly consists in the management of timber tree populations living in their natural environment. This approach is illustrated with the example of moabi (*Baillonella toxisperma* Pierre, *Sapotaceae*), a timber species from Cameroon.

For two and a half years (1994-1997), we measured survival, growth, fecundity and spatial distribution of every class of seedlings and trees of this species in permanent plots covering 347 ha, located in the Réserve de Faune du Dja and in the adjoining logging concession (South-East Cameroon).

After a description of the Dja's floristic diversity (chapter 1), we present the phenology and germination of moabi (chapter 2), seed dispersal and predation by mammals as well as impact of hunting on its natural regeneration (chapter 3), and then seedling growth in the understorey related to light availability (chapter 4) and finally the demographic parameters of its adult population: diametrical structure, growth, mortality and spatial distribution (chapter 5). Moabi start fruiting from 70 cm DBH, some individuals reach 280 cm DBH as maximum size and trees are cut over the legal limit diameter which is 100 cm. The density of adult trees is 0.1 stem/hectare. The specific growth curve is calculated by mean of three different methods: measurement of 273 living individuals for a period of 2,5 years analysed with both Gompertz's model and a polynomial model; annual growth rings counting for 10 trees; and carbon dating for 4 trees.
On the basis of these observed values of fecundity, survival and growth, we build a matrix model (Lefkovitch 1965, Usher 1966, Favrichon 1995) which reproduces the evolution of class sizes of moabi over a period of time (chapter 6). This demographic model is a management tool which can be used for predictive simulations. On the one hand (chapter 7), we quantify the impact of the present logging practices on moabi population dynamics. Thirty years after first logging, moabi population will recover 27% of the initial number of adult stems and this reconstitution level will be 83% after 300 years.

On the other hand (chapter 8), the matrix model enables to assess the impact of forest management scenarios designed by changing management parameters. We successively simulate (1) the elevation of limit diameter from 100 to 130 and 160 cm, (2) the lenghtening of rotation period from 30 to 60 years; (3) the reduction of impact of logging from 10 to 5% of the ground area and (4) the increase of growth speed due to the implementation of selective thinning. These simulations enables to compare the cumulative timber production yielded over a period of 480 years by the present logging practice *vs* an extremely conservative management scenario (limit diameter = 160 cm; rotation time = 60 years; reduced impact logging; selective thinning). This approach based on tree population dynamics with regard to their natural regeneration logically fits into the classical scheme of natural forest management plans in Central Africa baesd on selection system. It enables quantitative recommandations for long term timber production from these forests to be formulated and, consequently, contributes to their sustainability.

Keywords: Cameroon, Tree population dynamics, Management

Using Forest Inventory, Remote Sensing, GIS and Growth Models to Monitor Some Sustainability Indicators at Management Level

by
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Abstract

Criteria and indicators for the sustainable management of forests have emerged as a central element of international and domestic forest policy discussions. The Third Ministerial Conference on the Protection of Forests in Europe, that took place in Lisbon, Portugal, in June 1998, adopted the six Pan-European criteria for sustainable forest management. The European countries involved in this conference committed themselves to promote the development and implementation of national criteria and indicators, taking into account specific country conditions, as well as to improve the quality and promote the necessary adaptations of national data collection systems, to fulfill the needs of information to assess sustainable forest management. In Portugal, the definition and implementation of adequate indicators to be used at a practical level in the assessment and monitoring of forest management sustainability at management area level have attracted particular interest since then. The implementation, in practice, of the proposed indicators strongly rely on the availability of forest inventory and mapping of forest resources over time, seldom available in Portugal at the management area level. In this context, a management area is a forest area, subdivided into management units (stands) that is subject to the same management plan. The objective of this poster is to analyse alternative methodologies of up dating forest resources information, including spatially specified information. Data from the continuous forest inventory of the National Forest of Leiria are the basis for this study. The National Forest of Leiria is a state property with an area of 11,000 ha located in the coastal dunes of Marinha Grande in central Portugal. Most of the area (8,700 ha) is made up of pure maritime pine stands managed for high quality timber production. A relative small percentage along the coast is protection forest with the maritime pine as dominant species (2,000 ha) and a little more than 300 ha are devoted to other land uses. The forest is subdivided into 342 management units approximately rectangular that are sometimes subdivided into 2 or more stands. For management purposes, a continuous forest inventory systematically covers the forest since 1979 with an intensity of one 500-1,000 m^2 plot per ha (two plots per ha till 1988) and a periodicity of 5 years. Alternative methodologies of up-dating forest information were simulated on the basis of these data, including the use of traditional forest inventories of different intensity, combined or not with the use of growth models, as well as the use of remotely sensed information and other ancillary data available in a GIS system that is available for the area.

Keywords: Remote sensing, GIS, Forest inventory.

Growth Models to Control Sustainability of Forests in Transition

by

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Abstract

In Central Europe there is an increasing trend to convert even-aged to uneven-aged forests, aiming at a *Dauerwald* (permanent forest) forest management system. Under this situation the former age class methods, derived from the "normal forest model", or from the dbh-class models based on de Liocourt's negative exponential dbh-class distribution, are appropriate to both, determine and control sustainable annual cut with respect to age classes or dbh-classes and the way how to best approach the *Dauerwald*-structure of the forests.

Two developments in European forest science help this situation: (i) individual tree growth models have been developed, aiming at the substitution of classical yield tables, and (ii) forest inventory designs have shifted to permanent sampling methods in order to more accurately identify changes in forest structures and damage.

This presentation will demonstrate that combining both, permanent inventories based on angle count sampling and the distance independent individual tree growth model PROGNAUS, will enable foresters to choose harvesting strategies, appropriate to achieve both high value sustainable yield and uneven-aged forest structures.

The example presented is a forest management area of 1270 ha, where more than 40 years ago the clear cut system was abandoned and replaced by target diameter harvest. In 1988 permanent plots were established. Sample trees were selected using Bitterlich's angle count method with a basal area factor of 4 m²/ha. The first remeasurement in 1998 served to calibrate the growth model PROGNAUS. With the calibrated model, different harvesting scenarios are calculated for a 40 year period. Stocking volume, dbh- and stem quality distributions are compared .

Keywords: *Dauerwald* management, Individual tree growth models, permanent forest inventory

Nutrient Management Guidance for Enhancing Sustainable Forest Productivity

by
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Abstract

Guidance on the nutrient management requirements to support enhanced productivity goals for new plantations of loblolly pine (*Pinus taeda*) in the southeastern United States or of Douglas-fir (*Pseudotsuga menziesii*) in the northwestern United States is developed. Sustainable forest management with enhanced productivity is needed on commercial forestland as opportunities for timber harvests from public forests declines in the United States. A suite of Excel spreadsheet “models”, derived by simplification of simulation models, is provided at two Internet websites for use by the Forest Industry in their stand management planning. A three-step procedure is designed for use with personal computer systems.

First, the productivity goal for a new plantation is estimated for the specific soil and climate conditions of a field site to be planted with selected planting stock and managed with practices that enhance productivity (e.g., planting density, vegetation control, fertilization, thinning). The target biomass projection for each year of the new plantation is determined from growth and yield models available to the forest company or from the 3PG spreadsheet model calibrated for plantation growth. The 3PG model was developed by Landsberg and Waring (1997, Forest Ecol. and Manage. 95:209-228).

The nutrients required to support the target growth are next estimated with the REMSS spreadsheet model. This code determines nutrient requirements from empirical relationships established from the nutrient content of stems, branches, foliage and roots of the two tree species. These calculations determine the time course of nutrient requirements for the target plantation growth.

In the third step, the soil supply of nutrients for the specific soil and climate characteristics of a selected site is determined with the NuCSS spreadsheet model. Soil data from forest company measurements or from estimates provided from soil databases are used to determine the annual nutrient supply from the soil to the vegetation. The difference between the REMSS vegetation nutrient demand and the NuCSS soil nutrient supply provides guidance on the fertilizer requirements to meet the target productivity. Repeated simulations with the spreadsheet models provide insight on the nutrient management requirements for sustaining enhanced forest productivity through several rotations. The procedures also estimate changes in soil carbon sequestration due to nutrient management. Supplemental features are included at the Internet websites. The nutrient status at a field site may be evaluated prior to planting by foliar vector analysis with the DIAGNOSIS spreadsheet model. This analysis can be made if foliar mass and nutrient data are available from the previous forest stand. Further, the Crystal Ball software may be used with all Excel spreadsheet models for conducting sensitivity and uncertainty analyses. Sensitivity analysis shows the important variables that contribute significantly to the outputs at each step. Sensitive variables need to be accurately determined. However, variability (uncertainty) of soil, climate and vegetation attributes is often large at field sites. If this variability is known, uncertainty analysis may be undertaken with Crystal Ball to estimate plantation nutrient requirements with statistical confidence intervals.

Keywords: Forest productivity, Nutrient management.

Modelling Norway Spruce Young Stand Development Based on IUFRO International Stem Number Experiment

by
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Abstract

There are an expectation of new plantation and regeneration on abandoned agricultural land in Europe. These new plantations should be ecologically stable and sound. The models for regeneration and young stand development are sought as one of the tool to reach the above given goals.

The presented model is based on the IUFRO international stem number experiment for Norway spruce where radical reduction of the number of trees per hectare in the juvenile stage has been done. The experiment was established in 1971 in eight years old spruce thicket originated from planting in regular spacing with density 2 500 trees per hectare. The series consists of five obligatory treatments with two replications. The stand is situated on previously cultivated agricultural land in 5th (spruce-beech) vegetation degree on elevation of 600 m above sea level. The pattern of experiment includes control plot 1 without thinning. All other programmes are based on first heavy thinning (top height 10 m). Thinning regime 2 represents heavy treatment in young age (top height 12.5 and 15 m). The regimes 3 and 4 (fully mechanised selection) are similar treatments planned later when the stands achieve top height 20 and 22.5 m.. Thinning along with treatment 5 (commercial thinning) is to be done only when 80 m^3 of stem wood can be removed on trees with DBH over 12 cm excluded 400 crop trees.

The data set gives detailed information on every tree growth including the stem and crown shape and the position of the tree within the stand. The data are recorded since 1971 and represent high quality long time period for juvenile growth stand. The higher volume of stem wood (474.7 m^3 per hectare) is accumulated (last survey in 1998) in the control stands 1, but total production (together with volume removed by thinning) is the highest on plot 2 (541,1 m^3) as well as the volume of selected trees - 217.5 m^3. Various thinning programmes affected stability of experimental stands in favour of tended stands.

The model could help with the formulation of the growth process of young Spruce stands under very new silviculture regimes which should create the stable stems with low value of stem sliminess coefficient and long and vital crowns. It is expected that these silvicultural regimes could increase the vitality of the stands suffering in Central Europe by the air pollution and other climate stress.

Keywords: Norway spruce, IUFRO, Modelling.

Sub-Plenary Session: A6

Sustainable Management of Natural Resources:

Criteria and Indicators for Sustainable Forest Management. A Perspective at the Level of Forest Management Unit

Coordinators

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Sustainable Forest Management by The Private Sector In Malaysia

by
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Abstract

Forest management in Malaysia, including in the State of Sabah, has always been carried out by the public sector, viz. the Forestry Department, even though forest harvesting and the processing of forest products is usually managed by the private sector. Semi-governmental organizations also exist which are responsible for managing some areas of forest lands. Concessions are usually given for harvesting as logging concessions after which the responsibility of "management" reverts back to the Forestry Department. In 1997, the Sabah State Government made a major and bold decision to "privatise" forest management in the state by establishing ten Forest Management Units (FMUs), whereby, the private sector is given considerable areas of logged over or currently being logged forests, to be managed over a concession period of 100 years. The FMUs cover an area of about one million hectares or about a third of the land area of Sabah, with each FMU ranging between 60,000 to 160,000 hectares. The FMU Agreement requires the agreement holder to prepare a Forest Management Plan (FMP) within two years after signing the FMU Agreement. The Forestry Department of Sabah sets certain criteria for development of the FMUs, and they must approve the FMP before any developmental activities can be carried out. For the preparation of the FMP, a forest inventory must be carried out to assess the quantity and quality of the standing timber stands while a social survey must also be carried out to assess the status of the communities living within and around the FMUs.

As most of the areas have been logged, some more than once, the FMU owner has no other option but to invest into reforestation and afforestation activities, in order to increase and improve the forest stands. However, as forestry is a long term investment with returns taking considerable periods of time, the FMU owners are faced with raising capital for these purposes. One option considered is to seek approval for developing a small portion of the FMU for agro-forestry and forest plantations, but no decision has yet been made by the authorities. International funding is also an option being examined.

It is too early to make a conclusion on the wisdom of the State in forming the FMUs, but this has offered an excellent opportunity for the private sector to be involved in forest management on a long term basis. It is also the hoped that these FMUs will ultimately be managed on a sustainable basis.

Keywords: Malaysia, Private sector, Sustainable forest management.

Key Issues in the Application of Criteria and Indicators for Sustainable Forest Management

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Abstract

Sustainable forest management (SFM) integrates social, economic and environmental factors, and must reflect the goals and outcomes negotiated among those with legitimate interests in forests. The relative weightings given to these factors will vary substantially depending on local circumstances. Thus a working definition of SFM must capture 'local' issues and values and on-going dialogue is needed to refine management objectives and targets over time. Stakeholders must be prepared to state their objectives and preferred outcomes in a transparent manner. Increasingly, communities are demanding a capacity for adaptive forest management based on assessment of the outcomes of forest management activities. The application of Criteria and Indicators (C&I) at appropriate (management unit) scales can assist with measuring such outcomes. Criteria describe the components of sustainability and indicators are being developed to measure aspects of each criterion. Consideration of scale issues is critical to the application of C&I, and this issue was addressed at an international conference in Australia in 1998 organised by IUFRO, CIFOR and FAO. To provide a useful basis for adaptive management, they will generally need to be applied to a sample of representative forest management units (coupes, compartments). Information collected at finer scales often needs to be synthesized or aggregated for interpretation at larger (Regional, State or National) scales. The relevant scale for data collection and interpretation will vary for different forest values (Criteria) and management goals (e.g. soil and water values at the site scale; social values at larger scales). Practical application of C&I requires that the steps of indicator selection, monitoring, and evaluation of trends be addressed as linked processes. Insufficient attention has been paid to monitoring and evaluation, which are critical steps in adaptive forest management.

Establishing clear and shared forest management goals is essential to guiding application of C&I. The goals should be expressed in measurable terms enabling agreed indicators and associated performance measures or targets to be established. Thus forest management plans will reflect expectations, how they will be measured, and how evaluation, review and communication of findings will be conducted. The scientific underpinning for indicator selection, monitoring and evaluation should provide guidance to these decisions.

Monitoring must address spatial and temporal scale issues. A stratification of the forest environment is needed to guide sampling and scaling-up from point measurements where this is required. Risk assessment can be used to guide monitoring of those areas where there is a perceived threat to SFM. The frequency of temporal monitoring should be varied according to the likelihood of important temporal change in the indicator being used. The key point is that monitoring should be thoughtful and strategic if it is to be cost-effective. The science and application of sustainability indicators in forestry is still in its infancy. C&I have the potential to help track temporal change in forest values and to facilitate adaptive management, but expectations need to be kept realistic. Much could be learned from initial efforts to apply a modest 'core-set' of indicators at the forest management unit level. Close linking of research, monitoring and forest management will facilitate progress.

Keywords: Sustainable forest management, Criteria and indicators

Criteria and Indicators for The Assessment of Sustainability at The Forest Management Unit Level – A Neotropical Perspective

by
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Abstract

The contribution of forestry to GDPs in the neotropics is small, but market trends and extensive natural forests indicate significant potential for sustainable forest management (SFM). The growth of forest certification and a number of C & I development processes demonstrate willingness and capacity to adopt SFM in the region, and a IUFRO Sustainability Task Force Conference/Workshop in Costa Rica reviewed C & I development for SFM in the neotropics in 1999. Public sectors may see the adoption of C & I as an advance, but for the private sector and communities, current concepts of sustainability may lean too far towards environmental rather than financial and economic aspects; all sectors are concerned about the lack of financial incentives for SFM rather than logging or land use change. Arguments for more people-centred approaches to SFM emphasize the lack of participation of certain stakeholders in C & I development and the likely benefits of assessing the sustainability of livelihoods. The technical and scientific basis for C & I for production in natural neotropical forests is well established, but assessment of ecosystem health and integrity in general, and soil, water and biodiversity in particular, continues to require precautionary approaches; indicators for contributions to climate change mitigation, and SFM for plantations, largely remain to be developed. Much more effective information transfer by scientists, research on both socioeconomic and biophysical aspects, the inclusion of sustainability assessment in higher education curricula, progress towards a concept of SFM which is less restrictive to the forest manager – probably based on an explicitly adaptive concept of management – and a more inclusive focus on scale are priorities for C & I development and adoption in the neotropics.

Keywords: Sustainable forest management, Bolivia, Costa Rica, FSC, ITTO, Lepaterique, Tarapoto

Introduction

The neotropics are one of the environments in which the quest for sustainable forest management (SFM) offers the greatest challenges, and the development and implementation of Criteria and Indicators (C & I) as a tool for "conceptualizing, implementing and evaluating" (Stork *et al*. 1997) SFM may potentially offer the greatest rewards. Challenges arise on all fronts, from the ecological (the complexity of the natural forest coupled with the requirement that forest management conserve biodiversity, for example, or the poverty and swift degradation under inappropriate use of many soils) to the sociocultural and political (continuing demand for forest land for settlement and agricultural use, environmentalist pressure for forest preservation rather than conservation through sustainable management) and economic (the current lack of financial incentives to switch from traditional logging to SFM). Rewards may come, on the other hand, if the development of C & I contributes, as it could, to the fulfillment of the potential for sustainable forest management which the neotropical region possesses. Regarding this potential, de Camino (1999a) points out that while the contribution of forestry activity to gross domestic product (GDP) in the region is currently small, the neotropics retains a large proportion of its natural forest cover, in comparison with tropical Asian and African countries where the capacity of natural forests to supply timber is declining. He adds that the neotropics have large land areas suitable for plantation forestry and proven capacity in the execution of this activity, while the large areas of secondary forest (including that developing on abandoned agricultural land) may be highly productive. Trends in market demand for forest products and awareness of the value of the ecological services provided by the region's forests represent clear opportunities for progress towards SFM (de Camino 1999a).

Progress towards sustainability is stepwise, of course. One of the first operational steps towards the sustainable management of natural tropical forests for timber production is that from traditional logging methods to reduced-impact logging (RIL). Although RIL may often result in lower costs for timber harvesting, destructive logging is still common in the tropics as a whole (Putz *et al.* in press). That the first step towards SFM so often remains to be taken is one indicator of the amount of work which remains to be done, but should nevertheless be set against what de Camino (1999a) calls the "explosion" of forest certification in the neotropics, with 48 FMUs now certified in Latin America, most of them during 1998 and 1999, and representing 10% of the total forest area certified globally. The neotropics has a clear lead over tropical Africa and Asia in the advance of certification. Although the area certified is minimal in relation to total forest area, this advance is not mere confirmation that forests are being well-managed, as it might be in North America or Scandinavia, but clear evidence of willingness and capacity to progress from non-sustainable forest exploitation towards SFM in the region (de Camino 1999a). Certifiers are only one potential user of C & I, of course, and other evidence of progress in the neotropics is provided by the international, regional and national C & I development processes reviewed in the present paper. From their inception, all these processes have focused on both national and FMU levels. The emphasis on the FMU distinguishes the neotropical processes from, for example, Montreal and Helsinki – possibly in recognition of a more urgent need to "conceptualize, implement and evaluate" SFM at this level in the region.

It was against this background that the IUFRO Task Force for Sustainable Forest Management carried out its second Conference/Workshop on Criteria and Indicators at CATIE, Turrialba, Costa Rica in November 1999[1]. This series of activities was conceived as a response to the growing attention being directed, globally, to all aspects of sustainable forest management, and had the overall objective of involving the scientific community with stakeholders in the development of C & I for SFM. The general objective of the Turrialba event was to contribute to the development of scientifically-based Criteria and Indicators for the sustainable management of primary, secondary and plantation forests in the neotropics, at the FMU level. The present paper summarizes and reviews the proceedings at Turrialba, following the specific objectives of the event: to review the development and implementation of Criteria and Indicators in the Neotropics, to review the state-of-the-art of scientific knowledge of the sociocultural, financial, economic, policy and institutional, technological and biophysical factors which determine the sustainability of the management of neotropical forests; to evaluate the suitability of this scientific knowledge, and the ways in which it is presented and communicated, for the satisfaction of the expectations of stakeholders in the management of forests, to identify priorities for future research and development work on C & I for neotropical forests, and develop proposals for action to be implemented in the short term. Conference proceedings are in preparation and will be available from the authors of the present paper.

The Turrialba Meeting – a Neotropical Perspective on C & I Development

Status of Current Proposals and Processes for C & I Development in the Neotropics

Presentations on current proposals and processes in the neotropics were preceded by an overview of C & I development since UNCED 1992 by Castañeda (1999). Castañeda

[1] IUFRO, CATIE, CIFOR and FAO: International Conference and Workshop on Indicators for Sustainable Forest Management in the Neotropics: formulating multisectorial action in the development and implementation of scientifically-based indicators. Tropical Agricultural Centre for Research and Higher Education (CATIE), Turrialba, Costa Rica, 9-12 November 1999. Sponsored by IUFRO, CATIE, the Centre for International Forestry Research (CIFOR), the Food and Agroculture Organization of the United Nations (FAO), the World Wide Fund for Nature (WWF), GTZ (Germany) and the Directorate for Development Cooperation and Humanitarian Aid (COSUDE), Switzerland.

reminded the audience that the International Tropical Timber Organization (ITTO) began to work on C & I before UNCED. Leigh (1999) presented the ITTO process at Turrialba. The initial ITTO C & I set was endorsed by member countries in 1992, so this process is by far the most advanced of those relevant to the neotropics. ITTO's seven Criteria are valid at both national and FMU levels though the indicators naturally differ between these levels. In common with all the other processes reviewed at the Turrialba conference, except that of Costa Rica (see below), ITTO has not yet developed C & I for plantations, as natural forests were considered to be the main focus of the international debate on forests. The initiation of C & I development by ITTO was a response to pre-UNCED warnings of the lack of progress towards SFM in the tropics, the role of Criteria as an instrument for defining and communicating the characteristics of SFM, emphasized at Turrialba by Prabhu *et al.* (1999), being endorsed by Leigh (1999). The ITTO C & I became a basic tool for the evaluation of progress towards the organization´s "Year 2000 objective" - that significant advances be made towards trade between member countries in timber from sustainably managed forests. The original C & I were nevertheless considered deficient in aspects such as biodiversity and the involvement of communities in forest management. A revision of the ITTO C & I was carried out in 1998 in order to correct these deficiencies, take into account a number of elements of UNCED and other international agreements, ITTO´s own experience, the latest International Tropical Timber Agreement reached in 1994, and results of research and development work on C & I carried out by organizations such as CIFOR and TROPENBOS. Training activities and pilot projects to improve data gathering and reporting have been carried out by ITTO, and operational manuals for the application of the C & I have been developed for both national and FMU levels.

Tarapoto (begun by the signatory countries of the Amazonian Cooperation Treaty in 1995) and the Central American Lepaterique Process (begun in 1997) are more recent initiatives than that of ITTO. Lepaterique drew strongly on Tarapoto in the development of its FMU.-level C & I, as is shown by the its adoption of Tarapoto's four Criteria – Legal, Institutional and Policy Framework, Sustainable Forest Production, Conservation of Forest Ecosystems and Local Socioeconomic Benefits – with only slight differences of wording. Tarapoto is currently concluding a series of national workshops in which the original C & I set is reviewed with respect to its relevance to national circumstances and the abilities of countries to implement the proposal; the ACT countries are also focusing on the development of mechanisms for the systematic gathering and analysis of information for decision-makers (Palma and Toledo 1999). The final national revision of the proposal is that of Brasil, projected to be finished by March 2000. A second regional workshop (Tarapoto II) will then lead into operational testing of the C & I, at which point the Tarapoto Proposal will become the Tarapoto Process (Palma and Toledo 1999). To date, Lepaterique has consisted of one initial regional workshop at which the regional and national C & I were identified, two subregional workshops (one in Honduras and one in Costa Rica) where FMU level C & I were established, and seven national seminars. Currently, the continuation of the Lepaterique Process is assured by the involvement of the Central American Council for Forests and Protected Areas (CCAB-AP) and funding for the activity is currently being generated (Zapata 1999). The lack of participation of Caribbean countries in C & I processes, identified by Castañeda (1999) as one of the relatively few geographical gaps remaining in progress towards sustainability assessment, is beginning to be filled by the linkage of Cuba to Lepaterique, and a strong Cuban delegation was present at Turrialba.

Costa Rica started developing its national standard in 1994, led by the private sector, followed by the academic, public and NGO sectors (the Bolivian case is referred to in the section on stakeholder viewpoints). A first achievement of this process was the laying down by the 1996 Forest Law that all management of natural forests should follow a standard for SFM (Campos and Muller 1999). The same Law also created the National System of Forest Certification and the National Commission of Forest Certification, these being directed at the domestic market in order to complement international certification schemes. C & I based on the FSC Principles and Criteria, and covering primary and secondary forests as well as plantations, became law between 1998 and 1999 after a consultative process involving more than 200 people. The C&I take into account specific characteristics of Costa Rican forestry such as small FMU.s, a highly fragmented landscape and a market for a large proportion of native tree species. The standard established is currently being applied and validated over a three year period. Future work will focus on the international endorsement of the standard, the development of national policies linking certification with the ongoing Environmental Services Payment programme and the creation of domestic markets for certified forest products.

Stakeholder Viewpoints

Stakeholders raised a number of crucial questions regarding the development and adoption of C & I in the neotropics. The President of Costa Rica's Chamber of Forestry reiterated the leadership of that country's private sector in the development of the national standard for SFM, and emphasized that some of the country's certified forest management operations are internationally known (Alfaro 1999). Understanding of the need for sustainability assessment is nevertheless still limited to a small group among the private sector, while the forestry profession has arguably not contributed as it should to the process. Alfaro argued that from the point of view of the private sector, the balance between economic, social and environmental sustainability could easily become inclined unfavourably far towards the latter two aspects, with the last decade seeing the imposition of numerous responsibilities on the forest owner while rights and freedom in the use of the resource have been progressively eroded. Similarly, pressure groups must recognize that progress towards SFM must be gradual. She concluded that these and several other challenges remain to be faced up to if a type of SFM which satisfies the needs and aspirations of private forest owners is to be achieved (Alfaro 1999).

Points of view from rural communities were presented at the Turrialba meeting by representatives of communities involved in the management of natural forests in Guatemala and Honduras. Cortave (1999) and Castro Pérez (1999) spoke on the basis of experience in the management of community forest concessions in Guatemala's Petén Department, which contains a significant proportion of Mesoamerica's remaining forest. These communities are well organized with respect to forest management – ACOFOP unites 30 communities involved in forest management in the Maya Biosphere Reserve in the northern Petén (Cortave 1999) while an association of community members involved in forestry has formed around each concession, such as that of La Pasadita (Castro Pérez 1999). The two community representatives expressed similar concepts of sustainability in forest management, referring to the satisfaction of the needs of present and future generations, through the generation of satisfactory levels of income by activities with which a majority of the community are in agreement. As indicators that the forest is being well-managed the communities take the maintenance of forest cover and productivity, the harvesting of both timber and traditional non-timber products with low impact and minimum wastage, and the continuing disposition of community members to participate in the work (Cortave 1999, Castro Pérez 1999). Five community concessions are currently certified, including La Pasadita. The two speakers reported that the communities recognize and appreciate the prestige, raised public image and access to new markets brought by certification, while regretting the costs entailed in meeting the certifier's standards – which may mean that timber is sold on the national market at a loss (Castro Pérez 1999) - and questioning aspects such as the requirement that communities with high illiteracy rates carry out monitoring. Illegal timber harvesting outside the concessions is one of a number of factors which affect the sustainability of the concessions, but which are beyond the control of their managers.

Perhaps predictably, the public sector point of view, as presented by Guzmán *et al*. (1999) on the basis of the Bolivian experience, was in general more at ease with sustainability assessment, as currently practised, than in the cases of the private sector and the rural communities. Guzmán *et al*. set their presentation in the framework of Bolivia's new forestry law, promulgated in 1996, which saw the country move from a typical neotropical scenario of "timber mining" with little state control, to an environment in which SFM is firmly on the agenda and in which new actors – private individual forest owners, and communities, for example – have begun to play important roles. The Bolivian government´s forest management norms (equivalent to indicators) set a high standard which has permitted the achievement of voluntary certification by private forest owners, concession operators and rural communities. Guzmán *et al.* (1999) warned, however, that prices and markets for forest products are still not favourable for SFM in Bolivia (see below). Finally, they provided a clear pointer regarding research needs for for further C & I development during the coming years, observing that "due to the scarcity of information on the long-term impacts of harvesting on the structure, composition and biodiversity of the forest, the principles of graduality and precaution established in the forestry law are basic to the assumptions on which forest management is currently founded … many of these assumptions await testing using the information which will be generated by studies in permanent sample plots …".

The forest worker, of course, is a major stakeholder in SFM and has a major contribution to make to the achivement of the goal of SFM. A statement from neotropical forest workers could not be obtained for the Turrialba meeting, though Alfter's (1999) report on work carried out on C & I for working conditions of forest workers in Zimbabwe contained many messages relevant to the neotropics. Alfter pointed out that detailed information on working conditions in forestry is often lacking for developing countries, so that social and specifically worker-related C & I are often poorly developed in international processes. Alfter and colleagues questioned company and worker representatives, and workers themselves, in eight Zimbabwean forestry companies, the questions concerning the core areas, derived from International Labour Organization (ILO) standards, of wages, health and safety, freedom of association, discrimination, child labour and training. Working conditions in eight Zimbabwean forestry companies were found to be heterogeneous, and while national labour laws were generally respected, salaries were found to be low and the safely of the majority of workers was not ensured. Bowling and Fitzpatrick (1998) concluded at a more general level that forest workers are in poorly paid, unstable and unsafe jobs, a situation which is not compatible with SFM. The areas of concern identified by Alfter (1999) and Bowling and Fitzpatrick (1998) urgently require attention if progress towards SFM is to be ensured.

The State-of-the-art of Scientific Knowledge as a Basis for C & I Development for Neotropical Forests

Revisiting the Need for C & I

Prabhu *et al*. (1999) suggested that Turrialba was an appropriate moment to revisit the reasons why C & I are generating so much activity, the ways in which they are being used and how they might contribute to improvements in real-world forest management. They asserted that one of the greatest challenges of C & I development is to reconcile the desirability of simple, practical indicator sets with the fact that forests and their interacting social and economic systems are complex systems, and that to expect simplicity may often be simplistic. C & I, they argued, must seek to address gaps and inadequacies in information and communication systems which arise, among other reasons, due to failure to recognize complexity, and which lead to inadequate management. Adaptive management strategies are required for SFM, based on monitoring and emphasizing the institutionalization of conscious learning; in such a context, sustainability would become a measure of the relationship between forest managers as learners and the complex environments in which they manage, and not an externally defined goal. The application of this approach in the neotropics is a medium-term goal.

Sociocultural, Financial, Economic, Policy and Institutional Aspects

The social and cultural aspects that should be taken into consideration in the formulation of C&I became a central question at the Turrialba conference. Brenes (1999) suggested that the success of forest management is a function of the interpersonal relationships between forest managers (the social system) and between them and the forest ecosystem, as well as the social environment in which SFM takes place. It is particularly important to note that SFM is receiving increasing demands at several scales: global, national and local; different decisions are necessary at each scale if SFM is to succeed. Realising the opportunities and meeting the needs of the rural environment is particularly important if society intends to alleviate poverty as well as maintaining or increasing the benefits of SFM. In this context, the basic social aspects that should be taken into consideration in the formulation of C&I are clear: property/use rights and living conditions of the local people, conditions for forest workers at all levels, participation and control of local people in the formulation of C&I, and crucially, the sharing of costs and benefits among stakeholders. Both Brenes (1999) and Davies (1999, see below) asserted that the priority given to people in C&I development for the neotropics is still insufficient and that much work on this subject remains to be done, a certain conceptual tension being evident between the views of social scientists on the one hand, and foresters and biophysical scientists on the other. This need for further work and perceived lack of balance between disciplines is reflected in other recent papers on social (and economic) C & I, and not only in the tropics; Colfer *et al.* (in press) report, for example, that gaining access to certain sectors of rural or indigenous communities is often difficult in the tropics, while Duinker (2000) comments that the dominance of Canada's national Criteria by ecological concerns seems to represent prevailing moods and the personal and profeesional attitudes of most participants in the C & I – SFM design process.

One of the main issues regarding financial sustainability of SFM in the neotropics is that the activity has been profitable only in a few cases and generally, the financial incentives for conventional logging and land clearance for agriculture continue to be greater than those for SFM (Davies 1999). The driving forces behind this situation are a number of market, policy and institutional "failures" related to the forestry sector – for example, the undervaluation of forest products and services and the lack of policy measures to change this situation. Moreover, the opportunity costs of SFM are also high because of the impact of discounting its net benefits over a long period, in contrast to the short-term profits generated by conventional logging and land clearance for agriculture. This situation has the effect of driving a wedge between the private and the social costs and benefits of good forest management; it is therefore necessary to develop mechanisms that allow for the forest owner, concessionaire or forest user to capture the benefits of SFM. Davies discussed several incentive mechanisms at the national and international level that could help to correct market, policy and institutional failures, including transfer payments (via taxes, trust funds, etc.), market approaches based on public good benefits (environmental services payments[2], certification, etc.), and property rights approaches. The opportunity costs of SFM need to be lowered through the promotion of agricultural intensification and the reduction of rural poverty. Davies pointed out that, in addition, the limited information on financial and economic aspects of SFM in the neotropics has focused on industrial forestry, and that stakeholders whose livelihoods depend on the forest via other types of interaction must be taken into account for progress towards sustainability. In the same vein, he perceived C & I development in the region as a "top-down", technocratic process, with an alarming gap between international/national agendas and local perspectives, stating that there has been little progress in developing C & I that are participatory, inclusive and reflect local realities, and allow for negotiation of trade-offs between rural livelihoods and environmental goals. He asked for greater emphasis on C & I that measure progress towards Sustainable Livelihoods (SL) in general, and poverty alleviation in particular, for stakeholders in forests. Echoing Brenes (1999), he stated that an SL approach would put people, their assets and activities, rather than the forest, at the

[2] The Costa Rican Forest Law (1996), for example, establishes an innovative mechanism where forest owners should be compensated by society for the environmental services these ecosystems provide. These payments are financed by a tax on fossil fuels, hydroelectric companies and carbon offsets sales.

centre of sustainability evaluation; livelihood indicators would have to be negotiated with the people concerned.

The economic aspects of SFM raised by Davies along with his discussion of financial aspects were carried further at the conference by Ammour (1999). The term "sustainable" requires that forest management and C & I take into account principles dealing with efficiency in the use of the forest resource, equity in the distribution of costs and benefits, and ecosystem integrity. Society is demanding that forest management should maintain the flow of several environmental services whose benefits are perceived at global, national or subnational levels, while most of the costs associated with the maintenance of services stay with the forest manager/user. In this respect, several speakers agreed that "internalising the externalities" of SFM should be a priority at the national and international level in order to make it financially profitable (Davies 1999, Ammour 1999, de Camino 1999b). The current lack of mechanisms that allow forest owners and countries to capture the benefits of SFM may mean that the maintenance of extensive forest cover might not be the best strategy, from the social and economic points of view, for neotropical countries.

Although decisions concerning the political, legal and institutional conditions that affect forest management are taken outside the FMU, those decisions play a crucial role in determining the success or failure of SFM. The current world economic model is resulting, in general, in a less favourable environment for SFM (de Camino 1999b), though the effects of policy differ between forest types and countries. As a result of the poor performance of the forestry sector in the past, governments tend to impose restrictive policies that in fact encourage illegal logging, making SFM less competitive. Effective control is therefore a basic condition for SFM, and continues to be absent in many neotropical countries (de Camino 1999b). Other conditions include clear property rights, including forest concessions, a proper structure of tariffs and taxes, and a the definition and implementation of national land use plans that identify forest lands for protection and forest lands for SFM. Forestry law in many neotropical countries continues to show easily identifiable weaknesses such as the reduction of freedom for the forester to implement SFM (restrictive, recipe type regulations), but also some positive trends such as the reduction of burdens for obtaining harvesting permits. De Camino argued that there is a general trend for more policy decisions that affect SFM in the neotropics to be taken outside the forestry sector and even the country or region itself. It was stressed that among favourable conditions for SFM are not only an increase of the control of forest managers over the forests they manage, but also their participation in the policy dialogue; in this respect the importance of efficient organisations of forest managers is evident.

Ecosystem Health and Integrity, Forest Productive Capacity and the Fixation and Storage of Carbon.

The maintenance of the health, condition, integrity and vitality of forest ecosystems frequently appears among Principles and C & I for SFM – for example, Montreal (Criterion 3, Maintenance of Forest Ecosystem Health and Vitality), FSC (Principle 6, "Forest management shall conserve … the integrity of the forest"), ITTO (Criterion 3, Forest Ecosystem Health and Condition) and CIFOR (Principle 2, Maintenance of Ecosystem Integrity). The definition of these concepts is still a matter of debate, however, as Schlichter et al. (1999) emphasized at the Turrialba meeting. This is a value-laden and regionally specific field – for example, any concept relating atmospheric pollution to ecosystem health seems unlikely to be relevant to either the tropical or the southern temperate forests of the Americas (Schlichter *et al*. 1999). Ecosystem integrity, they felt, seems to be a more easily definable and communicable concept then ecosystem health, integrity referring to the maintenance of the wholeness of ecosystems, the interconnections among their components and their self-organizing and complex character. Nevertheless, the establishment of indicators for the assessment of ecosystem integrity requires a certain degree of understanding of the system and the identification of key components and processes. Lack of knowledge of tropical forests therefore requires, provisionally, a precautionary approach to the definition of forest management standards and the assessment of sustainability. Precaution, Schlichter *et al*. warned, may bring opposition from those stakeholders who dislike having their freedom of action limited due to ignorance, while lack of funding for research may mean that provisional measures become permanent. They also warned that ecosystem integrity may depend on factors and processes at scales beyond that of the FMU – while indicators at the level of the FMU may be useful for the purposes of certifiers, then, they may not be giving sufficient information for an accurate assessment of the true sustainability of the management process, which partially depends in the landscape in which the FMU is located. (Schlichter *et al.* 1999).

Aspects of the sustainability of forest production were dealt with at the meeting by Wadsworth (1999), who observed that the Turrialba meeting was an opportune moment to review technical knowledge regarding production in neotropical forests in the light of new demands regarding sustainability. He began by suggesting that the definition of best practice for forest management is a more realistic basis for forest production and conservation than the elusive concept of sustainability. He felt it premature to conclude that no technical problems remain in the management of natural neotropical forests, but set out a number of elements of best practice for their silviculture which have been proven by decades of experience, and which may be used with confidence in the definition of standards and as input and process indicators for sustainability assessment. Selective harvesting of timber does not cause the collapse of lowland tropical moist forest ecosystems, especially but not only when RIL is adopted, due possibly to a large degree of ecological redundancy among the tree species of these forests. Timber productivity is greatest when stand basal areas are maintained between 15 and 25 m^2 ha^{-1} by silvicultural treatment, and may be raised to at least 5 m^3 ha^{-1} yr^{-1}, growth responses to liberation treatment by future crop trees being immediate. Poles (individuals $\geq$ 10 cm dbh) are more important than smaller individuals with respect to the evaluation of future crops, are normally present in sufficient abundance to ensure those crops, and show very low mortality after liberation. Timber harvesting should be integrated with the liberation of the trees which will form the next crop. Wadsworth (1999) finished by echoing previous speakers regarding the need for stakeholders in FMUs to receive the benefits of environmental services, and recommending that monitoring of the ecological response of the forest to management operations is carried out in a context of adaptive management.

Among the environmental services provided by neotropical forests, of course, is their contribution to the mitigation of global climate change through the fixation and storage of carbon. Kanninen and Masera (1999) discussed carbon and forest management at the Turrialba meeting, pointing out that sustainable development is the principal objective of the UN Conference on Climate Change and the Kyoto Protocol. The achievement of SFM is the major contribution which the forestry sector can make to this objective, though conflict between policy measures for climate change mitigation and those for sustainable production should be avoided. The inclusion of indicators related to carbon cycles in C & I sets for sustainability assessment automatically creates new information needs which will have to satisfied by additional research and monitoring (Kanninen and Masera 1999). The basic options for fixation and storage of C through forestry activities are the conservation and increase of forest area and the increase of biomass per unit area, though optimal strategies for a contribution of forestry to climate change mitigation will vary between countries in relation to areas of natural forest, levels of reforestation or afforestation activity and the principle uses to which forests are put. These authors considered the setting of objectives related to climate change mitigation in the management of neotropical forests to be unlikely in the near future, although basic elements of SFM such as RIL, fire control and the reduction of waste during transformation, as well as increased emphasis on long-lived forest products, all make a contribution to such objectives.

Soil and Water Conservation, Biodiversity and Plant-animal Interactions

SFM requires the assessment of soil and water as values in themselves rather than simply as factors which underpin sustainable yield. Lima *et al*. (1999) pointed out that most potential soil and water indicators of sustainability are relatively costly to measure as well as being highly site-specific and spatially and temporally variable, so that investment in research as a basis for the development of appropriate indicators is necessary. A precautionary approach to management must be implemented, they maintained, until valid soil and water indicators are in place. They also emphasized the need to involve stakeholders in discussions related to soil and water because of the importance of these resources to local people and "ongoing complaints" about possible effects of forestry activities on water quality and yield. Lima *et al*. (1999) recommended the adoption of *integrated catchment management* as the organizing concept for the management not only of soil and water resources in FMUs, but also for the maintenance of the capacity of the land and vegetation resources in general to produce goods and services - overall goals related to the sustainability of the catchment and its ecological and hydrological functions include the maintenance of productivity, the maintenance of biological diversity and the maintenance of hydrological processes. They also pointed out the importance of an integrated approach to soil and water management across several spatial scales, at each of which different environmental impacts of human activity on soil and water resources may be identified, each with its corresponding set of causes and possible indicators. The protection of riparian zones is an essential component of sustainability at the "micro" (FMU) scale, for example, and the existence and implementation of measures to achieve this are obvious indicators or verifiers for sustainability. Techniques for the identification of riparian zones must be refined, however, as these may not correspond with the areas which current forestry legislation requires to be protected, which may be defined simply on the basis of distance from water resources, as in the cases of Brazil and Costa Rica, for example. Lima *et al*. (1999) recommend that in general, monitoring of catchment parameters be carried out to provide feedback to management plans and codes of practice in an adaptive management context.

Besides the references to biodiversity conservation in the papers by Schlichter *et al*., Wadsworth and Lima *et al.,* two papers at the Turrialba meeting analysed this subject directly - those by Finegan (1999) and Guariguata (1999). Finegan reminded the meeting that although there is certainly no unanimity on the subject, a broad consensus exists that well-managed tropical forests can contribute significantly to the conservation of biodiversity, while the conservation of biodiversity is considered to be one of the factors which underpins the sustainability of forest management. Finegan's review of C & I sets relevant to the neotropics (he took in ITTO, Tarapoto, Lepaterique, Costa Rica and Bolivia, as well as FSC) emphasized the universal adoption of a precautionary approach, centred around input and process indicators. Indicators under this precautionary approach include the maintenance of strictly protected reserves within the FMU, required by FSC to cover each forest type found in the FMU – an extension of the so-called "coarse filter" approach to conservation which could usefully underlie all planning for conservation in FMUs. All the sets reviewed propose variations on the theme of identification and protection of "rare, threatened and endangered species". Finegan observed that this type of criterion and associated indicators might be better framed in terms of the current IUCN threat categories (among which the highly ambiguous term "rare" no longer appears); lists of fauna in different threat categories exist for many neotropical countries, though forest managers are still faced with the task of determining which species are likely to be present in a given FMU, and measures for their protection are unlikely to exist beyond control of hunting and habitat conservation. Finally, Finegan commented that the incompleteness of knowledge of tropical forest biodiversity is matched by a lack of techniques for its monitoring in managed forests in an adaptive management context. Some relatively easy-to-assess outcome indicators are relevant to biodiversity conservation in any forest type, however (many forest structural characteristics, for example) while others may give clear signals regarding changes in tropical forest biodiversity at different spatial and temporal scales (the composition and abundance of diurnal Lepidoptera communities, the guild composition of tree stands); preliminary approaches to monitoring should be developed and tested.

Within the general context of biodiversity conservation and the sustainability of forest management, Guariguata (1999) provided an invaluable perspective regarding the importance of plant-animal interactions in natural neotropical forests. The high levels of outbreeding shown by tropical tree species and the low densities of the populations of most of them, for example, render the presence of pollinators capable of covering hundreds of metres between conspecific trees vital to population viability. If forest area or the abundance of pollinators are significantly reduced, the size of seed crops per tree, or seed percent viability, may decline (Guariguata 1999). Besides being pollinated by animal vectors, the seeds of a majority of the tree species of neotropical moist forests are dispersed by animals and birds, and strong evidence indicates that the probability of seedling survival often increases disproportionately with distance from conspecific trees. Guariguata pointed out that reductions in population sizes - due to hunting or fragmentation, or both - of the medium-sized rodents which are key players in the dispersal of relatively large seeds can severely impact the seed dispersal process, with particularly important consequences for sustainability in forests such as those of the Guianas in which up to 50% of the tree species may be large-seeded and dispersed by such rodents. Finally, Guariguata cited evidence that grazing of seedlings and saplings by vertebrate herbivores, by reducing the likelihood that certain tree species come to dominate the forest, also plays an important role in the determination of forest composition - again, the absence of these animals may bring about changes in forest characteristics. Among indicators which would be appropriate for the assessment of animal populations and the tree demographic processes they contribute to are measures for the control of hunting in the FMU, changes in the abundance of key elements of the fauna as determined by simple monitoring techniques, seed removal rates, changes in the abundance and spatial distribution of reproductively mature trees and regeneration, and the existence and implementation of measures to restrict harvesting impacts on vertebrate-dependent tree populations in small FMUs; some but not all of these indicators are covered by CIFOR (1999), but they are generally absent from other neotropial C & I sets.

Discussion, Conclusions and Recommendations

The following discussion, conclusions and recommendations are based on largely on the resolutions of the conference/workshop, which synthesize the discussions held during the event and will be published in the proceedings. The conference delegates recognized that C & I are valid and useful tools for sustainability assessment and that significant progress has been made in their development for the management of natural tropical forests. Considerable work remains to be done, however. National testing and validation of existing generic C & I sets is one major priority, while the C & I sets often show internal inconsistencies and contradictions (de Camino 1999a) and FMU-level C & I for neotropical forest plantations have only been explicitly addressed by Costa Rica. It was also recognized that while the scientific basis of C & I is well-established in areas such as harvesting and silviculture for timber production, research is required on aspects such as soil, water and biodiversity, though the state-of-the-art papers on these subjects indicated scope for strengthening C & I using existing knowledge. The delegates also considered that C & I for sociocultural aspects require reassessment, as many stakeholders do not appear to have participated in the development of those which exist, and sustainability assessments can not therefore be expected to cover the interests of those stakeholders. The delegates felt very strongly that the effectiveness of the neotropical C & I process is severely limited by a lack of effective communication, on the part of researchers, of the existing scientific information which forms, or should form, the basis for C & I development. This viewpoint was expressed with respect to all the scientific disciplines represented in the conference programme, and a concerted effort for effective information-sharing, with the use of existing networks, or the creation of new ones, was recommended as one means of overcoming this major problem. Practical guides for the application of existing C & I were identified as a particular necessity. Regional and national institutions were called upon to assume leadership in work directed towards the resolution of these and other problems. Horizontal cooperation between C & I development processes may also be useful, and institutions offering intermediate or higher education in forest management and related fields were recommended to put sustainability assessment and its scientific basis firmly on their curricula. The delegates felt, in addition, that state forest services should play more active roles in the promotion and implementation of C & I as one of the legal requirements for forest management, while the absence from the Turrialba event of representatives of certifiers, although representatives of managers of certified FMUs *were* present, was regretted. Besides debate on the need for a more people-centred approach to sustainability assessment, the implications of the precautionary approach to biophysical aspects was also discussed. On the one hand, support was voiced for the implementation of C & I within a precautionary framework for crucial but still poorly known aspects such as soil, water and biodiversity, while on the other, there were strong calls for progress towards less restrictive and inflexible concepts of ecological sustainability which will give the forest manager greater freedom of action and pose less of a perceived threat to financial and economic sustainability (e.g. Alfaro 1999, de Camino 1999a,b). The use of existing monitoring techniques, and the development of new ones where necessary (Wadsworth 1999, Lima *et al*. 1999, Finegan 1999), permitting movement towards C & I-based adaptive management systems which "promote active and conscious institutional learning" (Prabhu *et al.* 1999) would contribute to the resolution of this tension and could be set as a medium-term objective. Appropriate institutional arrangements for the execution of monitoring are badly needed, however – this responsibility should not simply be assigned to the operators of each individual FMU. Finally, both invited speakers (de Camino 1999a,b, Prabhu *et al*. 1999, Lima *et al.* 1999, Finegan 1999) and conference delegates referred to the artificial and undesirable gaps currently existing in the concept and the focus of C & I development. The division between national and FMU levels, for example, leaves open intermediate spatial scales at which land use planning could contribute to sustainability at the FMU level, but at which managers of FMUs are unable to exert any direct influence.

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About Criteria and Indicators for Sustainable Forest Management

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Abstract

In this paper, we report on the main conclusions elaborated through presentations and discussions at the Nancy meeting, March 22nd – March 25th. We recall that Criteria and Indicators are at this fringe between so called hard science and social science. C & I are as well a tool for reaching a consensus as a set of guideline for making decisions, i.e. C&I reflect as well the state of consensus/conflict with a society. We then recall some issues which have emerged as crucial, such as scaling and harmonization. Some hints have been proposed on how to rely C&I and biodiversity, as biodiversity may be taken as a surrogate for sustainability. Some emphasis is put on the necessity to develop the usefulness of C&I as decision making tools. Finally, an hierarchical framework derived by Tropenbos is presented in the setting of harmonization.

Keywords : Criteria and indicators – Sustainable forest management – Tropenbos hierarchical framework

Introduction

Forest management is a very old and universal human activity as most of societies have set up rules for managing the forested areas belonging either to individuals or to communities, including the state. Despite this long tradition, forest managers have experienced in the past decades, and are still driven by a main shift in paradigm. This shift refers to the notion that sustainable yield is not the same as sustainable forest management.

Some European historical texts from the Middle Ages convey to us the rules according to which forest management was driven at those times. The long term sustainability of the forests was the first, among other, of the goals, leading to the rule that benefit from forest must rely on harvesting the interest, and not the capital, of the forest stock. Such a concern was explicit in many societies, all over the continents and the times, as regulating the access to resources is a corner stone of social organisation. Management practises were put on a scientific basis and within a compelling legal framework in several European countries by the beginning of the 19th century. The necessity of putting long term sustainability of forests cover as a compelling rule was at the basis of this system. Whether the management has been successful or not is another story, but this goal was firmly maintained. This period has lasted in Europe until the late sixties. The widely accepted assumption was that sustained yield is a surrogate for sustainability of all functions fulfilled by the forests. In the seventies, due mainly to the development of plantation forests, some question rose on the scientific relevance of such an assertion : there may be some conflict between sustainability of biological diversity, or recreation values, and sustained yield.

Simultaneously a tremendous extension of the functions is recognised to forest cover since the early seventies, which means an equally tremendous increase of requirements to be accommodated by forest managers . This diversification has lead to many conceptual developments, such as multipurpose forest management, where the diversity and equally relevance of needs as expressed by different stakeholders was explicitly recognised and taken into account in management tools. However, such an increase and diversification of requirements goes often with an increase of conflicts regarding the management of the forested areas.

In any country, whether in Boreal, Temperate or Tropical zone, whether developed or developing, such a change is obvious. Any reader can compare the state of forest affairs in his/her own country in the early seventies with current state. Functions recognised to forest areas are more diverse, stakeholders represent more diverse parts of the society, sometimes close to or sometimes far from the area where the forest is located, and conflicts for forest use are more widespread.

The need for regulating the exchanges between stakeholders, and the access to forest resources, has never been as acute as nowadays. There is a widespread consensus on the necessity for forest management to preserve the sustainability of all functions and values as recognised by stakeholders, but the consensus is not as widespread on how to implement in management practises this request for sustainability. Moreover, some requirements may be conflicting. One tool is currently developed for this purpose : to derive Criteria and Indicators for Sustainable Forest Management from current scientific knowledge.

Main Issues for C & I for SFM at FMU Level

What are C & I about

Most of the forest values have been allocated classically into a three fold framework which is

Productive values : wood quantity and quality, forested areas, etc. …

Biological values : conservation of local flora and fauna, …

Social benefit : recreation, suburban forests, etc …

Most of these functions were recognised at the forest management unit level.

Recently, some new values have emerged as equally important versus the former :

Extension of productive values to non wood products

Preservation of ecological functions at a landscape level, such as hydrological cycles, biochemical cycles, etc. …

Preservation of ecological functions at a global level, such as carbon sequestration

Preservation of biological diversity

Preservation of cultural and spiritual values

As mentioned above, it was felt some decades ago that the sustainability of the sole forest cover would guarantee the sustainability of all other functions. As these functions have widely evolved and are far more diversified, the questions arises to know whether this assumption is still valid. The current consensus is a sort of precautionary principle : it is not the case. However, the scientific basis for such an assumption is still a matter of debate.

Then, forest managers are faced with the obligation of proving that their management practises will not damage any of the functions or values of the forest. One objective of deriving Criteria and Indicators for Sustainable Forest Management at the Forest Management Unit Level on a sound scientific basis is to provide forest managers with reliable tools to evaluate and monitor sustainability of forest values as an outcome of forest management and protection practises. As such, C & I should be distinguished from certification issue, which deals with comparing forest management activities/progress for different forests at the same time, with accepted upon standards. There exist links between both, as certification can use C & I for deriving standards.

Scaling

One obvious difficulty is that the values are assessed at different scales : the forest management unit, the landscape, the ecoregion, and even the global scale. Assessing C&I at the FMU level can be an example of the motto ‘think globally, act locally’. It should be kept in mind that such a scaling is far from being either obvious or even relying on a firm and steady scientific basis. This is an immense, complex area where suitable research is highly needed. It is one objective of the Iufro task Force to share experience between stakeholder and scientists to evaluate the feasibility of such a programme.

Indeed, the necessity to deal with different scales is widely accepted even if recognised as difficult. Two levels are identified, National and FMU, and the scale of FMU is variable within and between countries. A new framework of multiscale approach, with common vocabulary, is suitable. An example for progress into this direction is presented in part two of this paper. There is a consensus on the existence of mutual interactions between levels, both as adaptation or influences. Relevant scale may be dissimilar between criteria, which makes the integration more difficult. Moreover, some criteria are better understood within the framework of nested scales.

Harmonization

There is however not yet a commonly agreed or shared definition of what a Criteria and Indicator for Sustainable Forest Management is, or should be, and we do not suggest any. Although some progress has been made and some clarification has emerged, such as the one presented in part two of this paper, discussions are still open as, sometimes, several viewpoints are presented in different arenas or publications, and it is too early to agree for an harmonisation of definitions which is a matter of long term research, and negotiation. Indeed, definitions are available, common definitions are requested but not yet operational.

The issue of sharing a common vocabulary is crucial. It is natural to expect a consensus on vocabulary for easing discussions and reaching a consensus. However, the case might be more complex, and it can be said that the reality of a common vocabulary is an outcome of a consensus on the ideas and concepts. In other words, it is impossible to separate the negotiations and discussions for harmonisation upon ideas and concepts from the one for harmonisation of vocabulary.

The level of reachable harmonisation is variable. Within the hierarchical framework of Principles, Criteria and Indicators presented in part two, it is commonly accepted that harmonisation decreases from principles to indicators. Principles are accepted as intangible whereas indicators are most commonly adapted locally. The situation of criteria is more unbalanced. Criteria are getting harmonised at national level, and such an harmonisation is still questionable for criteria at local level.

C & I Between Social and Biological Disciplines

Among the different, and overlapping viewpoints, we can mention that C&I for SFM are linked with the tradeoffs between current and future generation needs and protection and utilisation of forested lands. This is an example of the diversity of approaches related to C&I for SFM, which may be discouraging. However, two main streamlines can be recognised on a scientifically basis :

- One favouring ecosystemic approach, originating from ecological and biophysical sciences, where the main question is : how does the (biological) system work ?
- One favouring an approach with social science: how do human affairs interact with the functioning of the forest ecosystem ?

C & I and Biodiversity

Recently, a new streamline has developed on the link between sustainability issues and biological diversity issues. As there is a wide consensus that sustainable yield cannot be a surrogate for sustainability of the system as a whole, such an issue for diversity has not been settled. There is a widely spread temptation to use biological diversity as a surrogate for sustainability, and a danger that this assumption is not scientifically evaluated. However, it becomes clearer and clearer that biodiversity is not a surrogate for sustainability. This paradigm is linked with precautionary principle in conservation biology, and there exist some cases where society needs are not automatically fulfilled with highly diverse forests.

Another point is that there should be a differentiation between biodiversity and naturalness. For example, biodiversity can be conserved by management practices whereas naturalness cannot unless by protection measures.

Transfer into Decision Making

There is an opportunity for developing planning and management tools from C & I. They can be quantitative or qualitative, and the negotiation between stakeholders for agreeing on C & I and their scoring is part of the process.

Even if some progress is still needed, a suitable and reachable objective is to have sets of criteria and indicators to evaluate how the management practises reach social, ecological and biophysical goals for sustainability. As such, criteria and indicators are one of the means to monitor and evaluate forest management, and should be associated with benchmarks for rating and scoring. Such a process should rely on sound scientific basis but, more than a lack of knowledge, there is a lack of communication between scientific knowledge and tools for decision-making. For example, there is a need to convert scientific knowledge into valid operational techniques, without loosing genuine scientific information.

There exist several ways to implement this process:

- to develop a network of model forests, on which international co-operation should be enhanced, and for which stakeholders should be associated ;
- modelling and data analysis, keeping in mind that deriving C & I is not an optimisation process, and that black box models should be avoided.

Whatever the choice, there is an opportunity to develop international co-operation on data, measurements and validation on case studies and model forests.

C & I as a Bridge Between Science and Policy

The process of proposing C & I for SFM has started, in its actual form, in the beginning of the 90's at a intergovernmental level. Several processes are going on, and one major issue in SFM debate is to evaluate the state of the art for C & I at the FMU level, particularly in relation with the C & I as agreed at the national level by ongoing processes (ITTO, Helsinki, Montreal, Tarapoto, etc).

The debate on C & I for SFM has a very specific niche as far as relationships between science and policy is concerned. The demand for developing, adopting and assessing C & I on a firm scientific basis is high. Is it however sensible to expect such an achievement in the coming years ? There exist some disciplinary approaches, such as growth modelling, site evaluation, tree breeding, etc., which rely on a firm, well established and accepted scientific basis. This is not the case for C & I for SFM. For example, there is even a difficulty in assessing a commonly accepted definition. One reason may be that C & I are part of the debate within and between societies on the regulation of the access to forest benefit and resources. Those regulations vary widely between countries and societies, and every society may select the C&I adapted to its own regulation process. If true, this means there will be accepted, scientifically based C & I only when access to forest resources will be smoothly regulated by negotiation. Indeed, agreement on C & I for SFM means an agreement between stakeholders on how and why to manage or protect a forest, and failure of an agreement means there still exist a given level of conflict. Technical C & I will not solve the conflicts : this is a matter of negotiation. Technical C & I will be commonly accepted when the negotiation has ended successfully.

An Example : The Hierarchical Framework Derived by Tropenbos

In 1997, Tropenbos published the document 'Hierarchical Framework for the Formulation of Sustainable Forest Management Standards'. This publication is intended to serve as a manual for participants in any process aimed at developing a consistent standard for sustainable forest management SFM), at national and forest management unit (FMU) level. A standard is defined as a set of parameters on different hierarchical levels: principles, criteria and indicators (P, C, I).

Rationale

Existing sets of P, C, and I (C & I) for monitoring, reporting and assessment at the regional, national and Forest Management Unit (FMU) level contain a wide range of interpretations of terms. Confusion persists in the use of terms and the perception of the concept of C & I. Discussions and communication suffer from these deficiencies and comparisons between sets are difficult to make leaving room for not easily to recognise differences in requirements as to sustainable forest management. The call from IPF for developing a global consensus on concepts, terms and definitions related to SFM is still valid. The merit of achieving such consensus became apparent again in the discussion during the C & I conference in Nancy.

Communication and indeed understanding of sustainable forest management could benefit tremendously if we were more considerate in using universally accepted terms and if we would build in more consistency in the design of C & I sets. It would be helpful for effective communication if parties would use the same name for any particular thing, aspect or phenomenon. It is for instance very confusing if we discover that the word verifier used in the CIFOR template points to parameters that in fact are indicators by their nature and character. In this example confusion could have been avoided if the term verifier would have been used to refer to the more generally accepted meaning notably “source of information”.

Even more serious than mixing up terms is the fact that people participating in the development of sets of C & I have different perceptions and interpretations of the entire meaning of the concept of P, C & I.. We should ask our selves the question what do we try to establish, organise and control with a framework of P, C & I..

The purpose is to establish a **Transparent systematical relationship** between:

: Agreed (long-term) goals for the values (functions or services) of the forests.

: Implications of the realisation of these goals for the size and condition of the forests and for the interacting social system.

: Elements to direct management measures and/or to assess compliance with the required condition of the forests and the interacting social system or, in some cases directly with the formulated goals.

This systematical approach shows the translation from goals formulated in societal values to relevant forest management aspects in terms of forest cover, forest condition and condition of groups of the civil society. It is necessary to follow the systematical scheme closely in order to keep the discussion at the right level and to design a set of C & I that is effectively serving the purposes that it was meant to be designed for.

Basic Starting Points of the Hierarchical Framework

The proposed hierarchical framework has been developed on the basis of several starting points and considerations:

Types of parameters

In the framework a clear distinction is made between different types of parameters:

1. Input: an object, capacity, or intention, put in, or taken in, or operated on by any human driven process;
2. Process: the management process or a component thereof, or other human action, describing human activities but not the result of the activity;
3. Outcome: the actual or desired result of a management process which describes the state or capacity of the ecosystem, the state of a physical component or the state of the related social system or its components.

Vertical and horizontal consistency

The framework prescribes that a standard should be horizontally consistent, meaning that parameters at one hierarchical level (P, C or I) do not have any implicit or explicit overlap or duplication, while at the same time all aspects are covered. It should also be vertically consistent meaning that all the parameters are placed at the right hierarchical level, expressed in correct terms, and linked to the appropriate parameter on the higher hierarchical level.

Clear description of functions and characteristics of each hierarchical level

For each hierarchical level an extensive definition is formulated based on the proposed function and characteristics of the level. Besides, important points of attention for each level are given. Summarised:

* **Sustainable forest management (SFM):** The level of SFM represents the overall goal in the P, C & I hierarchy.
* **Principles:** 'A principle is a fundamental law or rule, serving as a basis for reasoning and action. Principles have the character of an objective or attitude concerning the function of the forest ecosystem or concerning a relevant aspect of the social system that interacts with the ecosystem'. The level of principles makes the meaning of SFM more explicit and comprehensive. It splits the goal into separate components which together fully cover the meaning of SFM. A principle should refer to a function of the forest (economic, ecological or social) or to an attitude to be held by society. Measures and prerequisites should not be formulated as principles.
* **Criteria:** 'A criterion is a state or aspect of the dynamic process of the forest ecosystem, which should be in place as a result of adherence to a principle. The way criteria are formulated should give rise to a verdict on the degree of compliance in an actual situation'. The function of the level of criteria is to show compliance with a principle in relation to the forest ecosystem, or related social system. Criteria should be formulated in terms of outcome. The combined set of criteria should cover the full scope of all the principles.

  * **Indicators:** 'An indicator is a quantitative or qualitative parameter which can be assessed in relation to a criterion., or occasionnally directly to a principle. It describes in an objectively verifiable and unambiguous way features of the ecosystem or the related social system, or it describes elements of the prevailing policy and management conditions and human driven processes indicative of the state of the eco- and social system'. Indicators attach assessable parameters to criteria. Therefore, they should be formulated in an objectively verifiable way. Quantitative indicators are preferred above qualitative indicators. Indicators can directly describe features of the ecosystem or social system which should be achieved (outcome indicators) but they can also indirectly describe human processes or input necessary to achieve SFM (process or input indicators). In practice, it appears that quite some process and input indicators are not necessarily indicative for just one criterion (e.g. 'there is a management plan'). In view of this reality a distinction is made between specific input and process indicators, and general input and process indicators. While maintaining the concept of vertical consistency specific indicators, including the outcome indicators are placed under the criterion they refer to. The general input and process indicators are put in a bag stretching along the full gammit of criteria.

  The actual assessment of management performance should be based on a comparison between the actual value of the indicator and its reference value (norm) [s]. By comparing the norm with the actual measured value, the result demonstrates by what degree management fulfils a criterion and complies with a principle.

* **Verifiers:**'A verifier is the source of information for the indicator or for the reference value for the indicator'. The quality of the verifier determines the credibility of the indicator value

Enabling Conditions

Following the logic and the consistency of the above described coherence between P, C & I it is felt that a certain group of parameters, referring to institutional and economic requirements, calls for a distinct position. This group of parameters is not deducted from the principles, but constitutes rather the enabling environment in which SFM may be achieved. This group of parameters will be elaborated at the level of indicators under the umbrella of enabling conditions. The common denominator, enabling conditions, will be placed at the level of criteria.

Conclusions

With the proposed hierarchical framework, Tropenbos aims to contribute to the development of globally comparable (not necessarily harmonised) and individually consistent standards. Some aspects however, need further attention and thinking. Examples are the linkage between standards for the national level and the FMU level and the distinction between criteria and outcome indicators. Tropenbos hopes that others may join to further develop the ideas for a hierarchical framework as described in this document.

Sub-Plenary Session : A7

Sustainable Management of Natural Resources:

Role of Forestry in Landscape Rehabilitation

Coordinators:

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Role of Forestry in Landscape Rehabilitation: Malaysian Experience

by
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Abstract

Malaysia, like many tropical countries worldwide, is faced with the serious problem of forest land degradation. Due primarily to agricultural development, including shifting cultivation, the forests of Malaysia have been seriously depleted and degraded. Assuming that a third of every hectare harvested would become degraded (including those areas currently under active logging, the previously mined land and those areas under shifting cultivation in Sarawak and Sabah), the extent of degraded forest land in the country will be over 1.5 million hectares. Hence, to sustain the economic, environmental, social and cultural benefits derived from the forests there is a need to repair the damage resulting from deforestation. Consequently, previous efforts towards this direction had involved restoration, rehabilitation and reclamation. Forest rehabilitation is expected to improve, if not to restore, the natural productivity as well as the environmental and aesthetic values of the degraded forested land. Traditional approach of forest rehabilitation usually involve planting a mixture of agronomic crops, particularly legumes and trees with erosion control capabilities, as the primary objective. Recent rehabilitation projects though have more demanding objectives, such as re-establishing a commercial forest. Most of the previous rehabilitation projects that were carried out in Malaysia primarily involved the planting of exotic species. However, the planting of indigenous tree species using different techniques has been recently emphasised. By using these different techniques of forest rehabilitation, it is expected that landscape rehabilitation technology can be applied to different land use and types of forests including urban areas, degraded coastal and hill forest and mangrove forest. Hence, to promote the role of forestry in landscape rehabilitation, forest rehabilitation issues must also be given appropriate recognition in policy and legislation by applying the principles through the recommended actions. This paper discusses the current status of reforestation in the country and the main techniques used in forest rehabilitation, such as line planting, gap planting, and enrichment planting. Moreover, in as much as policy matters significantly affect the success or failure of the rehabilitation/reforestation projects, the latter part of the paper includes issues related to government policy on forestry.

Keywords: Malaysia, Forest rehabilitation, Gap planting, Line planting, Forest policy

Introduction

Malaysia has a total land area of 32.9 million ha (approximately 330, 000 square kilometres) with 13.2 million ha in Peninsular Malaysia comprising 11 states and the Federal Territory of Kuala Lumpur, 7.4 million ha in Sabah and the Federal Territory of Labuan, and 12.3 million ha in Sarawak (Anonymous 1997). Its climate is equatorial with year round high temperature and high rainfall during the Northeast Monsoon from Oct/Nov to Feb/Mar. Humidity is always high and ranges from 70 to 98 percent.

As of 1998, its population was 22.23 million and the growth rate for the periods 1996-1998 was 2 percent. The 1998 estimates showed that Malaysia has almost 80 percent of its population staying in Peninsular Malaysia. Malaysia is categorised by the World Bank as an upper-middle income country. Its economy is one of the fastest growing in South East Asia. Foreign investment in the country is high and has made Malaysia the second most open market after Singapore. Among its trading partners are United States of America, Japan, Singapore and Taiwan (Anonymous 1996).

The Forests of Malaysia

Malaysia is fortunate to be endowed with extensive areas of valuable natural tropical rainforests. Malaysia has 20.1 million ha of the 1.7 billion ha of the world's rich tropical rainforests (Hammond 1996, Nik Muhamad & Mohd. Zaki 1996). Throughout the years, however, this resource has decreased mainly due to conversion of forest areas to other land use.

In 1998, 78 percent of the total forested land in Peninsular Malaysia is mainly in the states of Pahang, Perak, Kelantan and Terengganu (Tables 1 and 2). Tables 3 and 4 present the total forested area in the states of Sarawak and Sabah.

Status of Degraded Land in Malaysia

Over-exploitation of the forests through harvesting, degazettement of forest areas and human encroachment primarily caused forest land degradation in Malaysia (Nik Muhamad & Mohd Zaki 1996, Nik Muhamad 1995, Weidelt 1993).

One adverse impact of harvesting is land degradation, which is reflected by increased soil compaction and erosion, decrease in soil fertility and biological degradation of the soil. To counter this, the government has introduced replanting, rehabilitation and reclamation programmes.

Causes of Forest Land Degradation

The Malaysian forests are destroyed in two ways; natural and man-made. However, the effect of the former is considered insignificant as compared to that of the latter (Nik Muhamad & Mohd Zaki 1996, Nik Muhamad 1995). Among the human-related causes are the following:

Table 1. Forested Area by State in Peninsular Malaysia, 1998 (ha)

State	Permanent reserved forest	Stateland	Wildlife reserve	Others	Total forested area
Johore	363,450	36,022	48,905	0	448,377
Kedah	342,260	2,428	0	0	344,688
Kelantan	629,687	155,801	108,783	0	894,271
Malacca	5,424	1,200	0	0	6,624
Negeri Sembilan	168,034	3,896	0	4,020	175,950
Pahang	1,393,935	203,029	361,130	0	1,958,094
Perak	1,006,167	41,107	7,413	14,523	1,069,210
Perlis	10,409	1,078	68	0	11,555
Pulau Pinang	6,396	848	0	0	7,244
Selangor	246,732	0	7,886	0	254,618
Terengganu	557,661	33,000	77,507	0	668,168
Federal Territory	61	0	0	0	61
TOTAL	**4,730,216**	**478,409**	**611,692**	**18,543**	**5,838,860**

Source: 1998 Forestry Department, Peninsular Malaysia

Table 2. Forested area in Peninsular Malaysia (ha)

LAND	YEAR				
	1994	1995	1996	1997	1998
1) Permanent reserved forest	4,687,463	4,684,904	4,684,094	4,731,927	4,730,216
2) Stateland	594,433	590,486	521,528	504,025	478,409
3) Wildlife reserve	608,070	611,340	614,925	611,692	611,692
4) Others	0	0	0	5,225	18,543
Total forested area	**5,889,966**	**5,886,730**	**5,820,547**	**5,852,869**	**5,838,860**

Source: 1998 Forestry Department, Peninsular Malaysia

Table 3. Major forest types and Non-forest types in Sarawak (1996)

Type of Forest	Area (ha)	Percent (%)
1) Natural Forest		
Mangrove forest	127,741	1.02
Peat swamp	1,092,252	8.77
Hill mix dipterocarp forest	6,706,119	53.88
2) Other forest		
Secondary forest	3,883,863	31.2
Man-made tree plantation	449,446	3.61
3) Non-forest		
Non-tree Agriculture crop	104,839	0.84
Urban/settlement or build up land	35,749	0.28
Water bodies	129,341	1.03
TOTAL	**12,444,951**	**100.00**

Source: Annual Report, Forest Department Sarawak 1996

Table 4. Forest types in Sabah (1995)

Type of Forest	Area (ha)	Percentage of total land in Sabah (%)
1) Mangrove forest	317,400	4.30
2) Transitional, Beach and swamp forest	193,000	2.62
3) Undisturbed high forests Lowland dipterocarp forests and Highland dipterocarp forests	300,000	4.07
4) Montane forests	700,000	9.50
5) Other forests (Immature, disturbed and regenerating forests)*	2,799,220	37.97
TOTAL	**4,309,620**	**58.46**

* excluding plantation forests
Source: Annual Report, Forest Department Sabah 1995

- Excessive harvesting/commercial logging - In Peninsular Malaysia, the total logged area ranged between 55 and 48 percent of the total forested area (excluding wildlife reserve) in the PRF and state land between 1994 - 1998, (Table 5 and 6). Moreover, in 1998 a total of 114, 998 ha is opened for logging (Table 7).
- Commercial agriculture - forests are removed due to expansion of tree crop plantations (rubber and oil palm) which appear to be the sustainable uses of converted forest land.
- Shifting cultivation - In Sarawak, the area affected by shifting cultivation has increased from 2.25 million ha in 1960 to

3.33 million ha in 1985 due to shifting cultivation.

- Development projects - Bakun hydroelectric dam has inundated 69, 640 ha of forests for the reservoir.
- Mining - Lim *et al* (1981) reported that tin mining operations have produced some 250, 000 ha of barren, desert-like environment, a figure which is nearly one percent of the total land area of Peninsular Malaysia.
- Degazettement - Between 1986 and 1994, some 144, 406 ha of Permanent Forest Estates (PFE) equivalent to the size of Malacca have been degazetted by various State governments despite the 800,000 ha outside the boundaries of the PFE available for development.

Concept of Rehabilitation

The current rate of tropical deforestation and its environmental threat is apparently echoing the urgent call for an improved management of the forest recovery process, particularly, reforestation (Wilson 1988).

Table 5. Extent of Logged Area in Peninsular Malaysia (ha)

LAND	YEAR				
	1994	1995	1996	1997	1998
A. Total area	**1,145,541**	**1,146,346**	**1,098,656**	**962,534**	**962,534**
1. Permanent reserved forest	939,072	940,338	892,648	788,038	788,038
2. Stateland	206,469	206,008	206,008	174,496	174,496
A. Total Logged area	**634,877 (55%)**	**661,419 (57%)**	**577,426 (52%)**	**467,470 (48%)**	**462,293 (48%)**
1. Permanent reserved forest	471,869	493,203	443,495	318,919	313,581
2. Stateland	163,008	168,216	133,931	148,551	148,712
C. Area not logged	**510,604**	**484,927**	**521,230**	**495,064**	**500,241**

Source: 1998 Forestry Department, Peninsular Malaysia

Table 6. Extent of Logged Area by State in 1998 (ha)

	Area		Logged area	
STATE	**Permanent reserved forest**	**Stateland**	**Permanent reserved forest**	**Stateland**
Johore	0	0	0	0
Kedah	0	0	0	0
Kelantan	102,222	31,317	58,695	13,866
Malacca	0	0	0	0
Negeri Sembilan	0	0	0	0
Pahang	466,405	143,179	228,549	134,846
Perak	18,330	0	10,724	0
Perlis	0	0	0	0
Pulau Pinang	0	0	0	0
Selangor	51,711	0	10,795	0
Terengganu	149,370	0	4,818	0
Federal territory	0	0	0	0
TOTAL	**788,038**	**174,496**	**313,581**	**148,712**

Source: 1998 Forestry Department, Peninsular Malaysia

Table 7. Area Opened for Logging (ha)

LAND	YEAR	
	1997	1998
Permanent reserved forest	36,503	51,668
Stateland	61,906	41,849
Alienated land	41,277	21,481
TOTAL	**139,686**	**114,998**

Source: 1998 Forestry Department, Peninsular Malaysia

In order to overcome further degradation and hasten the recovery process, Malaysia has taken all of the three approaches identified by Lamb (1994). The first approach is **restoration** that attempts to recreate the original forest ecosystem by putting back the original composition of plants and animals that were once occupying the site. Second is **rehabilitation** which uses some of the original species and, where necessary, exotic species to reforest the site. This approach does not attempt to recreate the original ecosystem but to return the forest to a stable and productive condition by using some of the original species. Third is **reclamation** that uses one or more exotic species to achieve stability and productivity. This approach does not attempt to restore any of the original biodiversity at the site.

In as much as rehabilitation is a human-facilitated recovery process, the right forms and amount of input such as appropriate species, canopy/gap opening and silvicultural treatments, are necessary to enhance the process. Moreover, these silvicultural treatments or prescriptions for forest rehabilitation must consider the following; conservation of biodiversity, conservation of wildlife resource and its food source, accessibility and terrain of rehabilitation sites, and economics of the operations (Chai & Lee 1992, Lim 1992, Johns 1997).

The objective of rehabilitation may be the restoration of the degraded forest to its original pristine state in terms of its structure and function or, rehabilitation to a state that is similar in terms of its productivity or, to a state where there is some vegetative cover - that is, the establishment of industrial wood plantations and/or establishment of forests with as much natural structure and functions as possible (Lim 1992). The approach to take and the cost of rehabilitation will differ between different objectives.

Certain factors are considered important in the success or failure of the reforestation project (Walters 1997, Lamb & Lawrence 1993, Baguinon 1992, Lim 1992, Gomez-Pompa & Burley 1991, Oldeman & van Dijk 1991). These include:

Economic factors - factors involving the cost of rehabilitation

a) Finances - Often times, fast-growing tree species are chosen so that the return on the outlay can be recovered rapidly.
b) Manpower and management considerations and scale of operations
c) Land availability

Ecological factors – factors involving the natural environment and the plant species related to the natural regeneration of the forests. These factors address the problem of species-site compatibility.

a) Systems considerations – refers to the conditions of the site (topography, soils, rainfall, climatic regimes and vegetative cover) as these factors affect the survival and growth performance of the plants used in the rehabilitation scheme. This also involves the ecological succession patterns of the area.
b) Species considerations – refer to the growth rates, life span, seed supply, ecophysiological requirements for germination and growth, and tolerances and adaptability of the species to be used. This requires a thorough knowledge of the

indigenous flora and their seed production and propagation systems.

The choice of species is directly affected by the objective of the rehabilitation program. A restorative program requires greater number of species than a rehabilitative one. A complex system requires a greater understanding of more species, their interactions as well as a longer time to achieve some form of stability, equilibrium and an ability to sustain itself (Lim 1992).

Social factors - refers to human ecology. It is equally important to include the human element in any rehabilitation project as they can significantly contribute to its success (or failure). Walters (1997) stressed that social and economic factors were more important than ecological factors in determining the relative success of restoration efforts between and within different sites. These include people's knowledge about trees and tree planting, their patterns of land use and ownership, and their social organisation. Success of restoration efforts often depends on the management of these human influences which are either sustaining desired habitats or restricting their recovery. If the aim is to convince people to plant trees then it is just appropriate to understand the factors that motivate or limit them from getting involved in reforestation activities. The local people may have positive contributions by sharing their ecological knowledge, by providing skills, labour and materials to projects, and by conveying knowledge about restoration to other people (Walters 1997).

Constraints to the Use of Indigenous Species

In Malaysia, rehabilitation using indigenous timber species on a larger scale has encountered the following obstacles; irregular supply and recalcitrancy of seeds, high variability in growth yet of unknown genetic potential as seedlings are raised from stumps or wildlings (Lim & George 1996). Thus, the need for selection/breeding of indigenous timber species in the country is also urgent. Abas (1993) also identified some problems, namely; occurrence of drought which has affected the planting schedule and mortality of seedlings at the nursery and in the field; unpredictable flowering and fruiting of Dipterocarps; high mortality rate of wildlings; inadequate knowledge

and understanding of indigenous species; and high financial and labour-intensive requirements of weed control after planting. To address these concerns, Abas (1993) recommended the following; research on alternative methods of producing planting stock for large-scale replanting projects; further studies on the technology of rehabilitation (that is, various requirements of indigenous species); and further training and exposure for the local researchers to be able to handle future research in rehabilitation.

Rehabilitation Efforts

Cognisant of the urgent need to meet the domestic wood requirements in Peninsular Malaysia and to sustain timber exports in Sabah, the government moved for the plantation establishment of fast-growing tree species of *Acacia mangium*, *Gmelina arborea*, *Paraserianthes falcataria*, *Eucalyptus deglupta* and *Pinus caribaea* (Leslie 1989). In 1910, plantations of *Palaquim gutta* and *Hevea brasiliensis* with enrichment planting of *Neobalanocarpus heimii* were established in Peninsular Malaysia (Wan Yusoff and Abdul Rahman 1997). However, this endeavour failed due to lack of subsequent tendings. Between 1960's and 1970's, Peninsular Malaysia introduced the Taungya system as a means of artificial regeneration to re-forest patches of Forest Reserves damaged due to illegal cultivation. Illegal farmers were given permits to use the land with the condition that they would in turn plant tree seedlings provided by the Forestry Department. The tree species used were both exotic and indigenous; *Pinus caribaea*, *Dryobalanops aromatica*, *Shorea leprosula*, *S. ovalis*, *S. curtisii* and *Swietenia macrophylla* combined with agricultural cash crops mainly banana and tapioca. Again, this system was discontinued because of the cultivators' low response due to insecurity of land tenure, the accelerated development of large-scale agricultural schemes and the high costs of supervision.

Rehabilitation with indigenous species in Malaysia was also done at the 47 ha of the

Bintulu campus of Malaysia Agriculture University (UPM) through a joint project between Yokohama National University (YNU) and UPM. The project aimed to restore and recover the natural or at least quasi-natural forest ecosystems with native trees after the area has been logged and burnt for over 50 years (Mohd. Azani 1998, Miyawaki 1993).The concept has also been applied in Peninsular Malaysia using the gap and line planting, yet at an experimental stage.
Artificial regeneration with indigenous species, however, looks feasible and promising as indicated by the experimental/initial results of *Shorea parvifolia, S. leprosula, Neobalanocarpus hemii, Alstonia angustiloba, Dyera costulata* and *Azadirachta excelsa* (Ahmad Zuhaidi & Mohd Noor 1996, Lim & George 1996, Takai *et al* 1996; Ueda *et al* 1996, and Leslie 1989). Nevertheless, more research and development efforts on seed storage, vegetative propagation of superior trees and production of planting materials at reasonable cost are necessary (Lim & George 1996). As of 1998, plantations of exotic and indigenous species totalled 73,735 ha (Table8).

Table 8. Area of Plantation Forest by State in 1998 (ha)

State	Compensatory forest plantations	Teak plantation	Pine plantation	Rubber plantation	Azadirachta plantation	Total
Johore	19,607	0	647	0	0	20,254
Kedah	0	1,525	20	0	639	2,184
Kelantan	3,130	111	0	40	0	3,281
Malacca	0	0	0	0	0	0
Negeri Sembilan	4,790	40	669	30	25	5,554
Pahang	20,534	0	2,287	798	46	23,665
Perak	3,814	234	0	0	240	4,288
Perlis	0	453	0	0	5	458
Pulau Pinang	0	0	0	0	0	0
Selangor	9,022	0	823	588	75	10,508
Terengganu	3,287	0	0	211	45	3,543
Federal territory	0	0	0	0	0	
TOTAL	**64,184**	**2,363**	**4,446**	**1,667**	**1,075**	**73,735**

Source: 1998 Forestry Department, Peninsular Malaysia

Rehabilitation Methods

Two general categories of planting methods were tried in Malaysia; namely, open planting (applied in grassland and previously mined areas) and shade planting (applied in secondary forests or those in big forest gaps/openings)(Mohamad Azani 1998).

The open planting techniques involved line planting at different spacing (1m x 1m, 2m x 2m, 3m x 3m) and dense planting at three seedlings per m^2 as in the Bintulu project. The shade planting technique involved also line planting and gap/patch/clump planting as in the case of Chikus Forest Reserve, Perak. Gap planting at different gap sizes has also been tried but still at its experimental stage.

When applied to indigenous species, these techniques proved to be promising (Mohd. Zaki *et al* 1995). The open planting was favourable for the growth of the light demanding dipterocarp species. Other dipterocarp seedlings however, survived better but had low growth increment under partial shade. Mohd. Zaki *et al*'s (1995) experience in Sarawak also showed that open planting worked better when seedlings, particularly dipterocarps, have undergone hardening before planting for 6-8 weeks at the nursery and one month at the planting site. As of 1998, rehabilitation efforts in Malaysia has reached a certain level as indicated in Tables 9 and 10.

Problems of Policy Implementation

Although forest policy is clearly defined in Malaysia, its implementation is faced with various obstacles due to the constitutional separation of functions between the Federal and State governments. Land is a state matter. States may enact separate laws to pursue separate policies. The Federal Government's National Land Council may formulate policies and recommend measures for implementation but does not have the legal and administrative means to ensure that the policies are implemented (e.g. degazettement of natural forest areas)

Table 9. Rehabilitation Activities in Peninsular Malaysia

Activities	Target 1998	1998	Achievement (%)
1. Forest resource development (ha)			
a) Enrichment planting	1,678	1,295	77
b) Forest plantation	366	333	91
c) Planting of bakau	700	693	99
d) Planting of rattan	1,090	982	90
e) Open space planting	250	227	91
f) Nursery area established (sites)	1	50	
1. Social Forestry			
a) Forest recreational area established (no.)	10	10	100
b) Community forest (ha)	272	262	96
c) Urban forest (no. of trees)	155,614	147,294	95
d) Educational forest established (no.)	3	2	67
e) Highway planting (km)	50	50	100
f) Planting of bamboo (ha)	5	5	100

Source: 1998 Forestry Department, Peninsular Malaysia

Table 10. Enrichment planting in Peninsular Malaysia, 1956-1996- Malaysia

State	Total Area Planted	
	Area planted (ha)	**Percentage (%)**
Perak	7,275	31.5
Selangor	4,386	19.0
Kelantan	2,582	11.2
Pahang	2,519	10.9
Johore	2,390	10.4
Kedah	1,606	7.0
Malacca	956	4.2
Terengganu	619	2.7
Negeri Sembilan	602	2.6
Perlis	125	0.5
Total	**23,060**	**100**

Source: Wan Yusoff and Abdul Rahman, 1997.

Several commonalties and differences in forest policies and utilisation can be observed between the three principal States of Malaysia. Each State takes a different view of its forest and has different issues to cope with. Sabah harbours some of the world's richest remaining rainforest while the shifting cultivators are still a major cause of deforestation. Peninsular Malaysia has poorer forests and conversion of forests to permanent agriculture is the major cause of deforestation. Sarawak possesses valuable peat swamps where the much prized *ramin* trees are exploited. Like in other countries, Malaysian forest policies cannot work apart from economic and infrastructural policies.

Another significant policy is the indiscriminate awarding of timber concessions. Through this policy a substantial number of people are awarded but lack the knowledge on sound forest management principles. Hence, the lack of commitment to long-term investment and care for the environment. Thus, the concept of privatisation that has been highly successful in other sectors (and other countries) need to be incorporated in the Malaysian forestry. The Forestry Department and other related agencies could be relieved of the financial and manpower constraints they are faced with if some activities, including forest rehabilitation, are privatised.

Another major constraint to forest rehabilitation/restoration is the dispersed location of scientific knowledge on the subject. A sufficient body of scientific knowledge which can provide the technical backing for successful rehabilitation, already exists within the country. However, this body seems to be uncoordinated in such a way that the expertise is dispersed in the various research and academic institutions. Thus, a more integrated and co-ordinated research approach is much needed.

Lastly, research efforts need to be intensified. Some areas still need investigations, namely; quantitative and qualitative evaluation of degraded forest land using space technology, site-species quality studies, growth and yield studies, reproductive phenology, seedling regeneration and propagation, economics of rehabilitation, policy and the socio-political aspects, and agroforestry as an approach to rehabilitation and restoration.

Conclusions

Tropical deforestation involves the political, socio-economic, cultural, and ecological/ geographical conditions of the tropical countries and other countries of the world. Likewise, any forest rehabilitation scheme must also consider these factors. As such, reasonable and satisfactory solutions to this complex problem of tropical deforestation/rehabilitation demand a spirit of cooperation, assistance and collaboration, not only among the citizens of the country, but of the world.

As a process, forest land degradation is likened to a spider's web that hangs in the balance and is exposed to the wind. While intact, the web can withstand the pressure; if one thread breaks down, the spider can repair it. However, if the pressure is gradually increased, time will come when the spider succumbs to the wind and the web becomes totally destroyed.

As foresters, we need to create valuable forests, to manage them wisely and to take good care of this heritage/legacy for our future generations. A rich stock of timber is not enough, we need a rich nature, too. The current generation must salvage the remaining indigenous tropical forests if they are to leave a forest legacy to the next generation. Lost forest resources are not easily replaced. For some species, once lost they are forever lost. They go extinct and are gone forever. For others, replacing them may require enormous amount of money, time and effort. Some people think that oftentimes, it is economically better to manage the resulting existing forest than to replace what was lost. Socially, this may be more imperative. However, environmentally, replacement is the cry of the hour.

The web is our remaining intact forests. The spider is our foresters who can repair/alleviate the damaged web. Sadly though, by themselves, the foresters cannot effectively repair the damage. Forest protection management can no longer be treated in a strictly sectoral fashion, that is in isolation from the rest of natural resources development. Hence, the need for innovation and political commitment, particularly at the state level, to address the problem facing our forests and to ensure that the forest goods and services are sustainably produced for the most number of people in the longest time possible.

Unfortunately, we humans cannot just leave to nature the "unease" of our "misconduct" towards the forests. We must pay the cost of forest degradation - so rehabilitation (or assisted natural regeneration) we must do. And to discourage further loss of biodiversity, efforts must be directed towards the use of indigenous species, whenever and wherever possible. Hopefully, only then can we do something towards the fulfilment of the objectives of rehabilitation, which are to; outpace the rate of deforestation, restore biological diversity, diversify the products & increase the productivity of deforested lands, provide socio-economic benefits to both the government and rural community, and to supply raw materials to the wood industry so that the pressure on the remaining primary forests can be reduced if not eliminated.

As in other countries, the utilisation of forests has brought substantial increases in gross domestic product, which benefit the Malaysians. However, in like manner with other countries, a time will come when further removal of the forest will reduce instead of enhance the people's living standards. Hence, a rational development of forest management technology becomes an obviously urgent need – a holistic view that requires a more unified approach to forests on the part of the various governments (State & Federal).

Recommendations

Malaysia and other countries with similar situation can learn from the experiences and findings of the experts and may need to carry out any or a combination of the following recommended courses of actions: (Walters 1997, Nik Muhamad and Mohd Zaki 1996, Lim and George 1996, Wadsworth 1995, Abas 1993, Baguinon 1992, Robinson 1988):

Continuing research on alternative methods of producing planting stock for large-scale replanting projects

Further studies on the technology of rehabilitation (e.g. various requirements of indigenous species)

Further training and exposure for the local researchers to be able to handle future research in rehabilitation

Data base for rehabilitation efforts - survey & compilation of published papers on all aspects of natural regeneration & succession

Logistics support - prioritise and provide the needed technical and scientific back-up for any rehabilitation programme

Inclusion of human ecology - social, cultural, economic and political factors and the interactions between them

Continuing on-the-spot research and development in tightening the link between restored forest and farms - e.g. involves decision to chose farms or spaces in farmed landscape that are not under cultivation, avoid areas where burning is common, encourage permanent settlement by increasing farm productivity thereby discouraging farmland expansion

Discovery of alternative means of providing subsistence goods (food, fuel & housing materials) and alternative commodities to substitute those resulting from environmental destruction

Mapping of the successional patterns of reforestation area - botanical survey, soil and vegetation analysis and mapping, and classification of reforestation area into successional stages

Combining reforestation with agroforestry - for livestock production, tightly restrict access of animals by tethering and stall feeding

Silvicultural methods

a) seed production system - decision to use exotics is sometimes due to lack of knowledge of indigenous species and their seed availability, and their site preferences

b) species-site matching design - classify taxa based on the habitat type occupied by the wildlings
c) direct seeding, use of cuttings and bare root planting materials wherever possible - minimise nursery work and eliminate transport of seedlings from nursery to planting site and thus reduce cost

In summary, the future of using indigenous species for forest rehabilitation does not look bleak. Many research efforts in this field are underway. Although recognising that certain exotic species have a particular ecological or economic role to play, researchers in Malaysia are working on how to make better use of indigenous species. However, it is believed that positive outcomes can only be achieved if policies on sustainable forest management and a sustainable timber trade are comprehensive enough to cover three dimensions: ecosystem, timber yield and people's livelihood.

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Strategies for the Recovery of Biodiversity in Deforested Landscapes

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Abstract

Depending on the degree of degradation, size, and distance to forest, physical and biological barriers can significantly delay natural regeneration in degraded ecosystems. Tropical plantations can fulfill a variety of services including restoration of soil fertility and acceleration of natural regeneration. In a long-term program on ecosystem rehabilitation in the Latin American humid tropics, about half the species tested had positive effects on soils and good growth, making them attractive to farmers for reforestation. In studies of natural regeneration in plantations with indigenous species in the humid lowlands of Costa Rica, forest tree invasion was higher under plantations than in surrounding abandoned areas. Higher plant species richness accumulated under *Vochysia guatemalensis, Virola koschnyi, Terminalia amazonia*, *Hyeronima alchorneoides* and *Vochysia ferruginea,* all species commonly planted by farmers. Natural regeneration was high under mixed-species plantations, with values sometimes equal or higher to those found under pure plantations. The open pastures had the highest proportion of wind-dispersed seeds, while bird and bat seed dispersal was predominant in the plantations. High accumulation of litter on the plantation floor contributed to diminish grass growth and thus encouraged woody invasion.

In regions with larger agricultural fields and farther from sources of propagules, windbreaks and remnant trees in pastures may be important reservoirs of native tree species. Tree recruitment may be higher in windbreaks that are connected to forests. Windbreaks could be made more attractive to birds by including native, fruit-producing trees, by increasing their species and structural complexity, and by positioning them between forest patches to facilitate bird movement.

Examination of the role of strategies for recovery of biodiversity necessitates integrative approaches that consider factors influencing tree regeneration, other potential effects on the ecosystem, and economic, social and environmental constraints.

Keywords: Ecosystem restoration, Mixed plantations, Soil fertility, Succession, Tree species choice, Windbreaks

Introduction

It is becoming widely accepted that the conservation of biodiversity has to take place in managed landscapes as well as in protected areas (Pimentel et al. 1992, Brown and Lugo 1994, Guindon 1996, Lamb 1998, Harvey and Haber 1999). In many regions of tropical America, the landscape consists of a complex mosaic of forest patches, pastures and agricultural fields and is heavily influenced by human activity. Any efforts to conserve biodiversity within managed landscapes must be compatible with local livelihood needs and offer sustainable and economically attractive alternatives to local farmers. Strategies that provide various ecosystem services and fulfil local human needs, in addition to promoting the conservation of biodiversity, will have a higher chance of success (Cairns and Meganck 1994, Lamb 1998).

One strategy that can potentially facilitate the maintenance or recovery of biodiversity within agricultural landscapes is the establishment of native forest plantations on degraded agricultural lands. Tropical plantations can serve diverse economic, social, political and ecological functions. With considerably higher yields than managed native forests, tropical and subtropical plantations can make substantial contributions to world timber and pulp production (Wadsworth 1983, Evans 1992, Evans 1999, Sedjo 1999). Tree plantations can also be a source of cash, savings and insurance for individual farmers. Plantations may help stabilize rural populations in regions where shifting agriculture is the predominant land use. In combination with subsistence and commercial crops (agroforestry) or cattle (agrosilvopastoral systems), plantations have been used as tools in rural development projects worldwide. Plantations are often seen as alternatives to deforestation as they can provide products that otherwise would be taken from natural forests (Fearnside 1990, Mc Nabb et al. 1994, Mc Nabb and Wadouski 1999).

If plantation species are chosen with knowledge of their nutrient-use efficiencies and recycling capacities, they can be highly productive and also serve a function in ecosystem restoration projects. Particularly, tree plantations and tree-crop combinations represent productive land use alternatives for deforested lands with poor natural forest regeneration due to long distance to sources of propagules or intense site degradation. Among the latter, low soil fertility, soil compaction after abandonment from cattle grazing, and invasion by grasses and other agressive vegetation can be serious obstacles to both forest regeneration and conventional agriculture (Lugo 1988, Nepstad et al. 1991). As the area in degraded lands spreads out, emphasis is increasing on the use of tree species which can grow in such conditions and yield economic products (timber, fuelwood and other) as well as environmental benefits (soil conservation, watershed protection) (Evans 1992, 1999).

The initial step in ecosystem rehabilitation projects is to identify the most important constraints to crop or tree productivity, as well as defining the specific land restoration objectives. Some soils can be recovered through the use of fertilizers, others need more drastic rehabilitation techniques, and there are situations of extreme degradation where soils cannot be recovered at all (Dedecek 1992). The recovery of the soils' productive capacity is frequently very expensive, thus the techniques involved must produce financial returns to ensure their adoptability by the local farmers.

The choice of appropriate tree species for plantation forestry or agroforestry is influenced by knowledge on the species' performance and their economic and environmental benefits. Locally, tree species choice is determined by seed or seedling availability and information on silvicultural characteristics and management, including fast growth and the possibility of intercropping during early establishment. Most reforestation or tree planting programs and subsidies promote the use of well-known, often exotic species. About 85% of plantation forestry in the tropics is dominated by three genera: *Pinus*, *Eucalyptus* and *Tectona*, while there may be thousands of indigenous species suitable for similar purposes (Evans 1992, 1999). Native trees can be more appropriate than exotics because (1) they are better adapted to local environmental conditions, (2) seeds and other propagules are locally available, and (3) farmers are familiar with them and their uses. Besides, the use of indigenous trees in productive systems helps preserve genetic diversity and is in better balance with the local flora and fauna.

Rehabilitating Abandoned Lands in the Latin American Humid tropics

A research program to develop alternatives for the rehabilitation and use of abandoned lands took place from 1987 to 2000 in three humid forest regions of Latin America: the Atlantic lowlands of Costa Rica, the Atlantic rainforest of Bahia in NE Brazil, and the sub-tropical forest of Misiones, NE Argentina (Table 1). In these regions, common situations of rapid deforestation, loss of biodiversity, resource misuse and land degradation persist. Similar methods were used in the three locations: soil chemistry and nutrient cycling parameters were measured in pure stands of selected indigenous species, using adjacent areas free of trees (abandoned agricultural field or pasture, secondary/primary forest) for comparison. The size of each project varied with the sites: in Costa Rica the studies were the most complete (soils, above- and below-ground tree biomass, litterfall and forest-floor litter biomass and tissue chemistry), while in Bahia and Misiones the trees were part of a forest reserve or were in private farms and thus destructive sampling was not possible.

Sampling procedures and chemical methods are described in Montagnini and Sancho (1990, 1994a, 1994b), and Montagnini et al. (1995a, b, c). The soils under the species, grassy areas free of trees and adjacent young secondary forest were sampled for soil fertility and nitrogen availability measurements at the three research sites. Litterfall was mesured biweekly with litter traps, and forest-floor litter accumulation was sampled every three months at La Selva, while at Bahia data from existing studies was used.

Impacts of Trees on Soil Fertility

At La Selva, in just 2.5 years soil conditions improved in the tree plantations compared to abandoned pasture. In the top 15 cm, soil nitrogen and organic matter were higher under the trees than in nearby pasture, with values close to those found in adjacent 20-year-old forests (Table 2). The highest values for soil organic matter, total N, Ca and P were found under *Vochysia ferruginea*, a species common in mature and secondary forests in the region (Montagnini and Sancho 1990). Subsequent measurements revealed similar trends in the soil parameters in the three following years.

Table 1. Characteristics of the study sites mentioned in this article.

Location	**Mean annual rainfall and temperature**	**Soil type**	**Previous land use**	**Experimental setting**
La Selva Biological Lowlands of Costa Rica	4,000mm, 24ºC	Fluventic Dystropepts pH 4.3-4.6	1-3 yrs. agriculture, cattle	Pure plantation, 2mx2m, 2-6 yrs. old
Pau Brasil Ecological Station Porto Seguro, Bahia, Brazil	1,700mm, 23ºC	Oxisols (Haplorthox) pH 4.5-5.0	Shifting agriculture	Pure plantation, 2mx2m, 14-15 yrs. old
Eldorado, Misiones, NE Argentina (private farms)	1,700-2,400mm 22ºC	Acid, clayey Ultisols pH 4.5-5.0	50 yrs. of agriculture, pine plantations	Pure stands from natural regeneration, 10-20 yrs. old

Table 2. Topsoil chemical characteristics in pure stands of indigenous tree species at La Selva, Costa Rica; Porto Seguro, Bahia, Brazil; and Misiones, Argentina.

Site/Tree species

	pH (%)	C (%)	N (cmol.kg^{-1})	P	K	Ca	Mg
a- La Selva, Costa Rica[1]							
Stryphnodendron microstachyum	5.4ab	3.42ab	0.29b	5.6a	0.27a	0.45a	0.63ab
Vochysia ferruginea	5.4ab	3.76a	0.32a	7.1a	0.22a	0.73a	0.61ab
Vochysia guatemalensis	5.3ab	3.13ab	0.29b	5.2a	0.11a	0.25a	0.37ab
Hyeronima alchorneoides	5.1b	2.96c	0.22b	1.5b	0.09a	0.31b	0.21b
Abandoned pasture	5.3ab	2.73c	0.22b	4.9a	0.19a	0.32b	0.27b
Secondary forest	5.3ab	4.33a	0.33a	3.6b	0.17a	0.68a	0.55ab
b- Porto Seguro, Bahia, Brazil[2]							
N-fixing leguminous species:							
Bowdichia virgilioides	4.9	1.98def	0.16def	1.32def	0.06bcd	1.35bc	0.39de
Centrolobium minus	4.6	1.87efg	0.16def	1.19efg	0.05fgh	0.53hi	0.21i
Centrolobium robustum	4.5	1.65ij	0.13f	1.07fgh	0.05fgh	0.40i	0.16i
Inga affinis	4.9	2.10cde	0.18cd	3.64a	0.07bcd	0.76gh	0.49bc
Parapiptadenia pterosperma	4.9	2.38ab	0.20bc	0.78ij	0.08b	1.40bc	0.60a
Pithecellobium elegans	4.8	1.67hij	0.15ef	0.59kl	0.05efg	0.79gh	0.40de
Platymenia foliolosa	4.7	2.08cde	0.18bcd	0.13m	0.05efg	1.05cde	0.42cd
Non-N fixing leguminous species:							
Arapatiella psilophylla	4.7	1.94def	0.18bcd	1.45de	0.06bcd	0.38i	0.37de
Caesalpinia echinata	5.1	2.41a	0.17cde	1.54de	0.07bcd	1.17bcd	0.39de
Cassia spp.	4.7	1.94def	0.16def	1.40def	0.07bcd	0.56hi	0.34de
Copaifera luscens	5.0	2.02cde	0.17cde	0.63jk	0.06cde	1.15bcd	0.34de
Dimorphandra jorgei	4.9	1.97def	0.19bc	0.97ghi	0.03j	0.98def	0.32efg
Hymenaea aurea	4.4	2.00def	0.16def	2.03c	0.06bcd	0.26i	0.24hi
Macrolobium latifolium	4.7	1.90efg	0.16def	0.67jk	0.04hij	0.36i	0.25fg
Of other families:							
Bombax macrophyllum	4.8	1.78ghi	0.13f	1.42de	0.06bcd	0.84efg	0.33ef
Buchenavia grandis	4.6	2.06cde	0.14f	2.09c	0.06bcd	0.80fg	0.33ef
Eschweilera ovata	5.3	1.82fgh	0.31a	0.58kl	0.11a	1.38bc	0.53ab
Lecythis pisonis	5.3	1.99def	0.18bcd	0.23lm	0.04ghi	1.46b	0.32ef
Licania hypoleuca	5.0	1.63j	0.14f	1.61d	0.07bcd	1.31bcd	0.35de
Pradosia lactescens	4.9	2.15bcd	0.18bcd	0.81ij	0.05fgh	0.84efg	0.24gh
Primary forest	4.9	1.99def	0.15ef	0.96hi	0.08bc	1.23bcd	0.36de
Secondary forest	5.1	2.15abc	0.22b	2.46b	0.07bcd	2.20a	0.62[a]
c- Misiones, Argentina[3]							
Balfourodendron riedelianum	5.8	2.6b	0.34ab	n.d.	0.55bc	7.1bc	1.7c
Bastardiopsis densiflora	7.1	6.3a	0.65a	n.d.	1.28a	20.4a	3.4ab
Cordia trichotoma	6.4	4.0ab	0.46ab	n.d.	0.79b	13.6ab	2.6abc
Enterolobium contortisiliquum	6.1	3.4ab	0.39ab	n.d.	0.67b	8.7bc	3.5a
Ocotea puberula	6.1	4.4ab	0.59a	6.09a	1.11a	17.3a	4.7a
Grass control	5.8	2.2b	0.0.27b	n.d.	0.26c	6.3c	2.4bc

Sources: [1] Montagnini and Mendelsohn (1996), [2] Montagnini et al. (1994), [3] Fernández et al. (1995).
Note: For each site, differences among means are statistically significant when followed by different letters ($p<0.05$).n.d.: not detected

Based on the standards determined by the Ministry of Agriculture of Costa Rica for soil fertility assessments (Bertsch 1986), the cation levels (Ca, Mg and K) under most of the tree species were at or above the critical values for agriculture. In contrast, the cation levels in the adjacent abandoned pasture soils were too low for the subsistence crops preferred in the region (rice, beans). The standards set by the Ministry of Agriculture do not include N or organic matter. However, an indication of the importance of the improvement of the soil organic matter levels is given by the close relation found between organic matter content and the sum of bases (Ca+Mg+K), showing that the organic matter was responsible for much of the cation retention capacity (Montagnini and Sancho 1990). For example, based on this relationship, a 1-2% increase in soil organic matter (in the 4-6% range) would more than double the base content, reaching values in the range recommended for agriculture (Bertsch 1986).

Low crop yields in the humid tropics are often a result in part of unfavorable physical properties such as soil compaction (Cassel and Lal 1992). In our site at La Selva, soil organic matter also had positive influences on soil physical properties: the soil bulk density was lower (i.e., lower compaction) while soil moisture was higher under the trees than in abandoned pasture (Montagnini and Mendelsohn 1996).

The results of standard soil fertility tests used in agriculture (such as those shown in Table 2) may not always reveal the soil's productive potential, because they do not include all chemical forms of nutrients available for plant uptake. For example, although they make up less than 10% of the total soil N pool, mineral N (NO_3-+NH_4^+), are the forms of N available to plants. Nitrogen fertilizers are heavily used in the La Selva region, especially for the most demanding commercial crops such as bananas, in which case capital is available for fertilizer in a more extensive land use system. From the results shown in Table 2, *Stryphnodendron microstachyum*, a N-fixing tree, did not have an important effect on total N, but its litter decomposes faster than the other species, resulting in increased soil mineral nitrogen under its canopy (Montagnini and Sancho 1994a). Evaluating the effects of trees on soil P availability is even more difficult, although experiments with test crops can determine soil impacts. For example, in other experimental research, maize seedlings, grown in plots mulched with *S. microstachyum* and *Hieronyma alchorneoides* versus the other species' litter, showed the greatest initial growth and the highest N and P plant uptake (Montagnini et al. 1993). In these and in other related research at La Selva, the maize seedlings grown without mulch or fertilizer on soils from abandoned shifting agriculture fields grew very poorly, reaffirming the need for soil improvement techniques for growing conventional crops in the impoverished abandoned lands.

In Bahia, positive effects on at least five soil parameters were found under 15 out of the 20 species of the plantations, in comparison with primary and secondary forest (Table 2). Several species contributed to increased C and N, among others: *Inga affinis, Parapiptadenia pterosperma, Plathymenia foliolosa* (leguminous, N-fixing species), *Caesalpinia echinata, Copaifera luscens* (leguminous, non-N-fixing), *Eschweilera ovata, Pradosia lactescens* (of other families) (Table 2). Others increased soil pH and/or some cations, such as *Copaifera luscens, Eschweilera ovata, Lecythis pisonis and Licania hypoleuca* (Table 2, Montagnini et al. 1994, Montagnini et al. 1995a).

In Misiones, NE Argentina, the greatest differences in soil C and N levels under tree species and grass were found under *Bastardiopsis densiflora*, where they were twice those in areas beyond the canopy influence (Table 2) (Fernández et al. 1997). The pH was higher under *Bastardiopsis densiflora* and *Cordia trichotoma*, while the sum of bases (Ca+Mg+K) was highest under *Cordia trichotoma, Bastardiopsis densiflora* and *Enterolobium contortisiliquum*.

Tree Productivity in Plantations Used for Land Rehabilitation

As stated earlier in this article, land rehabilitation programs must use species and designs that not only help in soil recovery but also are productive. If a land rehabilitation system is productive it may represent an economic incentive for the local farmers. At

La Selva, the values of whole tree biomass for the plantations (Table 3) were greater than those reported for 4-year-old *Albizia lebbek* (Parrotta 1989), and for 5.5- year-old *Leucaena leucocephala* (Wang et al. 1991), both growing in dense plantations for biomass production in Puerto Rico. Values of total tree above-ground net primary productivity (calculated by dividing whole-tree biomass by tree age) lie within the ranges reported elsewhere for monospecific plantations in the humid tropics. The value for *V. guatemalensis* is close to that reported for *Gmelina arborea* (12.8 tons per ha/yr) in the Brazilian Amazon (Russell 1987); and to *Gmelina arborea* (12.7 tons/ha) and *Albizia falcataria* in the Philippines (11.3) (Kawajara et al. (1981), in Young (1989)). The increments shown here are however lower than those reported for some of the fastest growing trees in the humid tropics such as *Acacia mangium* (15.5 to 18.0 tons/ha in Malaysia), *Leucaena leucocephala* (20.0-30.0 and even up to 80.0 tons/ha in Hawaii an other tropical sites, Young (1989)). Biomass of the same species planted in other experiments at La Selva was consistent with the results presented here (Montagnini and Porras 1998, Shepherd and Montagnini 1999).

Natural Regeneration in Mixed and Pure Plantations of Native Species

In addition to providing a variety of economic and environmental services (such as timber production, carbon accumulation, soil protection, and land reclamation), plantations may help local biodiversity by facilitating forest tree regeneration and by providing habitats for forest animals (Parrotta 1992, Lamb 1998). Although in humid tropical regions it is often assumed that recovery of the degraded landscape through natural regeneration processes will take place within a time frame acceptable to the foreseen human use, forest regeneration is often significantly delayed by physical or biological barriers (Lugo 1988, Nepstad et al. 1991). The establishment of plantations may overcome some of these barriers by attracting seed dispersal agents into the landscape and by ameliorating local microclimatic conditions within the area, and thereby accelerating the recovery of these lands.

Table 3. Means, aboveground biomass and annual increments for the four native species in plantation at La Selva, Costa Rica[1].

Tree species	Aboveground live biomass, kg/ha				Mean annual Increment, t ha^{-1}yr^{-1}	
	Stem	Branches	Leaves	Total	Total	Stems
Stryphnodendron microstachyum	35,250a	15,250[a]	4,325[a]	54,825a	13.7a	8.8[a]
Vochysia ferruginea	24,750b	14,250[a]	5,925[a]	44,925	11.2b	6.2b
Vochysia guatemalensis	41,750a	6,500b	7,250[a]	55,500	13.9a	10.4[a]
Hyeronima alchorneoides	26,250a	12,250[a]	5,350[a]	43,850	12.0b	6.5b

[1] Differences between sites for a given parameter are statiscally significant (P < 0.05) when means are followed by different letters.

Mixed plantations may have considerably higher conservation value than single-species plantations. In addition, mixed plantations yield more diverse forest products than monospecific stands, helping to diminish farmers' risks in unstable markets, and if planned with consideration of each species' response to mixed conditions, mixed designs can be more productive than monospecific systems (Smith 1986, Burkhart and Tham 1992, Kelty 1992, Wormald 1992, Montagnini et al. 1995, Montagnini and Porras 1998). We are studying natural regeneration in young mixed and pure plantations with eight indigenous species at La Selva Biological Station in the humid lowlands of Costa Rica in order to determine the potential role of plantations in maintaining local biodiversity. The results so far suggest that plantations can accelerate natural successional processes in degraded pastures (Guariguata et al. 1995, Montagnini et al. 1999). Significantly higher plant species richness accumulated under plantations of *Vochysia guatemalensis, Virola koschnyi,* and *Terminalia amazonia* (all species commonly planted by farmers in the region) than in adjacent, unplanted areas (Table 4). In mixed-species plantations, abundance of woody regeneration was intermediate to that of pure plantations.

Natural regeneration was higher in understories with low or intermediate light availability. Most of the seeds entering the open pastures were wind-dispersed, while most seeds entering the plantations were bird or bat-dispersed. This suggests that the plantation may be facilitating tree regeneration by attracting seed-dispersing birds and bats into the area.

Table 4. Average number of individuals of regenerating seedlings in the understory of plantations and in natural regeneration controls, at 7 years of age, at la Selva Biological Station, Costa Rica.

Plantation 1:

Treatment	Number of individuals in 57 m^2
Vochysia guatemalensis	90.3
Calophyllum brasiliense	78.6
Jacaranda copia	57.1
Mixed plantation	87.6
Natural regeneration	28.6

Plantation 2:

Treatment	Number of individuals in 16 m^2
Virola koschnyi	19
Dypterix panamensis	9
Terminalia amazonia	44
Albizia guachapele	0
Mixed plantation	17
Natural regeneration	7

In another plantation with other native species in pure and mixed designs, also at La Selva, the highest abundance of tree individuals was found in the mixed plantation with 32.5 individuals in 32 m^2, followed by *Hyeronima alchorneoides* with 25.2, *Vochysia ferruginea* with 18.2, *Pithecellobium elegans* with 13.5, *Genipa americana* with 4.7 and the natural regeneration control with 2.2. The highest number of species was found in the mixed plantation (11.2), followed by *V. ferruginea* (8.2), *H. alchorneoides* (7.2), *P. elegans* (5.0), *G. americana* (3.2) and control (0.7). The majority of the regenerating individuals were dispersed by birds and bats. The different species of the plantations created different conditions of shade and litter accumulation, determining the abundance of the recruited and the surviving individuals (Carnevale and Montagnini 2000).

Strategies that provide various ecosystem services and fulfil local human needs, in addition to promoting the conservation of biodiversity, will have a higher chance of success (Cairns and Meganck 1994, Lamb 1998). Any efforts to conserve biodiversity within managed landscapes must be compatible with local livelihood needs and offer sustainable and economically attractive alternatives to local farmers. In addition to examining the ecological aspects of forest regeneration within plantations, this project also examines the socioeconomic feasibility of this conservation strategy.

Other Tree-Based Strategies for Recovery of Biodiversity in Deforested Landscapes

In other regions with larger agricultural fields and farther from sources of propagules, windbreaks and remnant trees in pastures and agricultural fields may be important reservoirs of native tree species (Harvey and Haber 1999, Harvey 2000). For example, the effects of planted windbreaks on seed deposition patterns were examined in dairy farms in Monteverde by Harvey (2000). The windbreaks were planted strips of trees about 5 m wide and 9 m tall and were 7-8 years old at the time of the study. Trees and rows within the windbreaks were spaced at 1.5 m. The most common species were *Cupressus lusitanica, Croton niveus, Casuarina equisetifolia* (all exotic species) and *Montanoa guatemalensis* (native). None of these species produce fruits that attract frugivorous birds, and their seeds are wind dispersed except for *Croton* which is gravity dispersed. Windbrekas were found to receive significantly greater densities and species richness of seeds of tree and shrub species than pastures: windbreaks received an average of 39 times as many seeds, and 67 times as many shrub seeds as pastures. In addition, windbreaks received an average of two times as many tree species, and more than two times as many shrub species as pastures. The differences in the seed rain entering windbreaks vs. pastures appeared to be due almost entirely to the enhanced activity of birds in windbreaks: bird-dispersed seeds occurred in greater densities (about 100 times greater), and number of bird-dispersed species was three times greater in windbreaks than in pastures. The high densities of bird-dispersed seeds within windreaks suggests that windbreaks increase forest seed recruitment by serving as habitat and/or movement corridors for seed-dispersing birds (Harvey 2000).

Windbreaks may serve as sources of woody colonists if the agricultural lands are later abandoned. Positioning of windbreaks within the landscape may affect seed deposition patterns by influencing the movements of seed-dispersing birds. Tree recruitment may be higher in windbreaks that are connected to forests. Windbreaks could be made more attractive to birds by including native, fruit-producing trees, by increasing their species and structural complexity, and by positioning them between forest patches to facilitate bird movement (Harvey 2000).

Remnant trees in pastures or agricultural fields may play an important role in conserving biodiversity within agricultural systems because they provide habitat and resources that are otherwise absent from agricultural landscapes (Harvey and Haber 1999). For example, in a survey of 237 ha of pastures in Monteverde, Costa Rica, Harvey and Haber (1999) found over 5000 trees of almost 200 species, with a mean density of 25 trees per ha. Primary forest trees accounted for over half of the species and over one-third of the individuals. More than 90% of the the species were known to provide food for forest birds or other animals. In addition, many of the species were important as sources of timber, firewood or fence posts for farmers. Reasons for leaving trees in the pastures included using them for shade for cattle, timber, fruits for birds, and fence posts. Results of surveys among farmers suggested that farmers in the region would be receptive to programs promoting the conservation of forest trees in pastures, if these programs would fit the particular requirements of shade management for cattle and if they allowed farmers to use a small proportion of their trees for timber, fuelwood or fence posts. The conservation of pasture trees must be part of larger conservation initiatives that includes the conservation of large forest tracts, key habitats, forest fragments, migration routes, and corridors (Harvey and haber 1999).

Conclusions and Recommendations

A number of economically valuable native tree plantation species were found to have positive impacts on soils in three regions of the Latin American humid tropics. Tree productivity and biomass were high for these species, therefore they would be preferred by farmers for reforestation. Studies of natural regeneration entering the understory of established plantations showed that certain species were more effective in attracting seed dispersers and favoring seedling recruitment. Mixed plantations gave good results in accelerating natural succession. Among the factors favoring woody invasion of plantation undestories, high production of leaf litter was most important in helping to suppress herbaceous vegetation and thus favoring competition by tree seedlings.

In addition to conventional plantations, planting trees in windbreaks, and planting or leaving trees in agricultural landscapes may contribute to conserving and restoring biodiversity by offering habitats for birds and other animals, and by enhancing seed dispersal into agricultural landscapes.

Examination of the role of strategies for recovery of biodiversity necessitates integrative approaches that consider factors influencing tree regeneration, other potential effects on the ecosystem, and economic, social and environmental constraints of the proposed systems.

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Multifunctional Rehabilitation of Forests in Central Europe

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Abstract

In the densely populated area of Central Europe (Germany), landscape in general and forests in particular are faced by an increasing number of different, partly contrary demands of society that can be summarised by the keynotes: wood production, nature conservation and leisure time activities. Besides that, the Central European Forestry has to struggle with political-economic and structural characteristics in the international wood market. Therefore some examples of new research activities are given to outline solutions and effects in multifunctional rehabilitation of forests at different scales: Summarising the results of the studies, a varied afforestation planning and a concept of forest use, which integrates the aspects of aesthetic values and of nature conservation with management systems, in combination with a selected net of total reserves and the creation of biotope-network structures would play an important role in an intelligent, sustainable land-use system for the future - following the intention of AGENDA 21 and the declaration of Rio.

Keywords: Nature conservation, Integrated land-use, Biodiversity, Afforestation, Germany

Introduction

In the densely populated area of Central Europe (Germany), landscape in general and forests in particular are faced by an increasing number of different, partly contrary demands of society.
These social aspects can be summarised by the keynotes: wood production, nature conservation and leisure time activities:

People have realised that a local sustainable wood production shows a lot of benefits, not only for the economy but also for the environment: (renewable raw material, CO_2-fixation, low output of transport energy).

People have become more and more sensitive to the importance of nature protection and the conservation of biodiversity, especially in a system close to nature like forests. Although Central Europe does not belong to the real world-wide „hot spots“ of biodiversity, the region has the international obligation for the protection of the endemic beech forest ecosystem.

People have discovered the forest partly as one of the last areas of silence (to get the experience of wilderness), partly as a place where they can carry out their new outdoor activities (mountain biking, canoeing, para-gliding).

Moreover, the Forestry of Central Europe has to struggle with political-economic and structural characteristics at the international wood market: a high-cost-situation for wood production; the splitting up of the forest area by location and by ownership; the prohibition of clear-cutting and legal provision of creation and conservation of stable, mixed, healthy forests. Besides that, the internal discussion about an adequate system for certification in forestry spoils a lot of time and energy.

In spite of these problems, forestry must face the different demands of the society. Therefore, scientific and practical forestry have to develop different solutions for those multifunctional tasks.

Examples of Multifunctional Rehabilitation of Forests

In the following, four examples of new research activities will be outlined in order to demonstrate solutions and effects in the multifunctional rehabilitation of forests in Germany at different scales:

Example 1: Afforestation Guidelines

Research Approach

During the last 10 years, the agrarian policy of the European Commission had aimed at the reduction of agricultural overproduction in the member states. One way to reach that objective was to increase subsidies for afforestation measures, whereby even productive farmland should be afforestated. In consequence, there was a great discussion about the pros and cons of forestry land-use of these areas. Professionals developed scenarios demonstrating, that the forest surface in Germany would increase by more than one million hectares in the coming years. Nature conservationalists spoke of a "darkening of landscape". In a research project our institute pointed out, which steps and instruments of land-use planning can help to cope with these landscape effects (AMMER 1997).

Results

Although the annual afforestation rates does not increase to the predicted extent, it was and it will be necessary for the future to develop so called *prototypes of afforestation* by including the target group of the planning process.
These prototypes of afforestation should correspond to the heterogeneous morphology of previously described visual landscape units. Besides the primary visual aspect, the prototypical design approach also manages ecological and economical issues in terms of amenity design. Afforestation guidelines may therefore contain verbal and graphic descriptions of prototypical landscape units, including the following parts:

- description of the status quo: basic information about the actual structure of land-use and landscape, the actual distribution of forests or information about geomorphology
- ecological and economical needs (restrictions by laws; preferences set by other ecological plans)
- the results of the public preference for providing food
- potential conflicts of interest (for example between landscape aesthetics and afforestation)
- Solution: recommendation of prototype

The development of prototypes of afforestation does not replace the need for local planning, but it can give the framework. In such an individual plan (for each community e.g.) aesthetic aspects (e.g. the design of forest edges), ecological improvements (e.g. biotope network structures, treatment of marginal sites) as well as forest parameters like tree species selection and mixture, age structure, stability, opening of the stands or the techniques of afforestation must be respected. More than now, the emphasis should lie on the nature-oriented alternative of natural succession (AMMER & PRÖBSTL, 2000).

Example 2: Redevelopment of Protection Forests in the Bavarian Alps

Research Approach

The forests in the high mountains of the Bavarian Alpine Region have always fulfilled a great number of different functions, which are essential for human existence in the Alps. They protect settlements, roads and communication systems against avalanches, falling rocks and landslides, thus providing the people a place for their outdoor activities (skiing, hiking, paragliding) and recreation opportunities in a charmful landscape, protect many rare and endemic species and last but not least supply timber as a valuable raw material.

In the consequence about 60 % of the forests in the Bavarian Alps are protection forests (147 000 hectares). Unfortunately parts of these protection forests have been weakened by air pollution and are overage. In many cases browsing of game prevents natural regeneration and thus intensifies the creeping deterioration of its protection function.

Face to this situation, a programme for restoring the protective capacity was initiated by the Bavarian State Forest Service. On the surface of about 8 % of the protection forests (12 000 hectares), where remarkable degradation of the stand or the menace of erosion and avalanches were obvious, regeneration measures are carried out. This includes according to the degree of necessity, biological measures like afforestation or engineering (various types of wood constructions, figure 1). In four selected areas the activities were investigated by scientific methods. After 10 years of monitoring, some first results of the success of these measures can be stated (AMMER & DETSCH 2000).

Results

Wood constructions

After 10 years the different types of wood constructions against snow movements are in excellent shape. Only 0,5 % of the about 400 investigated snow rakes were damaged, the loss rate of the ground joists (n=1119) were only 1 %. The damage of the snow trestles (11 %) came from a singular avalanche in the test site where the maximum of opening was combined with the minimum of construction intensity.

On the contrary, the results of the evaluation show that snow nets and palings had great problems with snow movements: about two-thirds of the constructions were damaged.

The combination of snow rakes, snow trestles and ground joists lead to a decisive reduction of snow movements and avalanches in the forest stands. However, they cannot guarantee a complete stabilisation of the areas, not even directly in the space between the constructions.

Development of plants

It can be stated generally, that ten years after the starting of the project, the development of plants on these extreme sites is much slower than often predicted. Besides, the plants have grown up differently. The so called pioneer species like *Pinus mugo mugo, Sorbus aria, Pinus syslvestris* and *Larix decidua* can grow up better, the more the stand is opened up, but their contribution towards stabilisation of the snow movement is rather low. The typical species of the climax vegetation unit „Berg-mischwald“, *Fagus sylvatica, Abies alba, Picea abies* and *Acer pseudoplatanus* have some problems with starting but if they are established, the broadleaves can reach height growth rates of more than 50 centimetres per year. Looking at the natural regeneration, *Acer pseudoplatanus* can colonise the stands if the competition of grass is not too high. In each case the expensive building of a fence against browsing of game was necessary. A positive correlation could be shown between the growth of plants and the protection effect of the wood constructions, especially if the plants are positioned right below the construction. Although you can find snow damages also inside of constructed areas, the impact of the damage is less grave than outside. Coniferous species like *Pinus sylvestris* and *Picea abies* suffer from extreme snow pressure especially in the height classes of 1 to 4 meter. According to their flexible shape and to the leafless wintertime, broadleaves (and *Larix decidua*) can stand the snow movements and therefore they get less damaged. Although the development of the young trees after ten years can be described as satisfactory, the complete regeneration of the stands can be found only in one test area.

Example 3: Ecological Effects of The Conversion of Spruce Monocultures Into Mixed Forests

Research Approach

In Germany, large areas of the landscape are dominated by spruce forests (*Picea abies* L.), which are not natural in lower regions. The preference of Norway Spruce in forestry is due to its fast growth, the versatile use of its wood, low demands to soil quality, low sensibility to weather extremes and relative resistance against the grazing by deer.

Figure 1: Snow rakes protect young firs against snow movements

But deterioration of soil quality, gradation of bark beetles and other insects as well as storm damages showed the risks of spruce monocultures. Spruce plantations are also accused of being unsuitable habitats for animals and to be responsible for the reduction of forest invertebrates (Jedicke 1997). As the Bavarian State Forestry has seen the disadvantages of spruce monocultures, spruce stands have been reconverted since the 1950's with the goal to mix about 30-40% deciduous tree species into the spruce stands. This reconversion is realised by planting mainly beech groups (*Fagus sylvatica* L.) under the thinned spruce canopy or into canopy gaps.

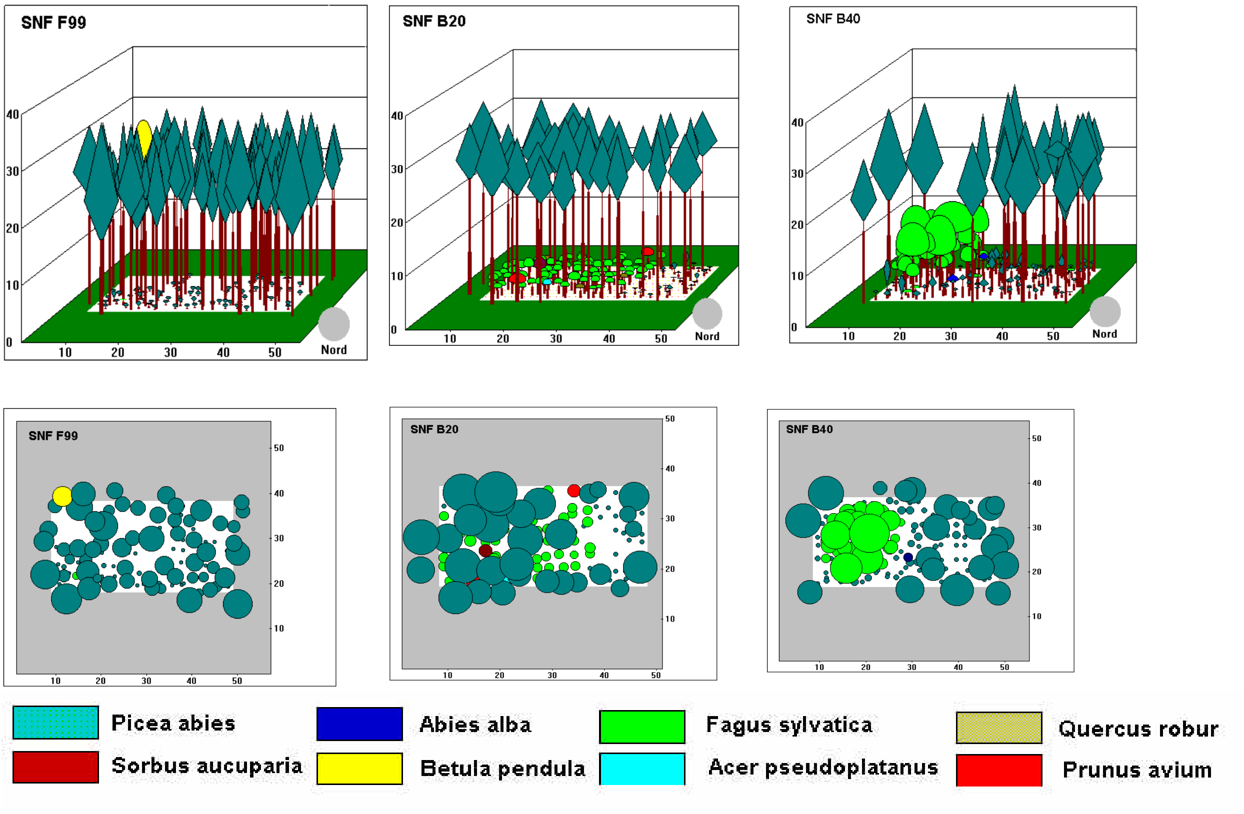
The structural diversity and the invertebrate fauna of different stages of the reconversion process (20- and 40-year-old beech groups; mature spruce monocultures, natural beech stand; 30-year-old spruce stand) were investigated in a space for time substitution" in two test sites in Bavaria (MATTHES 1998; ENGEL 1999).

Results

In summary it has to be stated, that the system of group-wise cutting and starting regeneration beneath the canopy layer is an excellent method to reconvert monocultures into mixed stands. The variability of illumination beneath the canopy layer is necessary for an heterogeneous stand structure and creates ecological niches. Besides the artificially planted tree species (beech, fir), also naturally growing deciduous trees like birch or mountain ash or shrubs of early succession stages appear and increase the species diversity of such stands (see figure 2).

Predators of the mesofauna (Carabidae, Staphylinidae, Araneae, Opiliones, Pseudoscorpiones, Chilopoda, Dermaptera, Formicidae) as well as the saprophagous macroinvertebrates (Diplopoda, Isopoda, Lumbricidae) show a higher abundance and numbers of species in beech woods than in spruce forests. Hence, the reconversion of spruce monocultures is a contribution to higher horizontal and vertical structure in the forest; it increases the mosaic and thus provides a greater number of different habitats for the fauna, especially at the edge of the beech groups.

Figure 2: Development of a conversion stand (3-dimensional model by NAGEL 1996)



although the fauna of most of the beech groups, especially the older stages, is very similar to that of the spruce forests, there are already typical species of deciduous stands immigrating into the isolated groups; some species even show a preference for these stages;

the greater faunistic diversity of the young beech groups compared to the older ones seems to be due to the dense structure and moist microclimate, but the size of the groups might play a role, too, so that planting size should be at least 1000 m^2 , which is also an acceptable size from the operational and economical point of view.

Example 4: Structural and Biological Diversity in a Comparison of Nature Forest Reserves and Managed Forest Stands

Research Approach

In Germany discussions between nature conservation and forestry representative are currently taking place about the issue, which level of nature conservation and natural dynamics can be achieved in managed forests. To de-emotionalise the current discussion we compared nature forest reserves as „indicator areas" for naturalness with managed forests; They are expected to provide information about the integration of nature conservation in forest management concepts.

In a comparative study, two nature forest reserves (beech/oak) and three variants of managed forests (spruce – spruce/beech – beech/oak) were investigated by the same methods, embracing the entire spectrum of ecosystem strata: soil, vegetation and forest trees (stand structure including canopy). Faunistic species groups typical of each stratum were selected and captured by different trap systems. An inventory of macrostructure and their relationships to the biocoenosis completes the research activities

(Detsch 1999; Schulz 1998; Schulz 1996). The project focus on the question: What is the common ground and what are the differences between nature forest reserves and managed forests concerning stand structure and species diversity?

Results

Structural diversity

Several parameters of structure were selected to describe structure-diversity concerning stand composition and macrohabitat provision. The results show that structural diversity is higher in the nature forests reserves than in the managed test areas. The reserves present a wider range of diameters and an exponential structure of stand stock. Another parameter to describe the horizontal structure diversity is the spatial distribution of the trees within the stand. In the nature forests, the values of this index are tending to random or cluster distribution, while the trees in the managed forests are distributed more regularly. However, the indices of intermixture of trees and of vertical structure come to their maximum in the managed test area, stocked with broadleaves (beech, oak). Here, the selected thinning methods create a situation of higher structural diversity than in the unmanaged forests.

Regarding the diversity and richness of microstructures (e. g. dead wood, root plates, brush piles) in the different test areas it can be resulted, that the unmanaged forests show a higher amount and diversity of dead wood (about 200 solid meter/hectare for the reserves versus 10 solid meters/ha in the managed forests). Finally the small-scaled mosaic of natural succession stages in the nature forests (states of decay close to states of regeneration) produce a higher variability in natural edges than in the managed forests with its homogenous age-class system.

Species diversity

An analysis of different organism groups revealed, that the differences between nature forest reserves and managed forests are less grave than expected. But distinct differences were found between the strata (canopy – stem area - ground).

As demonstrated in figure 3, there are organism groups

that follow the supposed degree of naturalness (beetles and fungi). The correlation is evident : both groups find in the nature forest reserves much more of their main habitat structure: dead wood.

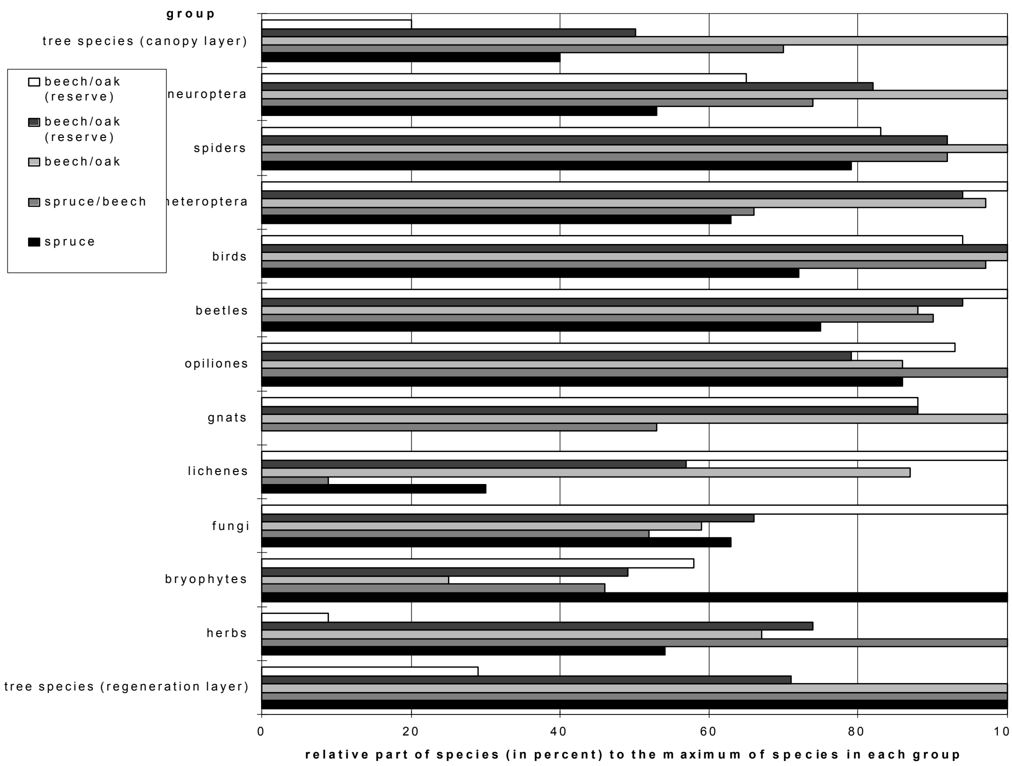
that show no differences in species diversity between the test areas (opiliones, spiders, birds with exception of the spruce area). For invertebrate predators like opiliones and spiders the naturalness of the stand is less important than the existence of micro habitat structures of the surface (brush piles or little branches) which they can find in each stand type.

that were registrated in higher species numbers in the broadleaf variants (managed or unmanaged) than in the coniferous stands (heteroptera, gnats). For the gnats the degradation of the pH-value in the soil caused by the slow mineralisation of coniferous needles seem to be a negative factor. For the heteroptera which mainly prefer the canopy area the broadleaf crowns show more habitat diversity (dead wood, epiphytes).

whose maximum of species diversity has been found in the managed broadleaf forest (neuroptera, lichenes, tree species of the mature stand and of regeneration). It can be estimated that for these groups especially the oak plays an important role for biodiversity within the investigated managed forests. Besides, many other tree species can exist in the neighbourhood of oaks and also the regeneration under the thinned canopy layer of oaks is very diverse.

that present higher species diversity in the test areas dominated by spruce (bryophytes, herbs). The hygrophile group of moss like the high humidity of closed coniferous stands and for the group of herbs it can be said, that in managed mixed forests (with coniferous and broadleaf trees) also a mixture of plant can be found that originate both from broadleaf and coniferous vegeta-tion units.

Figure 3: Investigated organism groups and the relative part of species to the maximum of species found in each group



Nearly the same results are determined by regarding the distribution and the share or rare species (Red-List-Datas). In summary, it is obvious that in our test sites a clear correlation between naturalness of the stand and highest diversity is only given in some cases mostly related to the higher amount of dead wood. Therefore the managed forest and in particular the broadleaf type is of great importance for nature conservation and species diversity.

Conclusions

The stated examples show, that the efforts of forestry are on the right path for the rehabilitation of landscape in Germany.

Even if the rates of **afforestation** remains on a tolerable level, it should be set at a higher value in the planning process than in the past. In such a participative planning process, prototypes of afforestation can help to define the demands of the different actors. In the second step an interdisciplinary approach involved in the landscape planning process will show the best results.

The measures for **regeneration of the alpine forest systems** must be continued even at very high costs and even if the activities will not be blessed by success until several years to come.

The **efforts of conversion** made in the last 40 years in many forests in Germany show first positive effects by increasing structural and faunistic diversity. The conversion program should thus be continued.

A **small-scale, nature-oriented forestry** is able to keep a balance between the maintenance of species biodiversity and the integration of dynamic processes into managed forests.

In any case the **game population has to be reduced** in a way that browsing does not prevent the growth of the young trees. This is important for the Alps as well as in the conversion stands of the lowlands.

Summarising the results of the different studies, a concept of forestry use, which integrates the aspects of aesthetic values and nature conservation with management systems, together with a selected net of total reserves and the creation of biotope-network structures would play an important role in an intelligent, sustainable land-use system for the future - following the intention of AGENDA 21 and the declaration of Rio.

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Restoring Protection Against Natural Hazards in European Mountain Forests After Wind Disturbance: How much Human Interference?

by
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Abstract

Protection forests are forests on steep slopes that have the primary function of protecting people or assets against natural hazards such as snow avalanches and rockfall. In this paper, the current state of protection forests in central Europe, and an approach to managing these forests are presented. If large-scale wind disturbance occurs in a protection forest, fast recovery is needed to restore effective protection. Since silvicultural measures often do not cover their costs with the socio-economic conditions that prevail in central European mountain forests, natural forest dynamics are increasingly being relied since this often ensures sufficient protection. The old view that doing is better than leaving is increasingly being questioned. Decision-making about dealing with wind-disturbed forest areas needs to take into account the decreasing effect of the thrown or snapped trees in preventing natural hazards. Moreover, the increasing effect of the recruitment, especially the advance regeneration, the risk of a bark beetle outbreak when thrown or snapped trees are left lying, and the effects of harvesting on regeneration need to be considered. To choose among different management options, checklists based on the current state of knowledge are used. Since many protection forests are currently far from having the small-scale target stand structure, wind disturbance can also be seen as an opportunity to create forests that will be more resistant to future disturbances, and that will be able to recover from them faster.

Keywords: Protection forest, Windthrow, Regeneration, Silviculture, Central Europe

Introduction

Protection forests are forests that have as the primary function of protecting of people or assets against natural hazards such as snow avalanches, rockfall, debris flow, and floods, or against adverse climate (Plate 1, Brang et al. in press). This definition implies the simultaneous presence of 1) people or assets that may be damaged, 2) a natural hazard or a potentially adverse climate that may cause damage, and 3) a forest that has the potential to prevent or mitigate this potential damage (Wasser and Frehner 1996). On many sites in European mountain forests, site conditions enable forests to offer continuous and effective protection. In the mountain regions of Switzerland, protection forests cover 8-45% of the forest area, depending on the region and the definition of a protection forest (Brassel and Brändli 1999).

The protective ability of a protection forest is mainly provided by trees. Tree stems halt falling stones (Cattiau et al. 1995). Tree crowns prevent, by snow interception and by snow release, the build-up of a homogeneous snow layer that might glide as a compact blanket (In der Gand, 1978). Even dead trees lying on the ground may act as dams to prevent and stop downslope mass transfers (Mössmer et al. 1994). Managing protection forests therefore means maintaining a certain tree cover continuously. The stands should always be a state that meet minimum standards for stand structure. Such standards have been defined for specific natural hazards and site conditions (Wasser and Frehner 1996, Renaud et al. 1994). The ideal structure of a protection forest is often a small-scale mosaic of patches (patch size <0.1

ha) in different developmental stages (Ott et al. 1997 pp. 21, 50), or even a single-tree selection forest (Schütz 1994). On sites where natural disturbance regimes (White and Pickett 1985) create this patchy mosaic, human interference is unnecessary to maintain effective protection. However, on other sites large-scale disturbances such as windthrow prevail, or the current forest condition (e.g., unstable stands with short-crowned, slender trees) favors such disturbances. In such cases, protection forests need to be managed in order to decrease the likelihood of large-scale disturbances, by replacing them with small-scale human forest dynamics.

In central Europe, socio-economic conditions have relieved the pressure on forests as a timber resource. In protection forests, which occur mainly on steep terrain with a slope between 50 and 100%, timber harvesting is costly and may even not cover its costs. Timber is therefore not usually a primary economic factor in European protection forests. In three mountain regions of Switzerland, for instance, no timber harvesting has taken place on 6, 19 and 41% of the forest area for at least 50 years (Brassel and Brändli 1999 p. 187). In many stands, management therefore aims not to maximize revenues, but to minimize losses from timber extraction. Natural forest dynamics are relied on as long as they successfully provide effective protection. However, it is difficult to decide when this is the case. In this paper, we present an overview of the factors to be considered when deciding whether or not to interfere with natural forest dynamics after wind disturbance.

The Current State of Protection Forests in the European Alps is Far from Ideal

Natural disturbance regimes would create the small-scale mosaic desirable in protection forests on the majority of sites in European mountain forests (Zukrigl 1991). However, most stands are far from having an ideal structure since they have been strongly shaped by human impact during centuries (Ott et al. 1997 p. 24). The current deviations from the ideal condition include too little structural and species diversity, insufficient regeneration and too little coarse woody debris.

Plate 1. The protection forest of Curaglia in central Switzerland 1 year after the storm Vivian. The area was harvested and planted, and temporary avalanche barriers were constructed.

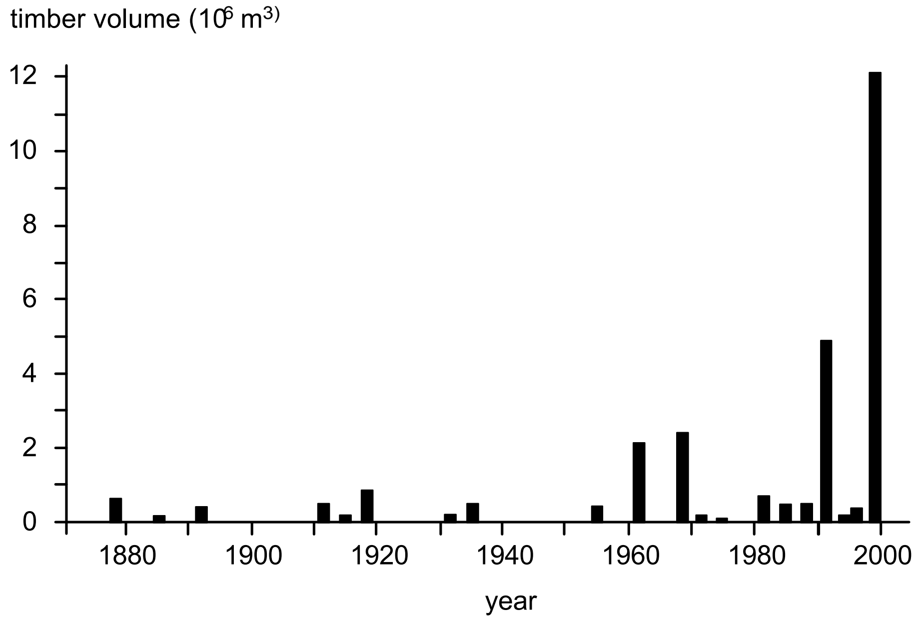
The stand structures are much more uniform in the current man-made forests than in old-growth forests. In the Swiss Forest Inventory the stand structure was classified as uniform on 68% of the plots (Brassel and Brändli 1999, p. 117). There are no representative data from old-growth forests on similar sites. However, a site-specific analysis of many case studies in Slovakian old-growth forests (Korpel' 1995) suggests that, without human interference, over three quarters of the Swiss forests would be structurally diverse (including *Fagus sylvatica* forests, mixed *Abies alba-Fagus sylvatica* and *Picea abies-Abies alba* forests, and subalpine *Picea abies* forests; Brassel and Brändli 1999, p. 67). In comparison to what is assumed to be the natural vegetation, *Picea abies* is over-represented in Swiss forests. This was shown using a site-classification model and tree inventory data, on sites where deciduous trees would be dominant without human interference (Kienast et al. 1994). On these sites, *Picea abies* occupied more than 75% of the total basal area on 21% of the plots. The proportion of another coniferous species, *Abies alba*, has been reduced by human impact. This shade-tolerant species is not competitive on large open areas and is much more heavily browsed by ungulates than most other tree species (Liss 1988). Its distribution has been greatly reduced by extensive clear-felling and grazing in the 19th century, and by high browsing pressure in recent decades (Eichenseer 1997). The volume of coarse woody debris currently amounts to 11.9 ± 0.5 m3/ha (mean ± SE, Brassel and Brändli 1999 p. 290) in Swiss forests, while in Slovakian old-growth forests, volumes of 50-280 m3/ha have been reported on similar site types (Korpel' 1997). Moreover, tree regeneration has been impaired by grazing, browsing (Brändli 1995), and a lack of coarse woody debris which is an important seedbed for several tree species (Mayer and Ott 1991 p. 14). In an analysis of Swiss National Forest Inventory data it was estimated that the regeneration cover is below target values on about 30% of the area on sites where *Picea abies* is assumed to be dominant (Brang and Duc, unpublished data).

Structurally homogeneous stands are less resistant to wind disturbance (Schmid-Haas and Bachofen 1991). Furthermore, the higher proportion of *Picea abies* means lower resistance to bark beetle disturbance since this species is most susceptible to this type of disturbing agent. Insufficient regeneration and coarse woody debris as a seedbed mean longer recovery periods after disturbances. In conclusion, deviations from an ideal stand composition and structure mean that with the current stands, effective protection is more likely to be impaired by natural disturbances, and will take longer to be regained after impairment by disturbances.

Wind Disturbance in Central Europe

Wind is a major disturbing agent in many forest ecosystems (Brünig 1973, Oliver 1980/1981, Canham and Loucks 1984, Martinez-Ramos et al. 1988, Foster and Boose 1995, Mitchell 1995, Vasenev and Targul'Yan 1995). In old-grown forests in central Europe, 8-15% of the forest area show visible signs of wind disturbance (Falinski 1976, Skvorzova et al. 1983 p. 172). In secondary forests in western Russia with large-scale wind disturbance, this percentage can reach 30% (Skvorzova et al. 1983 p. 172). This must be regarded as an extreme value for secondary forests. At the other end of the scale are two large districts in the Urals in Russia. Wind disturbance affected only 0.12% of the forest area in the 8400 km^2 district and 0.19% in the 8100 km^2 one over a 30 year period. In contrast, the storm Vivian in 1990 alone affected 0.4% of the forest area in Switzerland (Schmidtke and Scherrer 1997). The timber volume affected by wind disturbance has increased in recent decades in Switzerland (Fig. 1). The main reason for this is probably an increase of the standing volume (Brassel and Brändli 1999 p. 76). In contrast, there is not yet any empirical evidence for an increased frequency and/or magnitude of storms in central Europe (Schiesser et al. 1997).

Fig. 1. Development of timber volume affected by wind and snow load disturbance in Switzerland. The volume has increased in recent decades.



After the storm Vivian in 1990, 90% of the windthrow areas (size >0.2 ha, and with less than 20% canopy cover left) in Switzerland were smaller than 1.8 ha, and comprised 50% of the total windthrow area (Schmidtke and Scherrer 1997). Less than 1% of the areas were larger than 10 ha, but these made up 18% of the total windthrow area. In old-growth forests in central Europe, the individual areas affected by wind disturbance tend to be smaller than in secondary forests (Zukrigl 1991), although firm evidence is difficult to find since the remaining old-growth remnants are very small (Leibundgut 1982, Mayer et al. 1989, Korpel' 1995).

Wind disturbance often triggers other disturbances, especially by bark beetles (Strunz 1995, Schopf and Köhler 1995, Schmidtke and Scherrer 1997, Forster et al. 2000) which feed on weakened trees. After the storms in recent decades, the timber volume affected by secondary damage amounted to 30-60% of the initial wind disturbance (Forster et al. 2000).

The patterns of wind disturbance found in European mountain forests, especially protection forests, are similar to those presented above. In comparison to lowland forests on flat terrain, aspect has a greater influence on the occurrence of wind disturbance (Foster and Boose 1995). Although wind speeds are generally higher in mountain areas than in the lowland (Schüepp et al. 1994, Finnigan and Brunet 1995), there is no evidence for higher levels of disturbance in mountain forests. Several effects seem to counteract higher wind speeds in mountain areas: the adaptation of trees to wind (Mattheck 1989), lower tree height connected to lower site productivity (at least in a regional comparison), and a higher frequency of internal stand edges which are highly resistant to wind (Ott et al. 1997 p. 21).

Restoration After Wind Disturbance in Protection Forests

There are two principal ways of reducing the impact of wind disturbance in forest management: by enhancing the resistance of the stands to wind, and by promoting fast recovery. Managing for resistance, which should aim at preventing undesirable disturbances, is widely practiced (for even-aged stands, see Nielsen 1995 and Slodicák 1995, for uneven-aged stands, see Ott et al. 1997). However, there are always wind speeds higher than what the stands can resist. If such a disturbance occurs, fast recovery is needed until the recruitment ensures effective protection again. In this paper, we focus on the second case of managing for fast recovery after wind disturbance.

To determine the degree of human intervention, necessary in protection forests, a consistent procedure has recently been adopted in Swiss mountain forests, and several checklists have been developed (Wasser and Frehner 1996, Ott et al. 1997, BUWAL 2000, Brang et al. in press). The basic idea is to make use of natural forest dynamics as long as undesired effects are unlikely to occur, and to limit human interventions to those that are effective, justifiable (cost-effective), necessary, and feasible (Wasser and Frehner 1996, Brang et al. in press). The most important short-term management alternatives are: leaving trees (with the bark, or stripped bark of) in place vs. harvesting trees, planting vs. (or as a supplement to) natural regeneration, and using avalanche and rockfall barriers vs. relying on the effects of downed trees and surface roughness. Scientific evidence that can be used to underpin management decisions is increasing, but much of the procedure is still based only on the experience of forest managers.

Several factors need to be taken into account in applying this procedure to areas affected by wind disturbance, aside from the potential costs involved in any silvicultural measure (see also BUWAL 2000). First, the downed stems usually provide effective protection for at least one decade (Lässig and Schönenberger 2000), although empirical evidence about how long this effect lasts is lacking. Second, it takes 30-80 years until protection from the new generation becomes effective in subalpine protection forests (Ott et al. 1997 p. 33), and still 20-50 years in montane forests. While natural forest dynamics will, under most conditions in the European Alps, create stands that provide effective protection after wind disturbance, the time needed may be unacceptably long (Fig. 2). Given this uncertainty, an interventionist approach is still appropriate to protect people or assets directly threatened by natural hazards (direct protective effect, Brang et al. in press). In such cases, precautionary measures should be taken to ensure continuous effective protection.

Third, leaving trees in place may trigger bark beetle damage in adjacent stands, although a "clean" management, with immediate removal of every attacked tree, is in many cases unfeasible. Fourth, harvesting trees may damage advance regeneration (Fig. 3, Alexander 1957, Timoney and Peterson 1996). However, harvesting also creates exposed mineral soil, a safe site for the establishment of the seedlings of many conifers (e.g., Alexander 1984, Prévost 1992, Brang 1998). Fifth, downed trees are an impediment for browsing ungulates and therefore protect seedlings and saplings from browsing. Sixth, we can be more certain about the spatial distribution, growth and mortality of seedlings if they have been planted.

Managing for fast recovery must start before a wind disturbance occurs. A crucial element in fast recovery is the presence of established seedlings and saplings that wait for release (advance regeneration, Fig. 3). After a windthrow, the regeneration of climax species is often primarily from advance regeneration, while most of the seedlings of pioneer species re-establish after the disturbance (Fig. 3, Fischer 1992, Lässig and Moèhalow, in press). Lack of advance regeneration delays recovery or at least effective protection, especially on large areas. The pioneer species invading a windthrow area (Fig. 3), such as *Betula spec*., seem to be less effective in providing protection against avalanches than evergreen conifers, such as *Picea abies*. The patchiness that is usually observed in natural regeneration on wind-disturbed areas (Lässig et al. 1995) is not a problem but rather an advantage in protection forests, as long as the distance between individual patches is smaller than about 30 m. A diverse stand structure in the recruitment facilitates the development of structural diversity. In contrast, overly dense stands, especially those planted with regular spacings, are most likely to become structurally homogeneous with low individual tree stability, or require high tending costs to avoid this development (Ott et al. 1997 pp. 83-92). Planting is only used if advance regeneration is insufficient and coniferous seed trees are further than about 100 m away (Lässig et al. 1995), and if fast recovery is essential since planted seedlings usually grow faster than those from natural seedling establishment (Mosandl and El Kateb 1988).

Fig. 2. Schematic development of the protective effect after wind disturbance. Time steps: (0) disturbance, (1-4) and (8-11) protection effective, (4-8) protection ineffective since the sum of the effects of the downed logs and of the recruitment is insufficient. The period from 0 to 11 lasts 50-150 years.

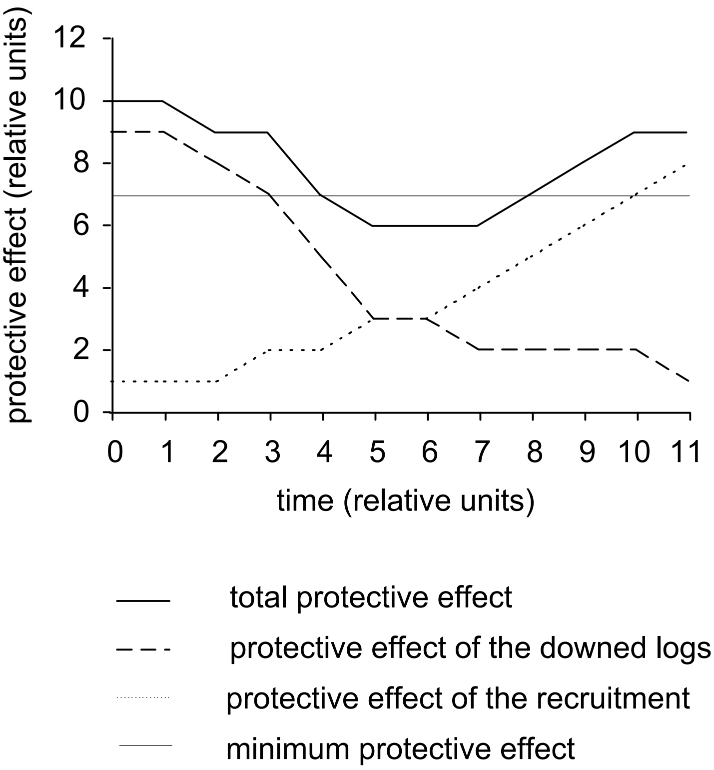
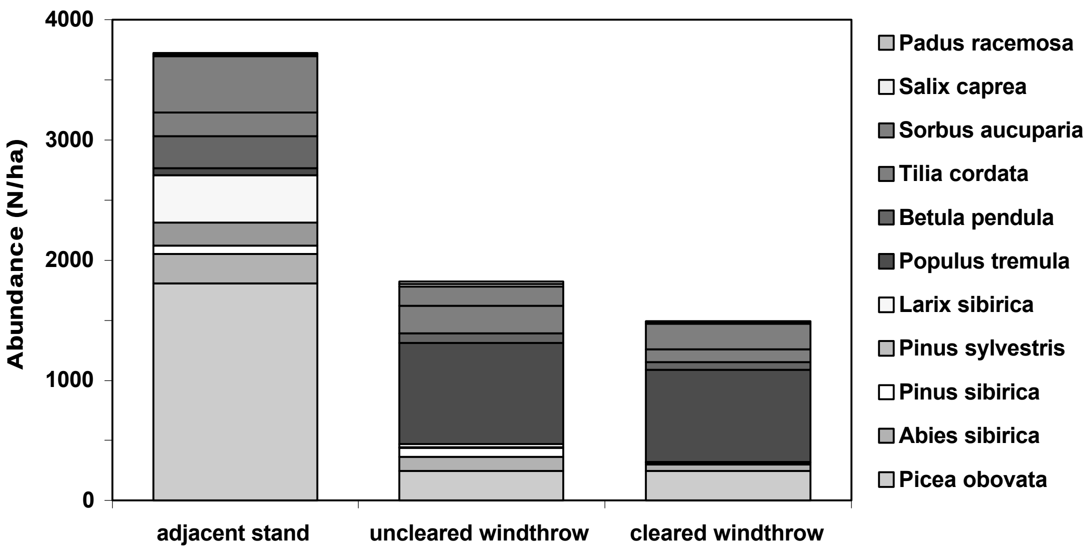


Fig. 3. Species-specific abundance of naturally established tree seedlings (height >20 cm) in cleared and uncleared parts of the windthrow area Šajtanka (central Ural, Russia) and in the adjacent forest, one year after a storm. *Picea obovata* and *Abies sibirica* are unable to grow to 20 cm height within one year; therefore, they are from advance regeneration in all areas.



In any case, the old practice of planting areas in regular grids has been abandoned to avoid structural homogeneity.

Conclusions

Over the past 20 years, the management of protection forests in Switzerland has changed profoundly, There was a strong belief that silvicultural measures would always be required in any situation to ensure continuous effective protection (Leibundgut 1982 p. 186). This belief was only partly based on scientific evidence. Socio-economic changes have caused a revision in silvicultural thinking. Since "leaving" is in many cases cheaper than "doing", a "smart laziness" (Ott 1990) has been adopted, meaning interfering with natural forest dynamics only if this is effective, justifiable (cost-effective), and necessary to ensure sufficient protection. "Doing" and "leaving" are now accepted as equally valid management options.

A stand damaged by wind obviously creates problems, especially in a protection forest. However, wind disturbances must also be seen as a silvicultural opportunity (Kasper and Schönenberger 1991) since stands that are far from having the ideal structure for effective protection may be transformed to structurally diverse stands that will be continuously effective. Moreover, wind disturbance seems to reduce the browsing pressure in adjacent stands because these areas are highly attractive to browsing ungulates. Finally, monitoring after wind disturbance (Schönenberger et al. 1992) helps us to understand forest dynamics better, including interactions among disturbances such as wind and bark beetles, and helps to scientifically underpin our approaches to the management of protection forests.

The general line of thinking about management options to restore wind-disturbed forests has been elaborated. Some simple decision support tools, such as checklists (BUWAL 2000), are available. Applying these tools helps us to avoid management failures. Current knowledge about the processes that take place after wind disturbance has been utilized tin designing these tools. However, we are far from having an adequate risk management approach (Quine et al. 1995, Valinger and Fridman 1999). The challenge lies in widening our knowledge in order to enable us to manage the risks associated with alternative management options. The storms, Lothar and Martin, which hit central European forests in 1999, have provided new opportunities for improving our approaches to dealing with wind-disturbed forests.

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Landscape Visualization in Rural Land-Use Planning

by
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Abstract

Landscape conservation and management are increasingly important goals in rural land-use planning. Integration of landscape management into natural resource planning is tied to possibilities of illustrating the impacts of activities. The different approaches to include scenic values to forest and land-use planning include landscape preference studies, preference modeling and participatory planning. In all approaches visualization can be a good instrument.

For routine planning efficient and inexpensive tools are needed. Today digital image editing and virtual landscape simulators offer the most sophisticated means of visualization. Digital image editing enables public evaluation of forest management alternatives for example in recreational areas or in urban forests. However, forest landscape simulators are less labour-intensive than image editing and offer flexible movement between different viewpoints. The greatest advantage of landscape simulators is that they can be linked to actual planning systems and to different type of forest data. In the future, participatory planning calls for more realistic illustrations , integration of visualization with different sources of spatial data as well as high interactivity of planning tools. Furthermore, additional research is needed to evaluate and compare the usability of different visualization media in forest planning.

Keywords: digital image editing, forest landscape simulators, landscape planning, multimedia GIS, visualization.

Introduction

Rural landscapes provide many amenity benefits such as experiential and ecological values. Landscape quality is also shown to have economic dimesion and for example to reflect in property values (Willis and Garrod 1993, TyrvŠinen 1999). Moreover, in many regions rural tourism becomes for a second or third economic area besides agriculture and forestry. Environment is evaluated mainly as a landscape (Zube et al. 1982) and its quality is a key element for the development of rural tourism (e.g. TyrvŠinen et al. 2000). Therefore, in forest management a balance between traditional economic and less tangible amenity benefits, important for the new means of livelihoods has to be developed.

In the forests are as much part of the nature as the rural cultural landscape. Because approximately 87% of the total land area in Finland is forested. Forest management practises, in particular forest regeneration has long-term impacts on landscape (e.g. Benson and Ulrich 1981, Karjalainen and Komulainen 1999). Furthermore, field afforestation and agricultural intensification have great effects on the visual landscape character as well as biodiversity values. In a country such as Finland with little open agricultural land (7 %), afforestation will hide the agricultural landscape of farm-houses and other traditional land marks behind a forest cover and may close up important distant views such as lakes. Cultural landscapes will become unrecognizable (e.g. Tahvanainen et al. 1996). Visual changes will be immediately and directly experienced by the public However, the quality of impacts of afforestation and forest regeneration depend on the landscape character and negative effects can be mitigated by landscape planning.

Recently, at the forest policy level the social sustainability has been increasing emphasis besides the economical and ecological aspects (e.g. Lisboa 1998). The national Forestry Law in Finland sets social sustainability as a parallel goal to economic and ecological sustainability in forest management (MetsŠlaki

1998). In addition to the traditional socio-economic objectives such as job opportunities and preservation of landscape beauty, The concept includes besides enhancing the opportunities for outdoor recreation and diversification of the means of livelihood in the rural areas. In the future, the multifunctionality will be emphasized in the EU's common agricultural policy, which means among other things, that in food production, cultural landscape heritage and landscape management needs will be considered (Kola 1999). Prerequisite for EU subsidies is that afforestation of land should be adapted to local conditions and compatible with the environment (Council Regulation 1999), which implies that the scenic impacts of afforestation should be addressed in the planning.

Although the landscape conservation and management may be recognised as a strategic objective, they are less successfully put into practise. The legal regulations addressing visual aspects of land-use planning leave wide space for interpretation and in forestry the visual impact analysis has evolved little so far. One of the main reasons is that at present there is no adequate and efficient tools for measuring and integrating landscape values in land-use planning and policy-making (McCormack et al. 1998, Nousiainen et al. 1999). However, objective measurement would place scenic beauty, as a resource, on a more equal footing with other more tangible resources, and would also provide better justification for land-use decisions.

Two main factors have increased the need for realistic visualization tools. i) A general trend towards smaller scaled forest management practices in many countries and ii) public concern about environmental impacts and tighter management guidelines which demand better and more accurate planning (e.g. Buckley et al. 1998). Traditionally, in Finland planning is carried out on one farm at a time. However, administrative borders rarely join physical, ecological or visual borders of the landscape. Often the activities of neighboring farms are as important as activities on the object farm. Therefore, landscape planning should preferably be made simultaneously both on the landscape level and on the farm level. The scale of planning should be chosen according to the scale of changes and the type of landscape. A uniform landscape needs larger evaluation than a small-featured or scattered landscape.

Participatory planning provides the citizens and interest groups a possibility to influence in decision-making in forestry. In Finland the method has been used in strategic forest planning at national level, but also in planning of state owned forests as well as in urban forest planning (e.g. Kangas et al. 1996, Loikkanen et al. 1997, FNFP 1999). The benefits of broad-based community involvement are many and there include promoting stronger sense of commitment of citizens, increasing user satisfaction, creating realistic expectations of outcome and building trust (e.g. Al-Kodmany 1999). It is important that the participants are equally informed on the impacts that land-use or natural resource management may have including their effects on scenery, recreation and other amenities. To avoid the problems of misunderstanding, information should be easily understood by all participants. Visualization is required in participatory planning of rural areas, where larger groups of people are involved. It is the key to effective public participation, since it is a common language in which all participants - technical or non-technical can relate (e.g. King et al. 1989).

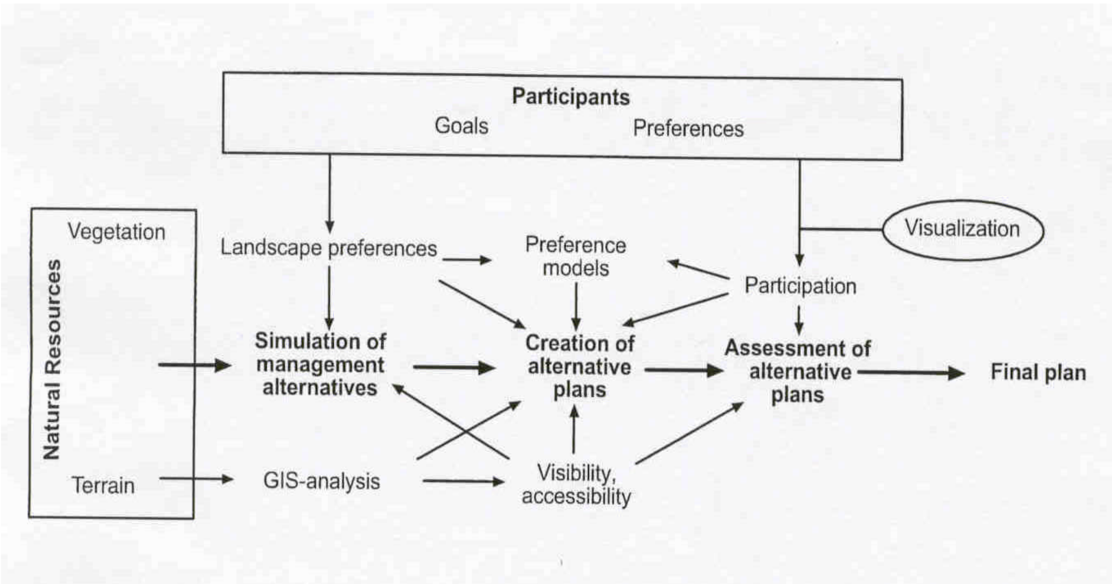
Conflicts in the use of natural resources may often arise from the fact that people have different mental images and ideas of the proposed activities. The attitudes towards forest management seem to depend to certain extent on the presentation format. Amount of verbal information is also shown to have an affect on the people’s acceptance of various management actions in relation to the forest environment (Jensen 1998). A study of Tahvanainen et al. (2000) indicate that preconceptions concerning different silvicultural measures in general did not consistently correspond visual perceptions. People may oppose certain management options although the impacts on landscape may be unnoticeable or even beautiful. Therefore visualization may decrease potential conflicts related to forest management.

Requirements for Visualization

The main part of landscape perception occurs through the sense of sight and therefore, integration of landscape management into natural resource planning is tied to the possibilities of illustrating the impacts of activities. The different approaches to include scenic values to forest and land-use planning include landscape preference studies, preference modeling and socio-economic studies. In all approaches visualization can be a good instrument. Furthermore, in multi-objective forest planning methods such as numerical optimisation procedures and choice models have been developed (Kangas and Kristiansen 1995, Pukkala et al. 1995). Although the the scenic beauty may be difficult to predict and express numerically, the impacts of management plans can be visualized for decision-makers (Fig. 1).

Landscape planning is unlikely to be successful without being linked with other forms of planning. Even when it does operate independently, it must usually take into account social and economic factors which condition these other forms of planning . Therefore forest visualization should preferably be linked to operational planning systems and tools such as GIS (e.g. Nousiainen et al. 1999). For public participation forestry experts and land-use planners need an interactive visual planning tool that enables the interest groups an citizens to fully participate in the process. In the planning meeting the planner and/or participants may interacting themselves or through a consultancy (Kangas et al. 1996.).

Figure 1. Different approaches to integrate scenic values to forest planning (adapt. from. Nousiainen et al. 1999).



Many interest groups, besides landowners, are interested in landscapes. The number and quality of groups vary according to the planning areas. The possible groups may include interested citizens local residents, tourists, NGO's , administrators and enterprises. There are different levels of participation. At its highest level the participant will make the decisions and the responsible organisation will only implement the plan. At the lowest level the focus is in delivering information during the public meetings (e.g. Loikkanen et al. 1997). The role of visualization is especially important if people without special expertise are involved in planning. It is important that changes both in landscape structure and vegetation can be recognised. The illustrations should be able to capture the details such as special shapes of trees, undervegetation and stones, which attract the viewer's attention and create experiences. The required level of realism is very high if the person knows the landscape thoroughly. This is the case with local residents and people frequently visiting a particular setting (e.g. Karjalainen and TyrvŠinen 2000).

Visualization is not only cheaper than on-site visits but it also offers laboratory conditions where many aspects affecting site evaluation can be avoided (e.g. heat, cold, rain, wind). However, landscape illustrations should correspond to the conditions in nature. Although many studies have shown that slides and photographs are acceptable substitutes for on-site visits if they include most of the scenic elements of the landscape (e.g. Shuttleworth 1980), opposite results have also been obtained (e.g. Hull and Steward, 1992). Visualization has also been criticized because it is not able to represent the whole richness of real nature. Photographs, for example, are not only less complex and less multidimensional but they also offer less interaction than real scenes (e.g. Karjalainen and TyrvŠinen 2000).

Visualization should also simulate the way people move in and perceive the environment. A good visualization tool enables flexible choice of viewpoints and the perspective of illustrations should be realistic. Perceptions are also dependent on the rate of speed, on the means of transport (e.g. on foot, by bike) and on the activities performed (e.g. Zube et al. 1982). In order to be able to account for this kind of variation simulation of different ways of moving in landscape is needed.

In forest planning the decisions concern the future and are impacts of silvicultural treatments are probably difficult for the ordinary residents to comprehend. In order to determine the effect of any particular change such as regeneration or afforestation, it is important that the visualization medium allows only one aspect of the landscape changing at a time. The desired changes in images should preferably be automatized, but at least they should be relatively easy to make. The method should enable to control variables such as light, colours and shades. Furthermore, visualization should be accurate and scientific. It is often important to know the exact size of the logging area and the amount of timber removed or trees planted to guarantee that the illustration corresponds to the reality. Therefore, the visualization medium should be linked with different kind of spatial forest data.

Moreover, the planning costs are limited and therefore visual impact assessment in forestry should not generate too much extra costs. The price of visualization package and the requirements for its running environment must be reasonable. Expenses can be restricted if the use of visualization tool is easy and not labor-intensive.

Visualization Methods in Forest Planning

Forestry professional and scientists have been investigating visualization techniques for many years addressing a range of forest management problems. The recent methods for illustrating changes caused by management include photographic manipulations and video techniques and multimedia GIS. Furthermore, sophisticated technological innovations such as computerized visual landscape simulations have been introduced (Zube et al. 1987, Karjalainen and TyrvŠinen 2000).

Digital image editing techique uses computer software in the manipulation of digital images which have been either digitized or originally taken with a digital camera. Digital image editing makes it possible the study of the effect of a particular change in landscape and control other variables such as amount of open space. The images produced are photorealistic, but also static and the method cannot be easily automized. Detailed changes in original images are time-consuming and costly to make (Fig. 2). There are, however, many factors affecting editing speed. For example, how accurately the original pictures are to be visualised, what is the quality requirement and for what purpose pictures are to be made (Tahvanainen et al. 2000). Furthermore, the pictures produced are, to a certain extent, open to inaccuracy because of the subjective evaluations present in the modification of the original pictures. Without the use of spatial data it is difficult to estimate the effect of change in the landscape accurately.

The available methods to simulate movement include *video* and *animations* (e.g. Vining and Orland, 1989). Using video simulation participants can actually see their comments and suggestions taken into in account. This feedback reinforces the participatory process and promotes the exchange of ideas. While video images are photorealistic and inexpensive, the simulation of change is labour-intensive. Furthermore, although animations are relatively easy to prepare with present computing equipment and freely available software, photorealistic animations are also laborious to produce.

Figure 2. The impact of forest management can be illustrated by digital image-editing are photorealistic, however detailed changes in original images are laborius to make.

Furthermore, GIS has been used in visual impact assessment in forestry, in particular, the aesthetics of forest cutblock shape, size and location are an primary interest. However, current GIS technology has not provide visualization functionality affording realistic presentations of the 3-D landscape. So far there has been relatively little integration of the scientific visualization techniques with commercial GIS software (Buckley et al 1998). However, with increasing functionality and hardware developments capabilities to represent and animate 3-D images of the landscape in real time are coming on-line within commercial GIS applications. Moreover, *multimedia GIS* have been recently tested in land-use planning (e.g. Weidenbach 1999, Weidenbach and Pršbstl 1999) This approach includes the use of digital video and sound, combined with graphic files and zoning maps. However, the use of multimedia GIS in participatory planning must be looked critically, because digital presentation with audiovisual effects may influence the audience more than a conventional analogue presentation of the land-use plan (Weidenbach and Pršbstl 1999).

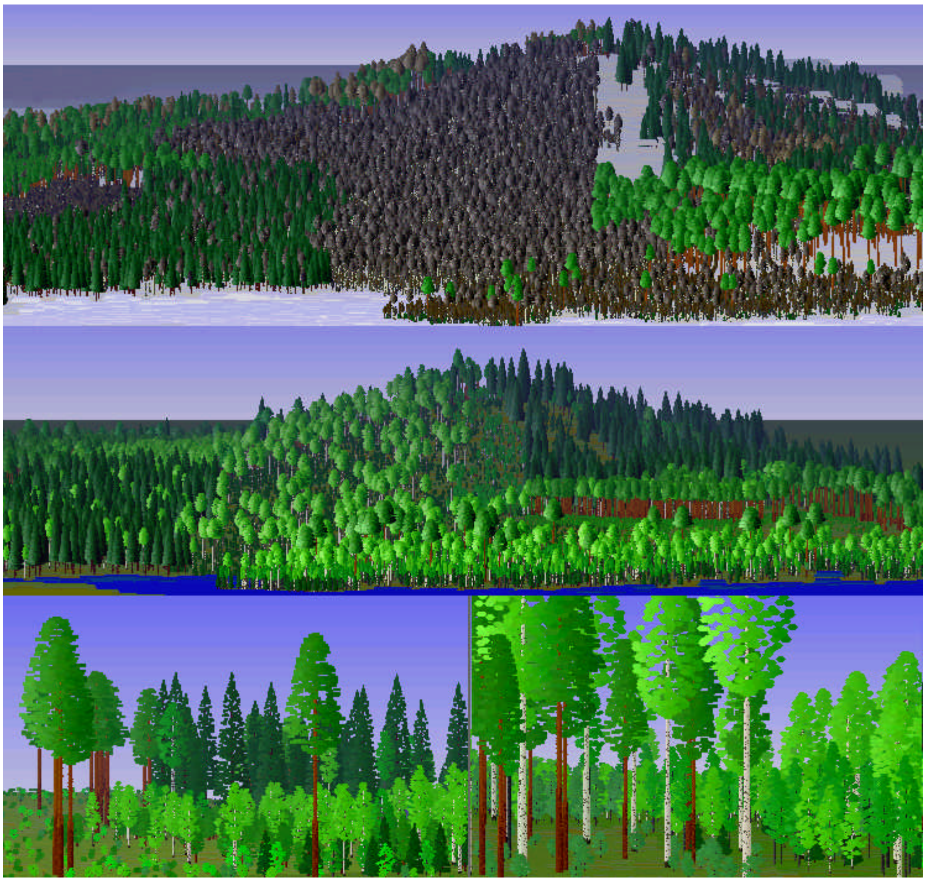
Virtual forest landscape simulators are based on the use of a digital terrain model, some kind of a map and forest data (Orland 1997, Uusitalo et al. 1997, Pukkala 1998). Examples of systems developed in Finland include the multiple-use forest management planning system, MONSU (Pukkala, 1998) and a commercial landscape simulator FORSI developed by private consultant and development enterprise Plustech Ltd. Other example include, Smart Forest –program, an interactive, three-dimensional visualization system developed by University of Illinois (Dept of Landscape Architecture) and the USDA Forest Service for visualizing scenic effects of use and treatment decisions (Orland 1994). The functions of the programs are rather similar and are based on map information, an elevation model, compartment data of the target area, and visual objects.

The illustrations of forest landscapes in the MONSU system are automatied computer line graphic drawings based on tree and site parameters, included in present forest planning systems. Trees can be illustrated by three different quality levels. The tree symbols are differently coloured two- or three-dimensional graphic symbols, whose species and size distribution correspond to the local tree populations as described in inventory data (Fig. 3). In FORSI and Smart Forest programs the two-dimensional visual objects generated from digitized photographs represent the main elements of a forest landscape (trees, shrubs, undervegetation, logging residue).

One advantage of the landscape simulators in visualization of forest plans is their flexibility; the observer is not limited to any predetermined viewpoints. They display topographical variation and perspective from a chosen vantage point. The programs enable a flexible assessment of both close-ups and long-distance scenes with updated forest data. The assessment of landscape from several viewpoints is possible. They also enable the simulation of a real-time movement in the landscape, but at present the capacity of current PCs limits the use of this property (TyrvŠinen and Karjalainen 2000). The programs are also able to illustrate the effects of seasonal change and atmospheric effects such as fog. Moreover, automatized visualization reduces the production costs of illustrations.

The visualization tool can be connected with a forest planning system, which means, among other things, that the evaluation of the scenic impacts of alternative plans is easy. Because MONSU program is developed for forest planning, the simulation of landscape changes by different management regimes is easy both at forest stand and forest area level. In FORSI and Smart Forest programs the simulations of forest operations are less easy to conduct; they are realized through a manipulation of the compartment or tree data.

Figure 3. An example of the near-view and long-distance view illustrations of a forest area produced



One of the disadvantages of landscape simulators is that the images may not correspond to the real world well enough (Karjalainen and TyrvŠinen 2000). Although the illustrations include some elements of the undervegetation such as berries and mushrooms, the special features and details of a particular landscape (buildings, shrubs, stones, special shapes of trees and single trees) are absent. Thus the forest simulators produce more or less standard landscape pictures. However, the quality of the illustrations depends to large extent on the viewing distance. Moreover, rare tree species and additional objects such as houses and recreational facilities can be added to the object library or added into the pictures manually.

At present rather very is known how well the visualizations correspond to the reality in different planning situations. There are some studies in which two or three visual presentation methods have been compared to each other (e.g. Pukkala et al. 1988, Nousiainen and Pukkala 1992, TyrvŠinen and Tahvanainen 1998). In the study of Nousiainen and Pukkala (1992), computer graphics and slides proved to be almost equal methods for the ranking of forest trails on the basis of scenic beauty and variation. However, it was found out that the recreational value of forest trails cannot be easily evaluated on the basis on computer graphics, presumably because low bushes, dwarf shrubs and obstacles on the ground were omitted from the illustrations.

Some studies suggest that computer graphics may be an adequate presentation format for public evaluation al.1998). In the study of TyrvŠinen and Tahvanainen (1999) images illustrating impacts of afforestation produced by an early version of the MONSU (multiple use forest planning system) and panoramic slides were evaluated by land-use experts and landowners. Nousiainen et al. (1998) tested the use of vector graphic illustrations in a participatory planning context in North-Karelia, Finland. Both studies suggest that computer vector graphics is an adequate medium in the comparison of different management alternatives in large-scale agricultural landscapes. In large-scale views, small landscape elements are not so important and merge easily with the background scenery.

Conclusions

Scientific visualization in forest planning systems allows planners to work effectively with landowners from wide variety of backgrounds and perspectives. The visualizations have to be tied to underlying databases and the links between visualization and data are verifiable, reliable and accurate. Currently visual simulation of forest may be only descriptive. The difficult task of evaluation remains for the planner and the participants. Visualization should be used more in decision-making process. It is often now regarded as decorative in function and is done to sell the resulting proposals in planning. Moreover, visualization can only be an important tool if it is integrated early in the planning process.

Presently, digital image editing and virtual landscape simulators offer the most advanced visualization methods for the needs of forest planning. The advantages of landscape simulators include that the landscape illustrations are automised and that they offer flexible movement between different viewpoints. Furthermore, virtual landscape simulators are able to link images both with forest inventory data and with the planning systems of forestry and agriculture. However, participatory planning calls for more realistic illustrations as well as integration with different sources of spatial data, real-time movement in the landscape and high interactivity. In addition, a good visualization tool illustrates the changes in the environment in a realistic manner both from the near and the distance. While many of these properties exist in current landscape simulators, they are not at present all incorporated in the same program. However, computer graphics systems are under rapid development.

Often the areas which are of main interest for landscape visualization are visually sensitive areas: urban forests, recreation areas, national parks, and other scenic environments. In such landscapes the illustration of details (e.g. the special shapes of trees and the spatial variation of undervegetation) remains very important. Detailed illustration is also necessary when the respondents are familiar with the environment, as the case is in urban forests. So far original or manipulated photographs are the best means of visualization -in particular when assessing visual impacts of forest management on close-ups with their special features.

There are technical problems in the visualization of landscape change and methodological problems in the evaluation of landscape beauty and lack of clarity in integrating the visual aspects in the planning process. For example because of the limited resources available in forest inventory, forest data do not have the details and richness, i.e. information on forest edges, undervegetation, individual big trees and their shapes, required if we are to create realistic images. One solution is to use mixed techniques. For example, illustrations could be produced by forest simulators and edited by image editing technique or using techniques such as image draping available in GIS.

The future prospects for landscape visualization in forest planning include a use of virtual reality techniques with multi-stimulus representations of landscapes. Nevertheless, it must be remembered that even at its best the visualization of the landscape cannot fully convey the real landscape experience. Illustrations are an additional tool and not replace the field work in environmental planning. Moreover, additional research is needed to evaluate and compare the usability of different visualization media in rural land-use planning.

Vantaa, Finland 10th March 2000.

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Sub-Plenary Session: B1

Forests and Society Needs:

Wood Products

Coordinators:

Bob Youngs
John Youngquist

The Social and Economic Impacts of Plantation Forests

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Abstract

The rapid increase of plantation forests is an important phenomenon. Fifty years ago plantation forests for wood production were quite rare. Most regeneration was natural, not planted. Since that time planted forests have become common throughout much of North and South America, the Nordic countries, and increasingly in parts of Asia. The onset of industrial forest plantations as a major component in the world's industrial wood supply can probably be dated from about the 1960s.

Planted forests now account for an estimated 34 percent of the world's industrial wood production . The portion coming from planted forests will certainly increase over the next few decades as more natural forestlands are set aside for environmental purposes and harvesting restrictions become increasingly stringent, thereby driving up the costs of wood from natural forests. Thus, the economic advantages of forests, which are planted in desirable, accessible locations, and in selected species will become increasingly attractive vis-a-vis wood obtained from natural forests and difficult sites in marginally accessible areas.

The social and economic impacts of plantation forests become increasingly important as the contribution of plantation forests to the timber supply continues to grow.

Keywords : Forest plantation, Social and economic impact.

Introduction

The rapid increase of plantation forests is an important phenomenon. It represents a fundamentally different way of providing for society's wood needs. The gathering of the bounty of the natural system is gradually being replaced by the introduction of an agricultural mode into wood production. Fifty years ago plantation forests for wood production were quite rare in most of the world; parts of Europe and Japan might have been the exceptions. While some forms of forest management were commonly practiced, most regeneration was natural, not planted. Since that time planted forests have become common throughout much of North and South America, the Nordic countries, and increasingly in parts of Asia. In earlier work I have argued that the onset of industrial forest plantations as a major component in the much of the world's industrial wood supply can probably be dated from about the 1960s.

Planted forests now account for an estimated 34 percent of the world's industrial wood production (Table 1). The portion coming from planted forests will certainly increase over the next few decades as more natural forestlands are set aside for environmental purposes and harvesting restrictions become increasingly stringent, thereby driving up the costs of wood from natural forests. Thus, the economic advantages of forest, which are planted in desirable, accessible locations, and in selected species will become increasingly attractive vis-a-vis wood obtained from natural forests and difficult sites in marginally accessible areas.

This paper examines the social and economic impacts of plantation forests. Although the literature on this topic is small, some studies touch on aspects of this situation and there are anecdotal events that provide some insights.

Overview

Figure 1 provides a long-term overview of the changes in forestry. For millenia humanity relied on the production of nature to meet its wood needs. Although there is evidence of some tree planting and silviculture back to the B.C. period, tree planting for wood products probably was not common on a larger scale until after 1800, and then only in parts of Europe. However, in the latter part of the 20th century things changed dramatically. Planting began in earnest after WW II and especially after 1960. The 1950s saw large-scale tree planting in Japan, restoring much of the forest that was depleted during the war. The Nordic countries also became active in tree planting as they recognized that lands abandoned by agriculture had substantial tree planting potential.

The late 1950s saw major tree planting in the U.S., precipitated by excessive agricultural production, through a program to take lands out of agriculture. However, by the mid-1970s, large scale planting was underway driven not by government programs, but by market forces. The 1970s and 1980s saw the intensity of the planting increase and move to a variety of new countries including Brazil, Chile, Argentina and Colombia in Latin America, as well as New Zealand, South Africa, Indonesia, Malaysia, the Philippines, China, and elsewhere. Much, but not all, of the activity was focused on industrial wood products. For example, both China and South Korean had large programs driven by protection and environmental objectives.

Most of this activity was in terms of fairly large-scale operations. Much of it was financed, at least in part, by government. Much of the tree planting occurs in government forests and incentive programs for tree planting on non-government lands are common worldwide.

Table 1. Global Harvests by Forest Management Condition

Forest Situation	**Percent of Global Industrial Wood Harvest**
- Old-growth	22
- Second-growth, minimal management	14
- Indigenous second-growth, managed	30
- Industrial plantations, indigenous	24
- Industrial plantations, exotic	10

Source: Sedjo (1999)[1].

Figure 1. Transitions In Forest Management and Harvests

Type	**Period**
Wild forests	10,000 BC - current
Managed forests	100 BC - current
Planted forests	1800 - current
Planted, Intensively managed	1960 - current
Planted, Superior trees, Traditional breeding	
techniques	**1970 - current**
Planted, Superior trees, Genetic modification	1999? - future

[1] This estimate has been revised to reflect the dramatic demise of Russian timber production.

These range from some programs, such as those that were once common in Brazil, that provide most of their benefits for large corporations and land holders, to the programs once common in New Zealand (but now discontinued), which provide subsidies to all tree planting. There are also some programs aimed at smaller wood lot owners. These include small-owner programs in Finland, the US South, as well as small-owner eucalyptus planting in Thailand.

Overarching Economic Impacts

There is no question but that the economics of plantation forestry are becoming more favorable through time. Clearly the competitive position of the forest plantation countries is improving, especially those with intensively managed, rapidly growing forests, compared to that of the countries producing from primary and secondary growth stands. As noted above, the availability of timber from natural forests is diminishing relatively, not so much from excess harvesting, but rather due to policy changes. It has been estimated that about 50 percent of the world's forests, most of it primary and old-growth forests, is inaccessible for harvesting under current conditions. Additional protection from harvesting is being provided through the creation of new set-aside and protected areas. Furthermore, forest management practices codes are becoming more stringent. For example, it is estimated that the new code in British Colombia adds 50 percent to harvest costs.

In the U.S. harvests from National Forests are less than 20 percent of what they were one decade ago. All of this raises the costs of wood from natural forests and improves the economic advantage of planted forests. Additionally, innovations in planted forest establishment, harvesting and biological stocking have improved the economics of planted forests. Thus, we observe that tree planting worldwide is estimated to be near 10 million ha annually, much of it in the establishment of new planted forests. In a study I undertook two decades ago (Sedjo 1983), I showed that the economic returns to plantations were very favorable *in some regions of the world.* Over the ensuing 20 years these areas have exhibited large increases in planting and wood production. Some, like Brazil, have progressed to be one of the world's leaders in pulp production (Sedjo 1999a). For many other of these countries forestry has become very important. These include New Zealand, which is exporting sawnwood; South Africa, a producer of pulp and paper; and Chile, which is producing both solidwood and pulp products for world markets. Today, Uruguay is moving ahead with the large establishment of plantations and is intent on becoming a major producer and Argentina is gradually shifting from meeting its wood needs from native forests to relying on plantation wood.

Thus, planted forests are fulfilling an important economic need in providing readily available industrial wood without large costs and price increases.

Additionally, they are providing a desired social function by deflecting some of the logging pressure away from fragile natural forests to planted forests, where their environmental impact is small. Finally, since plantations are established only on low productivity agricultural lands, plantation establishment does generally not require the destruction of natural forests.

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Plantation Impact on Local Communities

Concern is often expressed about the impact of plantations on local communities, especially when large external firms enter the region. From the perspective of the community, the large firms often invest large amounts of capital, some of which results in the creation of local employment and wealth. However, where external funds are provided, most of the proceeds to this investment are withdrawn from the community. Thus the local community experiences some positive effects but also some negative effects. Furthermore, within the local community there are likely to be winners and losers. Owners of land have the potential to benefit. However, users of land, such as sharecroppers and users of common property resources are likely to lose their use rights and may be disadvantaged.

Local labor may be benefited or disadvantaged depending on what the new industry does to overall labor and the demand for specialized labor skills.

I know of no systematic study that has tried to objectively assess the impact of the establishment of a forest plantation on the local community and its economy. Nevertheless, we do have some related and anecdotal information. It is clear that planted forests employ workers from the local community. Planting, management and harvesting require human services, as is transport to a processing facility or shipping point. Where large forest resources are present, wood processing facilities are commonly introduced. Sawmills, veneer mills and other processing facilities are common. Many of these activities can be undertaken on a small scale thereby often providing product for the local community while generating employment in the wood-processing industry. Additionally, of course, large-scale pulp and paper mills are associated with planted forests. These however, tend to be capital intensive and utilize relatively little labor.

Where the forestland and timber are owned by local people, the economic benefits accrue to the local owners and the community as stumpage payments (rents). Thus, planted forests surely generate local employment in forestry and related activities. Also, wood payments to local wood lot owners can add income to the local economy.

In some regions, such as the US South, forestry has been an activity that occupied farmers during the year when agriculture was slow, e.g., period other than agricultural planing and harvesting. In these situations, much of the agricultural equipment was adapted to forestry (Sedjo 1999b). Forestry, in this context, provided additional income and employment to the community, especially during periods of low economic activity in the major industry. This situation probably continues to persist in parts of the south where agriculture and forestry are both important economic activities. However, as plantation forestry becomes more specialized, the skills and equipment of the average farm worker will become less relevant.

How prevalent is the situation where agriculture and forestry coexist on fairly large scales in countries in which plantations have recently been established, e.g., South America or New Zealand, has not been systematically assessed. However, such a situation appears feasible.

A different type of situation has existed in northern Sweden. There, much of agriculture is not viable. Investments were made in mechanization so as to provide incentives in the form of high wages so that labor would remain in this region and not be drawn off to high paying urban employment. The government and the industry worked together to develop equipment appropriate to the task, and especially appropriate to loggers (Sedjo 1999b). Such an approach, however, is likely to be less viable in many of the regions where new plantations are being established, since many are in regions with plentiful low wage labor.

In some regions, however, forestry has replaced agriculture, e.g., Chile and New Zealand. Although this could be viewed as employment and income reducing, this need not be the case. In New Zealand, for example, forestry has replaced sheep paddies in many parts of the country. This shift was precipitated by the withdrawal of subsidies on sheep after a permanent decline in sheep prices worldwide. Thus, forestry proved to be a “godsend” in that it provided an alternative economic use of the land and human resources that were displaced from their earlier use. In Chile, the agricultural land converted to forestry was very marginal, thus its opportunity cost was low and it could readily be converted to forestry. Although, again, I know of no overall assessment, it is clear that the economic activity in the forest plantation region of the country is very substantial, and much greater than when the earlier agricultural regime prevailed.

There have been problems in some places, however. In coastal Brazil, there is concern that plantation forestry is displacing agricultural families and generating local hardship. And pressure is being directed to limit the areas established in plantations. In some regions, tropical forests, de facto, are being converted to plantations. Concerns have been expressed about the situation of indigenous peoples and the local community.

Conclusions

Like other changes in land use and economic activity, plantation forests have effects on the society in which they operate. Often, the influence has been positive, providing employment and income in regions where earlier economic activities are no longer viable. In many cases the nature of the plantation forests is significantly altered to adapt to local conditions including labor and capital availability.

However, where the land ownership is external to the region the impacts may be muted in that the land rents are transferred out of the region. Nevertheless, if the capital required for the plantation is imported and/or processing facilities are introduced to complement the forest resource base, net economic benefits probably accrue to the local community.

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Plantations For Fuelwood Production

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Abstract

The aims of this paper are 1) to understand the production and consumption of fuelwood over the world and the need of plantations for fuelwood production, and 2) to estimate the amount of CO_2 absorption by the world's forests and 3) to provide status of fuelwood plantation and forest biomass with its contribution to CO_2 absorption in Korea. In 1995 world fuelwood consumption was amounted to 1.7 billion m^3. India, the Peoples' Republic of China, Brazil and Indonesia – all developing countries with large population – had occupied the highest shares. Tropical regions accounted for three quarters of both production and consumption of world fuelwood and charcoal in 1994. By 2000, deficit amount of fuelwood production was expected about one billion m^3; 500 million m^3 in Asia, 300 million m^3 in Africa, 140 million m^3 in Latin America and 60 million m^3 in other countries. To meet the deficit, about 25 to 105 million ha of fuelwood plantation is required in developing region for the next 10 years. The total amounts of CO_2 absorbed by world's forests (above-ground biomass only) and its annual growth were 226.3 billion tons and 16.3 billion tons, respectively. In Korea, the total and annual CO_2 absorptions in the forests were 516.8 million tons and 37.2 million tons in 1990, respectively. Present biomass of forest in Korea was estimated at 317 million tons with 22 million tons of annual growth.

Keywords: Fuelwood, CO_2 Absorption, Biomass, Plantation

Introduction

Global warming and climate change have become a serious threat to the survival of biological organisms and the well-being of people around the world. The world's forests are habitat for diversity of life and yet they are increasingly suffering from human-induced stresses such as industrial pollution, large-scale clearing and land use changes for agricultural and urban development. Global warming poses an additional threat to the forests. According to the United Nations' Intergovernmental Panel on Climate Change (IPCC) in 1996, the most likely cause of warmer temperature is increased concentrations of greenhouse gases in the atmosphere. Depending largely on limited, non-renewable energy such as fossil fuels around the world adds significantly to the build-up of greenhouse gases. The main greenhouse gases are CO_2, CH_4, N_2O and CFC, of which CO_2 is the biggest contributor to global warming.

It is estimated that 76 percent of the CO_2 emissions are the result of fossil fuel combustion. Tropical deforestation and forest degradation account for an estimated 23 percent and the remaining 1 percent comes from cement manufacture (Food and Agriculture Organization of the United Nations; FAO 1997). Therefore, controlling the burning of fossil fuels and conservation or creation of forests as sinks of CO_2 can both contribute to reducing CO_2 emissions and mitigate climate change.

Much effort is being proposed to reduce CO_2 emissions and various forestry-based strategies have been carried out. Reforestation schemes, reduction of carbon tax by plantation, fuelwood plantation and substitution with alternative renewable energy sources have been suggested as strong ways of reducing carbon emissions. In this regard, the use of biomass energy in efficient and sustainable manner can offer many advantages for the environment and the economy. The potential of biomass as a renewable green source of energy has been widely studied as a means of mitigating global warming. Besides, biomass production is used diversely from immediate serve for food and medicines to socio-economic purposes (van Gelder and O'Keefe 1995).

The aims of this paper were to understand the production and consumption of fuelwood over the world and the need of plantations for fuelwood production, and to estimate the amount of CO_2 absorption by the world's forests. Status of fuelwood plantation and forest biomass with its contribution to CO_2 absorption in Korea was also provided.

Change in the World's Forest

According to FAO, the world's forest area was 3,454 million ha, covering about 27 percent of the earth's land surface. Of these, closed forests covered 2,858 million ha, comprising about 83 percent of the world's forest. However, between 1980 and 1995, the extent of the world's forests decreased by some 56,000,000 hectares (Table 1). Tropical forests covered nearly 50 percent of the world's forest, but they are disappearing by 12,600,000 ha per year during the recent years.

Table 1. Change in forest cover during 1990-95 (FAO 1997)

	Total forest in 1990 (10^3 ha)	Total forest in 1995 (10^3 ha)	Total change in 1990-95 (10^3 ha)	Annual change (10^3 ha)	Annual change rate
World	3,510,728	3,454,382	-56,346	-11,269	-0.3%
Total tropical area	1,796,927	1,733,959	-62,968	-12,594	-0.7%
Asia	490,812	474,172	-16,640	-3,328	-0.7%
Tropical Asia	295,041	279,766	-15,275	-3,055	-1.1%
Africa	538,978	520,237	-18,741	-3,748	-0.7%
Tropical Africa	523,376	504,901	-18,475	-3,695	-0.7%
North and Central America	537,898	536,529	-1,369	-272	-0.1%
Tropical North and Central America	84,628	79,443	-5,185	-1,037	-1.3%
South America	894,466	870,594	-23,872	-4,774	-0.5%
Tropical South America	851,223	827,946	-23,277	-4,655	-0.6%
Europe	144,044	145,988	1,944	389	0.3%
Former USSR	813,381	816,167	2,786	557	0.1%
Oceania	91,149	90,695	-454	-91	-0.1%
Tropical Oceania	42,659	41,903	-756	-151	-0.4%

The significance is that large-scale deforestation occurs in most developing countries, particularly in tropical Asia and Central America, showing the highest loss at an annual rate of over 1 percent. Currently, the world's forests are estimated to be net sources of CO_2 primarily due to deforestation and forest degradation in the tropics. Conservation of forests from deforestation and forest degradation in the tropics would reduce the current CO_2 emissions substantially and would also reduce the release of other greenhouse gases. The IPCC estimates that about 12 – 15 percent of the projected CO_2 emissions from fossil fuel consumption from now until 2050 could be offset by slowing deforestation, promoting forest regeneration and increasing the area in plantations and agroforestry systems.

Status of World Fuelwood Production and Consumption

Fuelwood production over the world showed continuously stable trend after sharp drop in 1985. This was resulted from improving energy efficiency and replacement of energy sources in industrialized nations from wood to fossil fuels such as oil, gas and electricity. Korea showed substantial downward in fuelwood production, while the most developing countries and tropical countries did continuous upward in recent years (Table 2).

In its proportion rate per total roundwood production, most developing countries in Africa, Asia and Latin America showed much higher share than that of developed countries (Table 3). Comparing production and consumption patterns in tropical vs. non-tropical countries, tropical regions accounted for three quarters of both production and consumption of fuelwood and charcoal in 1994. By contrast, they accounted for only 17 percent of production and 20 percent of consumption of industrial roundwood.

Global consumption of wood reached almost 3,400 million m^3 in 1994. Nearly half of the consumption was used for fuelwood, and the rest for a variety of industrial purposes. Over the last 30 years, fuelwood consumption expanded more rapidly than industrial roundwood consumption, growing by 60 percent to 1,707 million m^3 in 1995, while industrial roundwood consumption grew by 15 percent to almost 1,500 million m^3 (FAO 1997). Considering current growth rate of fuelwood consumption over the world, the amount of fuelwood consumption in 2010 is estimated at 2,487.7 million m^3. In response to increasing demand of fuelwood in near future, creation or enhancement of fuelwood plantation should be encouraged, particularly in developing regions.

Table 2. World fuelwood production (10^3 m^3) (FAO 1997)

	1980	1985	1990	1995
World	2,349,828	1,553,090	1,659,659	1,707,329
Asia	656,932	721,352	791,566	859,867
Bangladesh	3,345	94,933	28,538	30,739
Bhutan	1,068	7,649	1,360	1,463
Cambodia	4,225	6,864	5,654	6,518
China	154,651	104,571	188,477	203,999
India	192,397	208,034	237,625	259,470
Indonesia	114,878	127,339	139,119	150,267
Japan	361	325	103	500
Korea DPR.	3,650	1,750	3,941	4,127
Korea Rep.	4,535	1,598	2,051	394
Laos	2,422	2,716	3,175	3,689
Malaysia	4,861	5,537	6,319	7,113
Myanmar	14,431	16,019	17,645	19,246
Nepal	13,269	15,091	17,152	19,591
Philippines	25,863	29,263	32,535	36,314
Sri Lanka	7,902	8,563	9,095	9,739
Thailand	25,900	28,345	30,813	32,289
Viet Nam	21,957	24,486	27,262	30,166
Africa	289,159	333,917	382,147	443,227
Central America	41,138	46,140	51,129	54,614
Europe	48,824	55,559	48,541	82,820
North America	92,740	104,408	89,069	95,681
Oceania	66,313	8,536	8,552	8,552
South America	158,558	175,274	173,251	162,827

Population and income are considered as the major factors influencing the consumption and production of wood. Consumption usually rises with an increase in both population and income. However, in the case of fuelwood, an increase in income tends to lower consumption. In developing countries, the growth rate of fuelwood consumption is nearly equal to that of population. Table 4 shows continuous increase in fuelwood consumption of Asian countries. Particularly, four countries lead fuelwood consumption, which are in developing world with large population; India was the largest consumer with 226 million m^3 per year, China with 174 million m^3, Brazil with 172 m^3 and Indonesia with 129 m^3 (Table 5).

Needs for Fuelwood Plantation and its Contribution to CO_2 Absorption Over the World

People rely more on biomass than on all hydroelectric dams and nuclear fuel plants as their main source of energy for cooking and heating in the world combined. Estimates suggest that the number of people relying on wood fuel will increase to 3 billion by 2000. Among theses, perhaps 100 million users face fuel shortages as supplies of wood fuels dwindle. By 2000, deficit amount of global fuelwood production is estimated at one billion m^3; 500 million m^3 in Asia, 300 million m^3 in Africa, 140 million m^3 in Latin America and 60 million m^3 in other countries. To meet the deficit, about 25 to 105 million ha of fuelwood plantation is required in developing region during the next 10 years (German Bundestag 1990). In response, various approaches are being proposed to ensure sustainable supply of fuelwood and to identify alternative renewable energy sources. Creation of global biomass reserves through fuelwood plantations can provide opportunities principally in environmental and economic aspects.

Table 3. Fuelwood production, consumption and growth rate in the world (German Bundestag 1990)

	Fuelwood production in 1988 ($10^6 m^3$)	% of total roundwood production	Growth rate(%) of fuelwood production in 1980~1988	Fuelwood consumption in 1988 ($10^6 m^3$)	% of total roundwood consumption	Growth rate(%) of fuelwood consumption in 1980~1988
World	1,784.2	52	2.2	1,782.5	52	1.6
Africa	434.4	89	2.3	421.7	91	3.3
Asia & Oceania	797.6	73	2.2	789.5	70	2.0
Central & South America	277.3	72	2.2	278.3	73	2.4
North America	121.2	17	2.3	123.2	18	16.6
Europe	55.5	16	2.1	57.0	15	1.0
F. USSR	86.2	22	1.3	85.4	23	0.5

Table 4. Change in fuelwood consumption (10^3 m^3) in Asia during 1980 – 1994 (FAO 1997)

	1980	1985	1990	1994
Asia Total	635,589	711,386	787,590	850,574
South Asia	263,462	295,404	328,938	357,036
Bangladesh	22,936	25,620	28,110	30,620
Bhutan	1,029	1,137	1,277	1,334
India	201,921	225,141	249,274	269,157
Nepal	13,728	15,670	17,758	19,692
Pakistan	16,666	20,024	24,166	27,423
Sri Lanka	7,182	7,812	8,353	8,809
Southeast Asia	217,476	245,267	270,175	289,615
Cambodia	4,161	4,917	5,749	6,484
Indonesia	115,250	127,796	139,424	147,849
Laos	2,962	3,322	3,883	4,381
Malaysia	6,589	7,894	8,925	9,491
Myanmar	14,431	16,020	17,840	19,931
Philippines	25,857	29,290	32,562	35,530
Thailand	28,782	31,538	34,532	36,188
Vietnam	19,444	24,490	27,260	29,761
China	154,651	170,715	188,477	203,923

Table 5. The world's main fuelwood consumers in 1986 (German Bundestag 1990)

Country	Fuelwood consumption (10^6 m^3)	Country	Fuelwood consumption (10^6 m^3)
India	226	Philippines	30
China	174	Zaire	29
Brazil	172	Bangladesh	27
Indonesia	129	Tanzania	22
USA	102	Vietnam	22
Nigeria	91	Pakistan	20
Russia	87	Sudan	18
Ethiopia	37	Burma	16
Kenya	32	Nepal	16
Thailand	32	Columbia	15
Total	…..1,680		

Furthermore, it is considered as a practical application for enhancing CO_2 fixation capacity over the world and for reducing CO_2 emissions from burning of fossil fuels. Recent estimation suggested that CO_2 emission in the atmosphere generated from tropical deforestation was 1.5±1.0 billion tons and CO_2 emission from combustion of fossil fuel was 5.3±0.5 billion tons in 1980 (German Bundestag 1990). Based on the growing stock of the world's forests for 277,670 million m^3, biomass of the world's forests was estimated at 138,835 million m^3, which was calculated by multiplying growing stock by the estimated value of dry-specific gravity of tree species, 0.5. World's forests contained 226,301 million tons of CO_2 and absorbed 16,291 million tons per year, with 11,843 million tons of O_2 emission per year (Table 6).

Status of Fuelwood Plantation in Korea

In Korea, forests cover 6.4 million ha, which is about 65 percent of total land area. However, forests have been severely degraded during the Japanese colonization from 1910 to 1945 and Korean War from 1950 to 1953. The predominant causes for the forest loss were coming from large-scale clearing of forests and exploitation of forest resources for food and fuel. Besides, substantial amount of fuelwood was required for house heating in winter season. In response to critical demand of wood for fuel energy in local communities, Korean Government implemented massive plantation plan with some fast-growing trees during 1960s to 1970s. Of the total forestland areas, 30 percent is man-made plantation. This has greatly contributed to the fuelwood supply and to expansion of forests as carbon sinks (Table 7).

In the past, fuelwood supply for cooking and heating at the rural households was the very important function of the forests. The Government initiated national fuelwood plantation in 1945 at the end of Japanese colonization but halted at the start of the Korean War in 1950. Large-scale plantation was actually implemented from 1959. The target area was 1.2 million ha and at 0.5 ha of planted area per household enough for 2.4 million households in rural areas.

Table 6. Amount of CO_2 absorption and O_2 emission by forests and their annual growth in 1988 (German Bundestag 1990)

	Growing stock (10^6 m^3)	Growing stock (m^3/ha)	Biomass (10^6 tons)	CO_2 absorption (10^6 tons)	O_2 emission (10^6 tons)	Annual CO_2 absorption (10^6 tons)	Annual O_2 emission (10^6 tons)
World	277,670.0	77.1	138,835.0	226,301.1	164,519.5	16,290.8	11,843.3
Africa	38,790.0	54.9	19,395.0	31,613.9	22,983.1	3,161.4	2,298.3
Asia & Oceania	31,475.0	55.4	15,737.5	25,652.1	18,648.9	2,565.2	1,864.9
Central & South America	78,637.0	83.8	39,318.5	64,089.2	46,592.4	6,408.9	4,659.2
North America	46,354.0	101.0	23,177.0	37,778.5	27,464.7	1,888.9	1,373.2
Europe	15,418.0	112.5	7,709.0	12,565.7	9,135.2	628.3	456.8
Former USSR	66,996.0	84.6	33,498.0	54,601.7	39,695.1	1,638.1	1,190.9

However, the accomplishment was far less than the target. Over 6 years of implementation, plantation was 420,000 ha. Thus, the Government modified the plantation area to 364,000 ha, about one third of the original target, to be reforested by 1967. In 1973, the first 10-year Forest Development Plan for Rehabilitation and Restoration was developed. With this plan, 207,000 ha of plantation was additionally created and total plantation area reached 643,000 ha by 1977 (Table 8). The plantation was continuously expanded year by year. During 1976 to 1977, 127,000 ha of plantation – 20 percent of total plantation area – was developed through IBRD loan of US$ 4.4 million (Korea Rural Economics Institute 1978). Fast-growing trees such as *Pinus rigida, Robinia pseudo-acacia, Alnus* species and *Quercus acutissima* were plantedmostly from 1962 to 1972 (Table 9).

Table 7. Forestland area and growing stock by year (Ministry of Agriculture and Forestry, Republic of Korea 1998)

Year	Area (10^3 ha)	Growing stock (10^3 m^3)	Growing stock (m^3/ha)
1960	6,700	63,995	9.55
1970	6,611	68,772	10.40
1980	6,567	145,694	22.18
1990	6,476	248,426	38.36
1997	6,441	340,824	52.91

Table 8. Area of fuelwood plantation (Song 1982)

Year	Area (ha)	
	Planned	Established
1959-1966	800,000	-
1967-1972	514,000	436,000
1973-1977	207,000	207,000
Total	1,521,000	643,000

Table 9. Plantation of major tree species for timber and/or fuelwood production (1962-1992) (Lee 1994)

Species	1962 – 1972		1973 – 1992	
	Planted trees (10^3)	Area (ha)	Planted trees (10^3)	Area (ha)
Quercus acutissima	78,232	26, 077	18,819	6,273
Pinus rigida	1,252,387	417,462	634,483	211,494
Robinia pseudo-acacia	1,244,070	414,690	333,250	111,083
Alnus spp.	372,081	124,027	482,564	160,521
Total	2,946,770	982,256	1,468,116	489,371

Forest Biomass and its Contribution to CO_2 Absorption

Forest biomass in Korea was estimated by measuring net absorption of CO_2 by the growth of biomass in the forest including roots. Present biomass and annual growth of biomass in the forest was estimated from with the sum of biomass in trees, saplings, shrubs, grasses and herbs. Biomass in each group of species was divided into stem, branch and root.

Biomass in tree stems was estimated by multiplying growing stock of different stands, excluding I-grade stands, with dry-specific gravity of *Pinus koraiensis* and *Quercus mongolica*, 0.44 and 0.80, respectively. As of 1990, present biomass in tree stems was estimated at 143,566,000 tons (dry weight tons) with annual growth of 9,083,000 tons. Using ratio of branches, branch volume rate per stem volume, biomass in tree branches was estimated by multiplying growing stock of different stands by dry-specific gravity of tree branches. Present biomass in tree branches was 40,525,000 tons with annual growth of 2,617,000 tons.

For the estimation of biomass in tree roots, dry weight of root was used. For conifers, 23.96 tons per ha of mean root dry weight was estimated from 18 – 55 year-old *Pinus koraiensis*. For broadleaves, 23.85 tons per ha of mean root dry weight from 20 year-old *Quercus mongolica*. Assuming annual growth rate of tree roots was the same as that of tree branches, biomass in tree roots was estimated by multiplying present biomass in tree roots with growth rate of stem dry weight. Present biomass in tree roots was 111,805,000 tons with annual growth of 7,694,000 tons.

For the estimation of biomass in saplings, stem volume and annual growth of saplings were estimated by multiplying volume and annual growth of 5 year-old saplings, indicated in the stand yield table, with I-grade stand area shown in the Statistical Yearbook of Forestry. Present biomass in sapling stems and its annual growth were 5,931,000 tons and 712,000 tons, respectively, which were estimated by multiplying stem volume and annual growth of saplings with dry-specific gravity of sapling stems.

Due to deficient research data on the volume of sapling branches in Korea, ratio of sapling branches was not measured. Instead, ratio of shrub branches multiplied by volume of sapling stems was used, assuming annual growth rate of saplings was same as that of shrubs. Present biomass in sapling branches was 1,883,000 tons with annual growth of 127,000 tons. Applying same calculation method for the estimation of biomass in tree roots, present biomass in sapling roots and its annual growth were 5,148,000 tons and 345,000 tons, respectively.

Assuming shrub biomass estimated from pine stands located in Kwangju-gun, Kyunggi-do and from broadleaved stands in Mt. Baekwoon, Chollanam-do, was mean value of biomass in shrubs, present biomass in shrubs was 8,171,000 tons with annual growth of 2,164,000 tons. For the purpose of calculation, annual growth rate of stems and branches in shrubs in conifers was assumed at 17.6 percent, which was that of stems and branches of shrubs in broadleaved trees. Annual growth rate of shrub stems and branches was estimated by multiplying annual growth rate by with present biomass in shrub branches. Supposing leaves of shrub were newly grown every year, biomass in shrub roots and annual production measured in natural broadleaved forests of Mt. Baekwoon was applied. Estimation of biomass in herbs and grasses was based on the paper reported by Park (1986). However, his data were considered underestimation of its value. Supposing present biomass of herbs and grasses was same as annual growth of herbs and grasses, present biomass of herbs and grasses was 76,000 tons. Taken together, present forest biomass in Korea was estimated at 317,061,000 tons (Table 10) and annual growth of forest biomass was 22,818,000 tons (Table 11).

To produce 1g of biomass, forests absorbed 1.630g of CO_2 and released 1.185g of O_2 as of 1990. Total biomass, its annual growth and CO_2/carbon absorption in the forest were as follows: 516.8 million tons of CO_2 and 140.9 million tons of carbon absorbed by total biomass, and 37.2 million tons of CO_2 and 10.1 million tons of carbon by annual growth(Table 12).

Table 10. Total biomass in the forest (Korea Forestry Research Institute; KFRI 1996)

	Tree (10^3 tons)		Sapling (10^3 tons)		Shrub (10^3 tons)	Grass (10^3 tons)	Grand total (10^3 tons)
	Stem	Branch	Stem	Branch			
Above-ground	143,556	40,525	5,931	1,883	4,075	57	196,027
Roots	111,805	-	5,148	-	4,062	19	121,034
Total	255,361	40,525	11,079	1,883	8,137	76	317,061

Table 11. Total annual growth of biomass in the forest (KFRI 1996)

	Tree (10^3 tons)		Sapling (10^3 tons)		Shrub (10^3 tons)	Grass (10^3 tons)	Grand total (10^3 tons)
	Stem	Branch	Stem	….Branch			
Above-ground	9,083	2,617	712	127	1,448	57	14,044
Roots	7,694	-	345	-	716	19	8,774
Total	16,777	2,617	1,057	127	2,164	76	22,818

Table 12. Total biomass, its growth and CO_2/carbon absorption in the forest (KFRI 1996)

	Biomass (10^3 tons)	Absorption	
		CO_2 (10^3 tons)	Carbon (10^3 tons)
Present	317,061	516,809	140,948
Annual	22,818	37,193	10,144

Conclusion

World fuelwood production was 1,707,329,000 m^3 in 1995, showing stable trend after sharp drop in 1985. This was resulted from improving energy efficiency, replacement of energy sources in industrialized nations from wood to fossil fuels such as oil, gas and electricity, while fuelwood was still prevalent in most developing countries and tropical countries. Comparing production and consumption patterns in tropical vs. non-tropical countries, tropical regions accounted for three quarters of both production and consumption of fuelwood and charcoal in 1994. By contrast, they accounted for only 17 percent of production and 20 percent of consumption of industrial roundwood. World fuelwood consumption was the highest in four countries, which are in developing world with large population; India was the largest consumer with 226 million m^3 per year, China with 174 million m^3, Brasil with 172 m^3 and Indonesia with 129 m^3 as of 1986. As a whole, tropical countries in Africa, Asia and Latin America leaded fuelwood consumption. Considering increasing growth rate of fuelwood consumption in current years, fuelwood consumption in 2010 was estimated at 2,487.7 million m^3.

By 2000, deficit amount of fuelwood was estimated at one billion m^3, due primarily to massive consumption in developing countries with large population. To cope with such fuelwood demand, a development of 25 million to 105 million ha of fuelwood plantation is required in developing regions. In response, various approaches to ensure sustainable supply of fuelwood and to sequester greenhouse gas emissions are being made through sustainable forest management, reforestation and fuelwood plantation establishment. Growing stock of the world's forests was estimated at 277,670 million m^3 and biomass of the world's forests was estimated at 138,835 million m^3 in 1988. Estimation indicated world forests contained 226,301 million tons of CO_2 with 16,291 million tons of annual absorption.

In Korea, large-scale plantation was implemented by the Government during 1960s to 1970s and 643,000 ha of plantation was successfully achieved with some fast-growing trees including *Pinus rigida, Robinia pseudo-acacia, Alnus* species and *Quercus acutissima*. This has greatly contributed to fuelwood supply and to expansion of forests as carbon sinks. Today, this plantation is no longer supplying fuelwood due to replacement of alternative energy. CO_2 absorption of forests in Korea and its annual absorption were 516,809,000 tons and 37,193,000 tons, respectively. Present biomass of forest in Korea was estimated at 317,061,000 tons with 22,818,000 tons of annual growth.

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Plantation Grown Wood and the Environment

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Abstract

Although many of the issues raised about forest plantations are non-trivial, there are a number of significant environmental advantages of plantation establishment that appear to outweigh concerns, *if* plantation management practices can be developed to address concerns regarding sustainability. Foremost among the advantages is that establishment of highly productive forest plantations can provide large quantities of wood and fiber from relatively small land areas, raising the possibility that pressures for harvesting within natural forests can be markedly reduced. Moreover, assuming that forest plantations are carefully established and managed, they have the potential to produce a continuous, renewable stream of industrial raw materials that results in less overall environmental impact than other types of raw materials. Assessment of total environmental impacts over product life cycles show that structural and non-structural wood and wood fiber products made from plantation-derived raw material yield markedly lower impacts than similar products made from metals, cement, petroleum, or other raw materials. Similarly, examination of total environmental impacts of papermaking fiber production in forest plantations versus fiber production using annual agricultural crops shows significant advantages to wood fiber. Thus, forest plantations can yield environmental benefits that extend well beyond the geographic location in which they are located.

Keywords Environment, tree plantations, forest plantations, wood

Introduction

This paper examines the forest plantation balance sheet from an environmental perspective. Positive and negative aspects of plantation forests are identified and briefly examined. Particular attention is focused on life cycle impacts of wood production and use. Although given little attention in forest plantation literature to date, careful examination of environmental life cycle data for wood, and for materials that might be used as substitutes for wood, gives forest plantation establishment a new imperative.

The term "forest plantations" is widely used to describe 1) natural forests in which regeneration following selective harvest has been accomplished by planting seedlings of native, genetically modified, or exotic species, 2) native forests in which enrichment planting has been done, 3) secondary forests that have been planted, usually in rows, using native, genetically modified, or exotic species following clearing of natural forests, and 4) forests that have been planted on savannahs or degraded lands following mining or agriculture. Remarks herein focus primarily on plantations as described in 3) and 4) above.

Why Plantations?

Rising Raw Material Needs

One of the most compelling reasons for establishment of forest plantations is that consumption of industrial wood and wood for cooking and heating is rising steadily at the same time that efforts to reduce harvesting in natural forests are also increasing (Sutton 1999). As long ago as the 1960s Marsh (1962) observed that "natural forests grow too slowly to meet bulk forest products demands." In the decade of the '90s, the specter of record population growth led many to take note of rising demand for forest-derived resources. Lyons (1993), for example, observed that "large increases in demand for wood and fiber are coming by 2010." A year earlier, Leslie (1992) had suggested that the forest plantation area would "have to be increased by 30 percent in the immediate future" in order to meet needs for fuelwood and industrial wood. Given the plantation area in existence at the time (approximately 100 million ha), Leslie's suggestion translated to a global need for new plantations covering an additional 30 million ha. These estimates were followed by a stunning conclusion reached by the World Energy Council (1995) which indicated that between 700 million and 1350 million ha of land will be needed for biomass energy production by 2050. This figure implies a need for as much as a seven- to thirteen-fold increase in global forest plantation area, excluding what might be needed to provide increased volumes of wood for industrial uses. If these estimates did not in themselves provide a strong case for substantial forest plantation establishment, projected impacts of the current movement toward certification of managed forests would seem to suggest a mandate for increased plantation investment. For instance, one of several studies of the impact of certification (Lundstrom et al. 1997) suggests a decrease in long-term timber supply of 12-15 percent if Forest Stewardship Council management guidelines are applied to managed Swedish forests. Together, these kinds of estimates have served to greatly intensify interest in forest plantations.

Forest plantations are typically highly productive as compared to natural forests. Evans (1992) reported that plantations often produce 10 m^3 of wood/ha annually, that wood yields of 20-25 m^3/ha/yr are not uncommon, and that annual yields as high as 45 to 60 m^3 have been attained with some hardwood species. Sedjo (1999), using figures adapted from Clapp (1993), cites annual plantation yields averaging 10-40 m^3/ha, with some values as high as 70 m^3 ha. High plantation productivity has been well documented by many others (Hakkila 1994, Pandey 1995, Sedjo 1999, Steen 1997, Tiarks et al. 1998). In contrast to plantations, natural tropical moist forest commonly yields 1 to 2 m^3 /ha annually, which can be increased to perhaps 6 m^3/ha with management (Wyatt-Smith 1987); similar yields are recorded for natural forests in temperate regions (Sedjo 1999). Yields of up to 15 m^3/ha are reportedly attained in some types of managed dipterocarp forests (Wyatt-Smith 1987).

Restoration of Degraded Land

Land degradation as an impetus for forest plantation development is not unique to the tropics. Unsustainable agricultural practices in parts of the southern United States in the early 1900s, for example, led to establishment of large areas of tree plantations in the 1930s (Schultz 1999).

Today, it is widely accepted that forest plantations have great potential for restoring degraded sites in the tropics (Evans 1999, Parrotta 1992, Sawyer 1993). Evans (1999) observes that such plantings can be "astonishingly successful." Brown et al. (1997) note that the profit potential of forest plantations provides opportunities and incentives for implementing intensive management techniques as well as initiation of site rehabilitation activities. Evans (1999) points out that forest plantations not only have future potential, but that tree planting to achieve soil erosion control, whether on steep hillsides or as part of shelterbelts to reduce wind erosion, is already widely practiced.

A Source of Minimal Impact Renewable Materials

The Carbon Sequestration Issue

It has long been recognized that liberation of carbon dioxide and other gaseous emissions, as a result of combustion of fossil fuels and other human activities, has the potential to warm the earth's atmosphere. This potential was formally recognized in 1997 in Kyoto, Japan at the United Nations Framework Convention on Climate Change. Also given formal recognition in Kyoto was the capacity of forests to capture carbon from the atmosphere and to store or sequester it for extended periods. The fact that forests can capture carbon from the earth's atmosphere has led to a number of initiatives to preserve existing forests and to create new forest plantations for the purpose of carbon storage. There are many examples of forest plantations having been created for this purpose.

It is widely acknowledged that stored carbon stocks increase rapidly when a forest is established on land that was previously not forested (Harmon et al. 1990, Marland and Schlamadinger 1999). As dry wood is 49 percent by weight carbon, substantial carbon storage accompanies the growth of trees and the accumulation of woody debris on the forest floor (Figure 1). Carbon accumulation appears to be more rapid when a portion of the wood harvested is used in long-lived products, as opposed to short-lived products such as paper.

Scientific evidence also indicates that a net loss of carbon over the short term may accompany plantation establishment when mature forest is cleared beforehand. In this case, stored carbon is liberated as standing trees are removed, and as decay processes in the soil and litter layer accelerate (Harmon et al. 1990, Marland and Schlamadinger 1999). A net short-term loss appears likely even when a portion of the harvested biomass is incorporated into long-lived products. Over the longer term, assuming efficient conversion of a portion of woody materials into long-lasting products, net storage gains occur after thirty to forty years, even when the planted forests are periodically harvested.

Although it is often assumed that trees grown to offset CO_2 emissions need then to be preserved in order to keep the CO_2 from returning to the atmosphere (Marland 1993), recent research shows that carbon storage can be significantly enhanced by periodic harvest of trees and their use in long-lived products. Marland and Schlamadinger (1999) list four ways in which forest growth, harvest, and subsequent use of harvested biomass can impact carbon storage: 1) Growing trees can capture carbon dioxide from the atmosphere and store carbon as woody biomass, 2) Carbon can be stored for long periods of time in long-lasting wood products, and in wood-derived products buried in landfills, 3) Liberation of carbon contained within fossil fuels can be prevented by generating energy from biofuels, and 4) Because the production and use of wood products is highly energy efficient compared to alternative products, such as those made of steel, concrete, or plastic, wood use avoids liberation of carbon that would result from increased energy consumption associated with alternative materials (Figure 2).

Figure 1. Cumulative in Carbon Stocks in Soil, Forest Litter, and Standing Trees after Afforestation

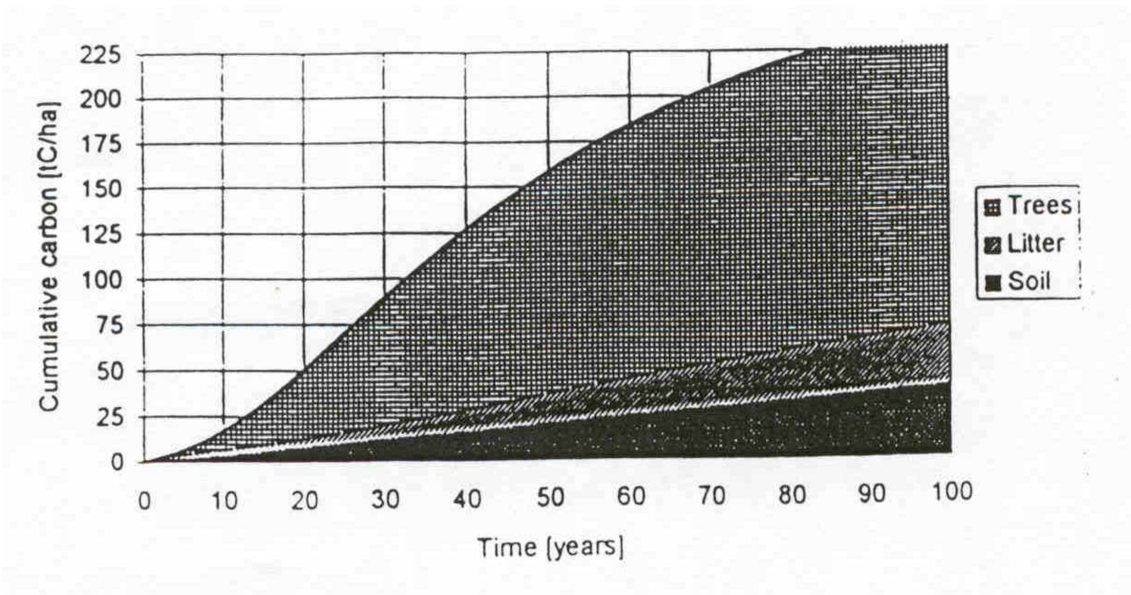
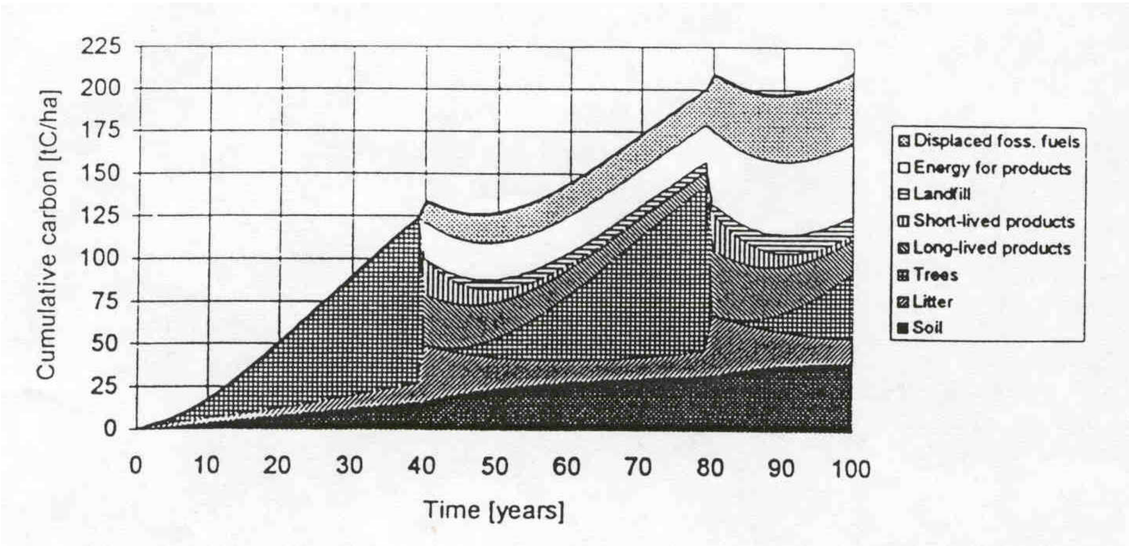


Figure 2: Cumulative Changes in Carbon Stocks with Afforestation and subsequent Harvest



Though not well understood, this latter point is extremely important, not only in terms of carbon liberation avoided, but from an overall environmental perspective as well. This topic is examined in more detail in the following section.

Environmental life cycle analysis (LCA) involves systematic examination of all environmental impacts associated with a given product. A thorough analysis considers impacts resulting from extraction, transportation, primary processing, conversion to semi-finished and finished products, installation, maintenance, and disposal or reuse. A key part of a life cycle analysis - the life cycle inventory (LCI) - examines all *measurable* raw material inputs, products and by-products, emissions, effluents, and wastes at all stages of extraction, production, use, and disposal.

Extensive LCA/LCI analyses have been completed since the mid 1970s, especially in western Europe, Canada, and Oceana. A few of these studies have examined wood and common substitute products; the results dramatically indicate the advantages of wood as an industrial material. Although a number of studies could be cited, findings from three recent analyses will be used to illustrate the environmental benefits of producing and using wood as a construction material.

Meil (1994) compared the manufacturing emissions and effluents associated with constructing a wood-framed, non-load bearing interior wall vs. a steel-framed, non-load bearing wall of the same dimensions. All effluents and emissions associated with all steps in the process were tracked, from forest harvest or mineral extraction, through to construction of the wall. The results demonstrate that selection of building materials can have very substantial environmental implications. Construction of the steel-framed wall was found to require 3.2 times more energy than construction of the wood-framed wall. Even larger differences were found in associated emissions and effluents (Table 1).

Table 1: Comparative Effluents and Emissions Associated with Constructing 90m^2 Wall Sections Using Wood vs. Steel Framing

Type of Emission/Effluent	**Wood Wall**	**Steel Wall**
CO_2 (g)	313,333	971,000
CO (g)	2,533	11,950
SO_2 (g)	370	3,694
NO_x (g)	1,011	1,575
Particulates (g)	187	591
Suspended solids (g)	12,180	495,640
Nonferrous metals (mg)	62	2,532
Cyanide (mg)	99	4,051
Phenols (mg)	17,715	725,994
Ammonia and Ammonium (mg)	1,310	53,665
Halogenated organics (mg)	507	20,758
Oil and grease (mg)	1,421	58,222
Sulfides (mg)	13	507
Iron (mg)	507	20,758

Another study by the Athena Sustainable Materials Institute (Canadian Wood Council 1997) examined energy consumption and CO_2 emissions in constructing a large office building. Three designs were evaluated: 1) a wood building (wood structural beams, wood cladding, wood-framed interior walls) on a concrete foundation, 2) a steel building (steel structural beams, steel cladding, steel-framed interior walls) on a concrete foundation, and 3) a concrete building (reinforced concrete beams, concrete panel exterior, concrete block interior walls on a concrete foundation. Differences in total energy use and carbon dioxide liberation associated with creating each building are shown in Table 2.

The environmental advantages favoring the use of wood in construction, as well as for other purposes, are many and substantial. In addition to the environmental advantages, wood is the only widely available industrial raw material that is renewable.

The inescapable conclusion to which LCI/LCA studies such as those referenced above lead is that assuming contemporary levels of efficiency in processing, and technically attainable durability in use, wood should be used to the greatest extent possible consistent with assurance of sustainability. As noted by Marland and Schlamadinger (1999), the greater the manufacturing efficiency and useful product life, the stronger the case for wood becomes. Thus, among the advantages of forest plantations managed to provide wood for long-lived products is vastly lower environmental impact per unit of industrial raw material produced.

A final point with respect to life cycle comparisons of various raw materials has to do with various options for producing papermaking materials. Paper production worldwide has soared in recent years, with production outstripping both population and GDP growth rates. This has served to stimulate interest in a variety of alternative papermaking materials, from agricultural crop residues, to agricultural crops planted specifically for the purpose of producing papermaking fiber. While the use of crop residues (in excess of those needed in sustainable farming) as papermaking raw material has long been practiced in many parts of the world and makes a great deal of sense, the specific planting of agricultural crops for this purpose is highly questionable from an environmental point of view. A recent analysis of the environmental impacts associated with papermaking fiber production using annual crops of kenaf, vs. fiber production in intensively managed tree plantations again suggested very significant advantages of wood fiber production (Bowyer 1997); differences in landscape impacts were particularly notable.

Table 2: Total Energy Use and Carbon Dioxide Emissions Associated with Constructing a Large Commercial Office Building of Different Materials

Construction	Total Energy Use[1]	Above Grade Energy Use[1]	CO_2 Emissions[2]
Wood	3.80	2.15	73
Steel	7.35	5.20	105
Concrete	5.50	3.70	132

1 GJ x 10^3
2 Kg x 10^3

Do Plantations Take Pressure Off Natural Forests?

There is disagreement about whether plantations take pressure off natural forests.

Perhaps the most pointed criticism of the natural-forest-saving role of plantations comes from Sargent (1992) who notes that production of large volumes of plantation wood will tend to drive down the price of wood in general, thereby stimulating demand for wood from plantations and natural forests alike. Mathur (1993) also suggested that plantations might do little to help protect natural forests, pointing out that production of wood is only one of many functions of natural forests. Ironically, Sargent's questioning of the environmental role of plantations is given credence by Lovejoy's observation regarding the potential impacts of a boycott of tropical timber (Lovejoy 1990). Lovejoy documented the findings of a workshop that included an assessment of the impact of a loss of timber demand on the value of natural forest. It was concluded that such a development would reduce the value of forests, making more likely a conversion to pasture or cropland. Following the same reasoning, should high wood production in forest plantations, in fact, result in reduced timber value, then the effect on forests could well be similar to that of a boycott.

The possibility for adverse impacts arising from timber demand shifts has led some to suggest that regulations and formal agreements may be needed to protect natural forests in conjunction with plantation establishment. Some, in fact, are now calling for the set-aside of vast areas of forest land in natural or non-managed reserves, with wood production shifted entirely to privately owned natural or modified forests or to intensively managed plantations. That is precisely the strategy that was pursued in both New Zealand and Australia as part of efforts to significantly increase the area of forest plantations.

Regarding the possibility of protection of natural forests as part of a plantation strategy, some authors have questioned whether seeking to abandon timber production in natural forests is a wise idea. More than 40 years ago Dawkins (1958), for example, wrote "Even where plantations are justified, it does not necessarily follow that all remaining naturally regenerated forests are best left unproductive. If they are, they may become vulnerable to destruction . . ."More recently, Sedjo and Botkin (1997), for example, gained a great deal of attention from the observation that we [society] could produce all the wood we want on very little land. Less noticed was their caution that it is not necessarily a good idea to prevent any harvesting in native forests. Whitmore (1999) echoed this theme, stating that although plantations can diminish pressure on native forests, the native forests should, nonetheless, continue to be managed extensively. Thus, the debate about whether forest plantations can take pressure off natural forests appears to have come full circle. An emerging view is that it would be a mistake to leave vast areas of natural forests in a non-managed state.

Environmental Issues Associated with Forest Plantations

Negative Impacts on Soil Moisture and Water Yield

Concerns about the impact of plantations on soil moisture and water yield are mostly related to apparent high transpiration rates and impacts on soil moisture depletion, increased moisture interception and evaporation at the canopy level, and reduced stream flow. Many references can be found in the literature to situations in which plantations have been established on pastureland, or on plots adjacent to land used for agriculture. Observations such as the following, from Calder et al. (1992) indicate great impact of plantations on site hydrology: "When eucalyptus is planted in areas where the roots have access to groundwater, as for example when planted next to irrigation canals, there is no doubt that growth rates are higher by a factor of at least five, and that water consumption is likely to be roughly commensurate."

Similar trends, although smaller in magnitude, have been reported in New Zealand in conjunction with establishment of pine plantations (Fahey and Rowe 1992, Fahey 1994). Schultz (1999) also reported reduced water yields from loblolly pine plantations in the U.S. It should be noted that all studies do not show that plantations reduce streamflow. Whitmore (1999) cites several studies that found either no change or higher stream flow associated with plantations as compared to other types of vegetative cover.

Erosion and Soil Degradation Resulting from Plantation Establishment

As noted by Whitmore (1999), the prospect of lowered yields as a result of site deterioration under intensive management of short-rotation tree crops has been a concern of foresters for decades. Recent literature suggests that this is still a major concern. Lai (1997), for example, expresses concerns about the effects of plantation establishment, pointing out that deforestation and change in land use associated with initiating plantation forests can lead to soil compaction, erosion, and depletion of soil organic matter, and thus degradation of physical and nutritional properties of soil. Evans (1992) observes that plantations tend to be kept in an early successional stage, with maximum removal of biomass from the site at harvest. He also reports that plantations are less efficient at trapping released nutrients, due in part to the existence of fewer roots near the surface. The result, he notes, may be significant nutrient loss from sites where trees are harvested. Binkley and Giardina (1997) strongly link a continued supply of soil nutrients to long term sustainability of high productivity in tropical plantations. They then note that rapid growth of tropical plantations leads to high rates of nutrient accumulation in biomass, and that harvesting at short rotation intervals removes large quantities of nutrients which may, over time, lead to depletion of soil fertility.

Will (1984), discussing the subject of monocultures in both temperate and tropical regions, indicated that where soil deterioration problems have occurred, poor forest management has usually been to blame. Lai (1997) said much the same thing, explaining that plantation forestry can lead to soil degradation as a result of soil or tree mismanagement, but that judicious soil and vegetation management can improve soil properties, minimize soil erosion risks, and enhance soil quality and productivity. He reports that growing leguminous crops in association with trees is a useful strategy for improving soil properties and controlling erosion. Evans (1999) has written extensively on the soil degradation question. Evans suggests that the evidence that has been gathered seems to indicate that productivity loss may not be as serious a problem as many have feared, and that instances of yield decline in the tropics and subtropics often reflect weed mismanagement or mismatching of species to site, rather than inherent shortcomings of plantation forestry practices.

Risks of Pests and Disease

One of the best discussions of the risks of pests and disease in natural versus plantation forests is found in a recent FAO Forestry Paper (Swedish Agency for Research Cooperation with Developing Countries 1992). On the one hand, it is noted that there are many documented instances of insects and disease causing extensive damage in natural forests, as well as an increasing number of examples of plantations that have been grown over many cutting cycles with few problems. The more than 100-year history of exotic rubber plantations in Malaysia is cited as one example of successful long-term plantation operation. On the other hand, a strong case is presented to support the contention that plantations, and particularly single species plantations, are at much greater risk to catastrophic insect and disease losses than are natural forests.

Strong criticism of even-aged, single species plantation forestry comes from Schultz (1999), who reports "Damage from pests and environmental stresses have become increasingly severe in [U.S.] southern pine forests over the past 50 years. This is principally the result of human changes in ecosystems from mixed species to rapidly growing even-aged stands of a single species such as loblolly pine. Research has shown that such development has altered many natural balances that previously kept pathogenic organisms in check in ecosystems." Perry and Maghembe (1989) and Widagda (1981) have expressed similar views.

There appears to be increasing recognition in the literature that the genetic base of a forest plantation is more important than the number of species that comprise it. Zobel and Talbert (1984) raised this issue, commenting that a monoculture established from rooted cuttings or clonal material would be at considerable risk over any extended time frame. In contrast, a plantation comprised of genetically diverse planting stock does not present great risk, even if composed of a single species.

As with other environmental concerns, many view pest and disease problems as due to factors other than use of exotic species or the planting of monocultures. Burdon (1982) listed four such factors: 1) inappropriate site choice, leading to stress-induced changes in the trees that increases their vulnerability to pests and diseases, 2) use of a poorly adapted seed source, 3) poor silvicultural practices, such as careless pruning and thinning, which can leave scarred live tissue open to infection, and 4) inadequate attention to nutrient and water requirements.

Impacts on Biodiversity

Hakkila (1994) describes plantations of the southern hemisphere and tropics as, in general, monocultures of introduced species that are of uniform size and spaced geometrically. Thus, he concludes, they are not capable of supporting biodiversity characteristics of native forests. Widagda (1981) also refers to complex versus simple structure within natural forests as a central reason for reduced biodiversity within plantations.

Few authors dispute that forest plantations support reduced levels of biodiversity than natural forest stands, but an increasing number challenge the contention that plantations necessarily have vastly lower biodiversity than surrounding native forests. Evans (1992) acknowledges that there is little diversity within individual plantation stands, but points out that production plantations usually consist of several age classes, with the result that the "forest" as a whole tends to contain different habitat types, such as open ground, areas of young trees, closed thickets and mature open stands. He explains that an additional source of habitat diversity within plantations is attributable to unplanted areas, including roads and tracks, gullies, rocky areas, and firebreaks that normally account for about one-fifth of the total plantation area.

Another part of the biodiversity debate involves the role that plantations play in restoring biodiversity to an impoverished landscape. Evans (1992) provided several examples of this, noting that planting of caribbean pine on poor savannas in Venezuela has led to a substantial increase in the deer population and the return of the jaguar, that planted cypress forests in Kenya and Tanzania are the home of thriving populations of the Sykes monkey, a species once driven to near extinction, and that the leopard is again found on the Nyika and Vipya plateaus of Malawi as a result of afforestation in these regions. Another study in the Canterbury plains area of New Zealand found the presence of many plant species that had been mostly absent prior to afforestation (Norton 1989).

Discussion and Summary

Were the human population small, and demands upon the world's resources negligible to modest, there likely would be few concerns about natural forests, and no forest plantations or even discussion of them. However, the population is anything but small, and population growth is dizzying. Moreover, consumption of natural resources is growing even more rapidly than population, and pressures on all of the world's natural systems, including forest ecosystems, are growing daily. Given this situation, concern about growing demands on the world's natural forests is certainly understandable. Understandable as well are concerns about development of vast plantations of often non-native tree species. Yet, at a time when it is increasingly obvious that bold initiatives are needed in order to balance the reality of human wants and needs with the necessity of protecting the environment, it is difficult to understand how one can realistically oppose *both* the exploitation of natural forests and development of forest plantations.

Despite environmental concerns and problems associated with the establishment and sustainable management of some forest plantations, the benefits that accrue from plantations of rapidly growing trees are so significant that further development of forest plantations is virtually assured. Benefits include high commodity production on relatively small land areas, vastly reduced overall environmental impact associated with wood production and use in comparison to available alternatives, and potential for concomitant restoration of degraded land areas and associated biodiversity.

To recognize the tremendous advantages of forest plantations or the inevitability of further development does not mean that environmental concerns linked to plantation development should be dismissed. Rather, it is to the advantage of everyone that forest plantations operate sustainably in every sense of the word, and that they provide the greatest possible array of benefits. In view of the size and recent growth of the forest plantation enterprise globally, and the nature of problems that have been encountered in conjunction with development and maintenance of some plantations, it is imperative that steps be taken to address known problem areas and concerns.

Recent findings suggest that many problems associated with plantation establishment and sustainability are traceable to poor planning and/or inadequate management. Research also indicates that questions about a number of issues do not yet have definitive answers. It is clear that great care will have to be taken in plantation management to ensure sustainable high-yield harvest over successive rotations. Given the scale of the emerging plantation enterprise, an aggressive and ongoing program of research should be given high priority.

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World View of Plantation Grown Wood[1]

by
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Abstract

The world's natural forests are under increasing pressure to meet demands for wood and fibre, while continuing to provide a vast array of environmental and social services. Future increases in demand for wood are likely to be met largely from forest plantations. This paper reviews the current extent of the global forest plantation resource, provides an assessment of the key wood production parameters (species, growth rates, rotation lengths), identifies a range of priority areas for future plantation research, and provides discussion and assessment of likely future wood supplies from plantation forests.

Keywords: Plantation forests, Resources, Wood production, Scenarios.

Introduction

Globally, the dominant trends for forest products are increasing demand for wood (resulting from increased populations and incomes) from diminishing, or more restricted, forest supply base. As forests are cleared, degraded, or withdrawn from production for conservation purposes or other reasons, the burden placed on the remaining production forest increases commensurately. Questions consequently arise as to the capacity of forests to continue to meet consumption demands, and these can only be answered by increasingly detailed analyses of sources of supply. During the past thirty years an evident decline in natural forest resources in a number of countries and the difficulties in accessing increasingly remote areas of natural forest available for wood supply, has resulted in an intensified focus on plantation forests. Plantations provide a potential means for alleviating potential future wood shortages and providing continuity of supply for existing industrial enterprises or household woodfuel needs.

Over the past several years FAO has intensified its efforts to quantify the potential extent of future wood supplies from forest plantations. Considerable effort has been applied towards collating and refining data on forest plantation areas, species, age-classes and yields. Nonetheless, the ideal of global plantation woodflow modelling being done with real precision remains elusive. Not only is much of the base national forest inventory data (area, age-class, increment, species, yield) incomplete, inaccurate, obsolete or otherwise unreliable in many countries, but many of the other key variables, for example, impacts of intensified management regimes, genetic gains from tree improvement programmes, and harvesting and processing technologies remain unmeasured or unreported. Data relating to qualitative change in forest resources and wood and fibre production are particularly scarce.

The data collection and refinement process is, however, ongoing and provisional data must necessarily be used in modelling to enable progress and key trends to be benchmarked and disseminated.

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[1] This paper represents the views of the authors and not necessarily those of the Food and Agriculture Organization of the United Nations.

Table 1: Estimated regional distribution of plantation forests in 1995

Country or region	Industrial plantation area (million ha.)	Non-industrial plantation area (million ha.)	Total plantation forest area (million ha.)
North America	**18.4**	**0**	**18.4**
United States	*18.4*	*0*	*18.4*
Central America	**0.5**	**0.3**	**0.8**
South America	**5.4**	**2.8**	**8.2**
Asia	**41.8**	**15.1**	**56.9**
China	*17.5*	*3.9*	*21.4*
India	*4.1*	*8.3*	*12.4*
Japan	*10.7*	*0*	*10.7*
Oceania	**2.7**	**0.01**	**2.7**
Africa	**3.6**	**2.2**	**5.7**
Europe	**8.7**	**0**	**8.7**
Former-USSR	**22.2**	**0**	**22.2**
Russian Federation	*17.1*	*0*	*17.1*
TOTAL	**103.3**	**20.4**	**123.7**

Sources: Pandey (1997), ECE-FAO (1998)

Current Plantation Forest Resources: Species and Areas

The Global Forest Resource Assessment 1990 estimated the world's total forest area to be 3.4 billion hectares with an additional 1.7 billion hectares classified as Other Wooded Land[1]

Plantation forests make up only a very small proportion of global forest area. It is estimated[2] that in 1995 the global area of plantation forests totalled 123.7 million hectares, approximately 3.5 percent of global forests.

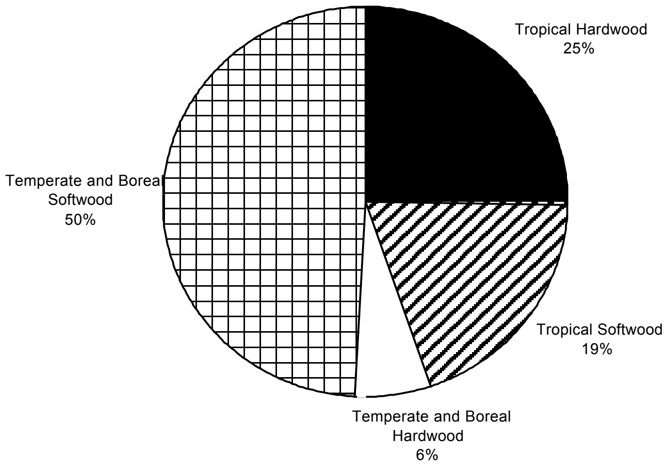
Table 1 shows that the Asian region has the largest proportion of plantation forests, with 45 percent of the total. More revealing is the dominance of a handful of countries in global plantation forest establishment. Five countries - China, United States, Russian Federation, India and Japan - have each established more than 10 million hectares of plantation forests. These five countries collectively account for 65 percent of the global plantation resource. The overall concentration of plantation resources in a handful of countries is further shown by the fact that only an additional 13 countries have an area of plantation forest exceeding one million hectares. Thus, 18 countries account for 87 percent of the world's plantation forests. Note, however, a number of European planted forests have reverted to semi-natural status due to the time elapsed since establishment.

At the broadest level, global plantation forests can be separated into tropical (including sub-tropical) and non-tropical plantations, and into hardwoods and softwoods. The global distribution of these areas is illustrated in Figure 1. Plantation forests in temperate and boreal countries are reported to cover 68 million hectares. Softwood species dominate in temperate and boreal plantation forests. Temperate and boreal softwoods are estimated to cover 61 million hectares and constitute 89 percent of the temperate and boreal plantation forest resource. Temperate and boreal hardwood plantations are estimated to cover almost 8 million hectares.

[1] Other wooded land: Land either with a crown cover (or equivalent stocking level) of 5-10 percent of trees able to reach a height of 5 m at maturity *in situ*; or a crown cover (or equivalent stocking level) of more than 10 percent of trees not able to reach a height of 5 m at maturity *in situ* (e.g. dwarf or stunted trees) ; or with shrub or bush cover of more than 10 percent.

[2] Sources: Pandey (1997) for tropical countries; ECE-FAO (1998) for temperate countries.

Figure 1: Global plantation forest resources by type and area 1995 (123.7 million hectares)



Sources: Tropical forest plantations: Pandey (1997): Temperate and boreal forest plantations: compilation

Tropical and subtropical forest plantation resources are estimated[1] at 55 million hectares, (about 45 percent of the global resource) for 1995. Tropical hardwood species are estimated to occupy 31 million hectares (about 57 percent of tropical plantation forest area). Tropical softwood species cover 24 million hectares.

Globally, the dominant forest plantation genus is *Pinus*. More than 40 percent of the world's forest plantations are planted with pines. This dominance largely emanates from temperate regions where large pine estates in the United States, the Russian Federation, and the southern plantation countries: Australia, New Zealand, South Africa and Chile, collectively contribute to a temperate pine plantation estate of almost 40 million hectares. *Eucalyptus spp.* are the most common tropical forest plantation species, with 10 million hectares planted. Brazil and India account for more than half of this area.

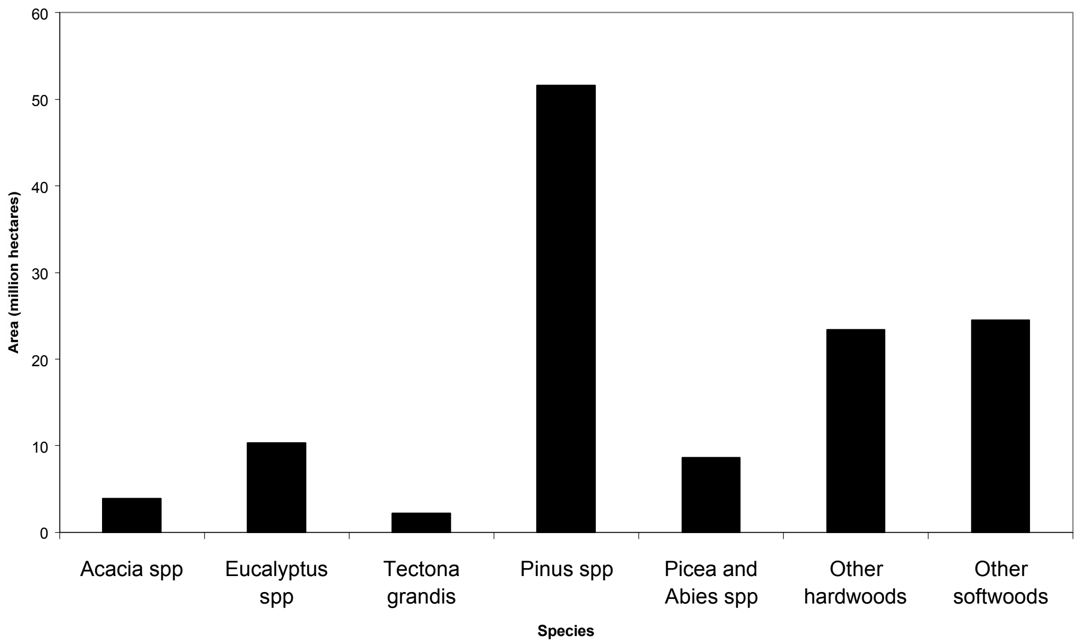
Other major forest plantation genera include *Picea*, *Abies*, *Larix*, *Acacia*, and *Tectona*, while the more than 6 million hectares of *Cunninghamia lanceolata* planted in China may make this the single most extensively planted forest plantation species. Figure 2 illustrates an approximate global species distribution for plantation forests.

Current Plantation Resources – Age Classes, Volume Increments, Rotations and Planting

Discussion of roundwood production, and the key variables that determine it (age-class, increment and rotation) is primarily relevant for the production of industrial wood.

[1] Tropical and subtropical plantation areas are drawn from Pandey (1997). The areas quoted throughout this paper are Pandey's Net Areas as opposed to Reported Areas. In an attempt to provide more accurate assessments of actual plantation areas Pandey, in some instances, applies a net down factor to the area of plantations reported to be present in particular countries. "Estimation of the net area, that is, the actual area of the stocked plantations excluding failed, harvested or doubly counted plantations, has been done by applying a reduction factor/success rate derived from inventory or survey of plantations". A more complete description of the process is provided in Pandey (1997).

Figure 2: Global distribution of plantation genera and species



Sources: Tropical plantations: Pandey (1997): Temperate and boreal plantations: compilation

Fuelwood production is often much less concerned with stem harvest volume, than with biomass production, notably branches, twigs and tops.

The discussion here will, consequently, focus only on forest plantations with a primary purpose of supplying roundwood for sawntimber, veneer and pulp (industrial plantations). If all forest plantations in Europe and the former-USSR are assumed to be for industrial purposes[1], then global area of industrial forest plantations in 1995 is estimated at 103.3 million hectares (83.5 percent of the total forest plantation area).

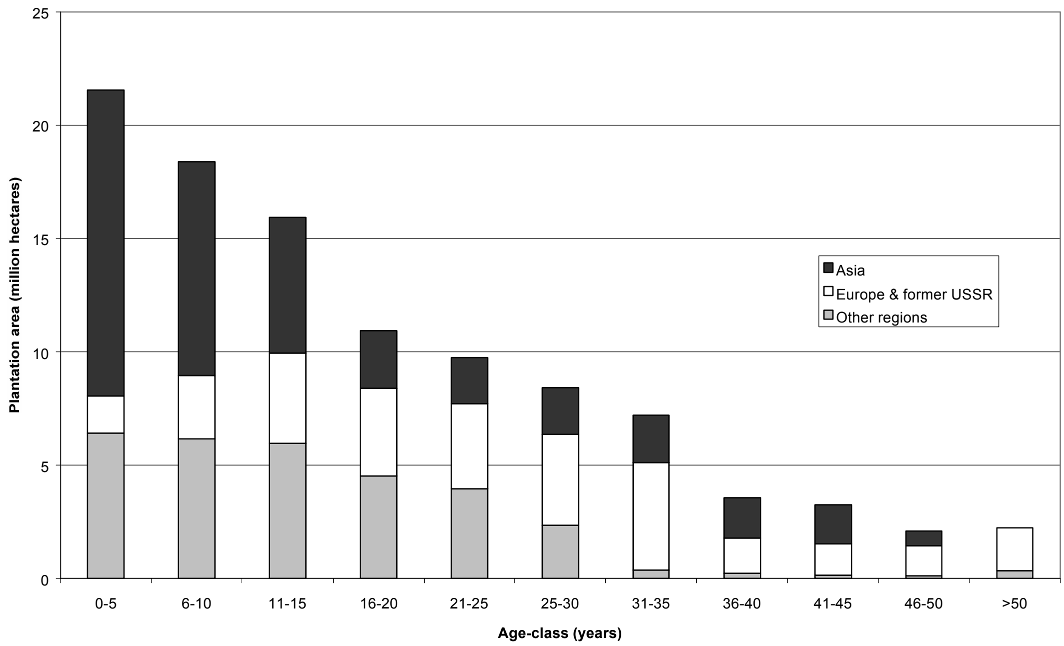
Age Classes

An absence of aggregated national plantation inventories for most countries means there are considerable difficulties in compiling detailed age-class structures on a regional or global basis. Nonetheless, forest plantation age-class information is of considerable importance since it enables more accurate assessment of the current level of wood production from plantations and likely future changes in production levels. Despite the scarcity of forest plantation inventories there is still much information available in various forms, the reliability and timeliness of which varies across countries and regions. FAO has commissioned a study[2] that derives representative age-class structures on a country-by-country basis, consistent with published information. It should be emphasised that these age class structures have been developed using a significant amount of data manipulation, the intention being to obtain structures that are representative of the "shape" of national data. The derived global age-class classification for industrial plantations, by region, is illustrated in Figure 3. Two dominant trends are apparent in Figure 3. Firstly, the preponderance of Asian plantation forests compared with the other regions is clearly evident.

[1] An assumption that ignores, for example, the establishment of, for example, recreational forests in countries such as United Kingdom, Holland and Denmark, and protection forests in mountainous countries such as Switzerland and Austria.

[2] Brown (1999)

Figure 3: Derived industrial forest plantation age-class structure by region 1995



Source: Brown (1999)

This is particularly the case for forest plantations established in the past decade. Asian plantations constitute 40 percent of the global total and 57 percent of the forest plantations established since 1985.

A second conspicuous feature of Figure 3 is the very high proportion of plantations aged less than 15 years, particularly in developing countries. Overall, 54 percent of industrial plantation forests are less than 15 years of age, with 21 percent planted between 1990 and 1995. Only 2.2 percent of plantation forests are aged more than 50 years. A further 16 percent are between 30 and 50 years of age.

This is largely the result of an acceleration in the rate of new plantation forest establishment, but also reflects the harvesting of mature forest plantations in the older age-classes and a general shortening of rotation lengths in many countries. Forest plantations aged more than 50 years are almost exclusively in temperate and boreal regions. Countries with significant areas of plantation forests established prior to 1946 include the Russian Federation, Ukraine, France, Portugal, Denmark, Ireland and South Africa.

Volume Increments

Forest plantation yield data, at a suitably aggregated level for global modelling, are both scarce and imprecise. While a vast body of literature assesses the yield of different species in research trials, the actual yield achieved on a commercial/operational scale are generally lower as the land is more variable, and the quality of establishment and silviculture is more difficult to control. Climate, altitude and geomorphology, matching of species to site, pests and diseases can have marked effects on tree growth at local levels. And small variations in annual yields can have major implications for final harvest volumes. For example, if a plantation estate yields 7 cubic metres/hectare/annum it will produce 40 percent more wood than at 5 cubic metres per hectare. Thus, at a global level, any consistent bias in yield data can badly distort the results. Initiatives such as the Tree Growth Potential Information System (TROPIS)[1] and the Sistema de Manejo de Informacion sobre Recursos Arboreos (MIRA) [2]are making

[1] Developed by CIFOR.
[2] Developed by CATIE.

significant improvements to the availability and quality of data, as well as the efficiency of research efforts.

Tropical regions may offer greater potential for future productivity gains than temperate regions. For example, while eucalyptus species, in the field, rarely yield more than 25 cubic metres per hectare per annum at present, significant advances may well be achieved in the not too distant future. In Brazil, for instance, hybrids of *E. grandis* with *E. urophylla* have, on some sites, attained growth rates of 70 cubic metres per hectare per annum (Campinhos, 1994). The extent to which such results can translate to the field, and particularly, whether other problems (for example, wood quality, or susceptibility to disease or windthrow) may arise from focussing mainly on growth and yield attributes remain important question-marks.

Rotation Lengths

Figure 4 illustrates comparative average yield data for temperate and boreal forest plantations. As shown, the highest yielding species are generally *Eucalyptus* and *Pinus* species, though these have a high degree of variability among various species and locations. At the other end of the scale are species adapted to very dry or very cold climates, which may produce only 1 cubic metre per hectare per year (at a national scale).

Rotation lengths in industrial wood plantations are determined by a number of factors: rate of wood and fibre production; desired wood and fibre properties; and maximisation of site productivity. However, the over-riding factor determining rotation lengths is generally profitability. Growth rates and wood properties should form part of an investment equation that marries costs and prices to determine the optimal length of time that the plantation investment should be "held". In terms of profit maximisation, rotation lengths, for single forest plantation blocks[3], are easily varied within a moderate time-span to capitalise on market conditions. Harvesting can be brought forward, or deferred according to prevailing market prices.

In terms of modelling[4], changes to rotation lengths can have significant impacts on predicted wood yields, but they are likely to be less important source of error than, for example, errors in estimated Mean Annual Increment, which will be compounded through the span of the rotation.

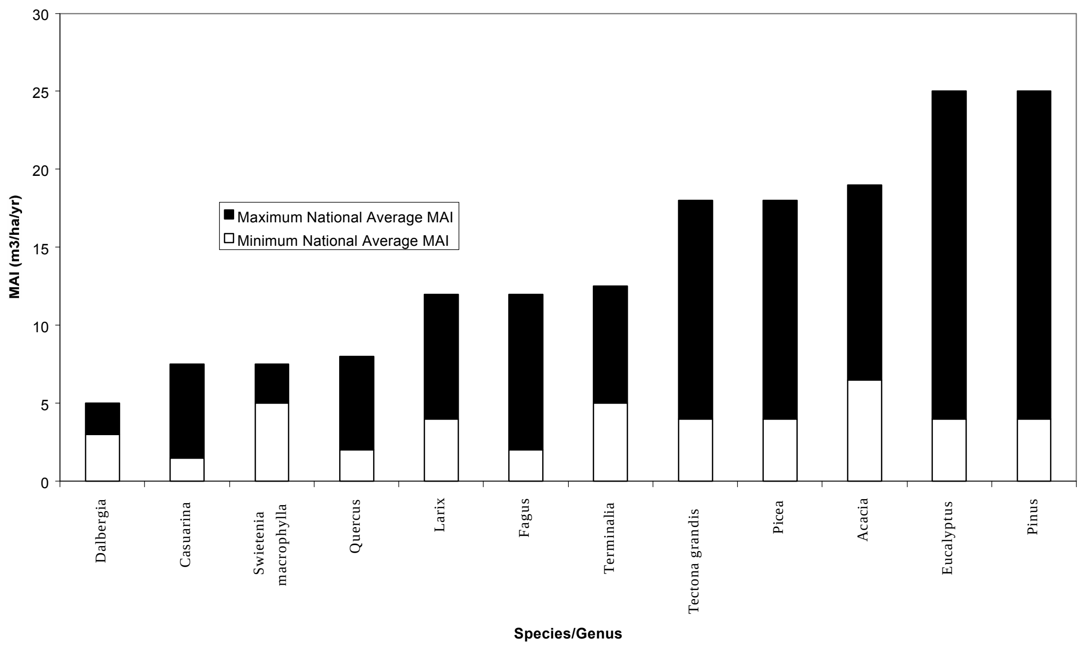
Planting

The question as to what role forest plantations might play in meeting future wood demands is inextricably linked to past and current patterns in plantation establishment. Plantation production, through to 2010 is almost exclusively dependent on trees already in the ground. Beyond 2010, future rates of planting will be increasingly important in determining the level of forest plantation production. Rates of plantation establishment vary annually in most countries and are driven by a range of factors including government finances, general economic conditions, incentives offered to private sector interests, perceptions of forestry profitability, successes of previous planting programmes, and perceptions of future supply-demand imbalances. Some of this planting (an unknown but, perhaps, large proportion) is, however, replanting of harvested areas. The current annual rate of new plantation establishment in temperate and boreal countries is estimated to be around 750,000 hectares, although this estimate does not include significant areas of enrichment planting and seeding in semi-natural forests.

[3] Profit maximising strategies will vary according to the size and age-class structure of a plantation estate, and long-run objectives of an investor. For example, a forest corporation owning multiple plantations of varying age-classes will have different cash-flow requirements and strategies to a single age-class, sole stand plantation owner.

[4] The modelling in Brown (1999) allows for harvesting to be distributed around an average rotation length and thus mimics some of the uncertainty between planned and actual rotation.

Figure 4: Indicative national-scale forest plantation yields by species (MAI at harvest)



Primary source: Leech (1998)

Forest Plantation Production

Current Harvest from Forest Plantations

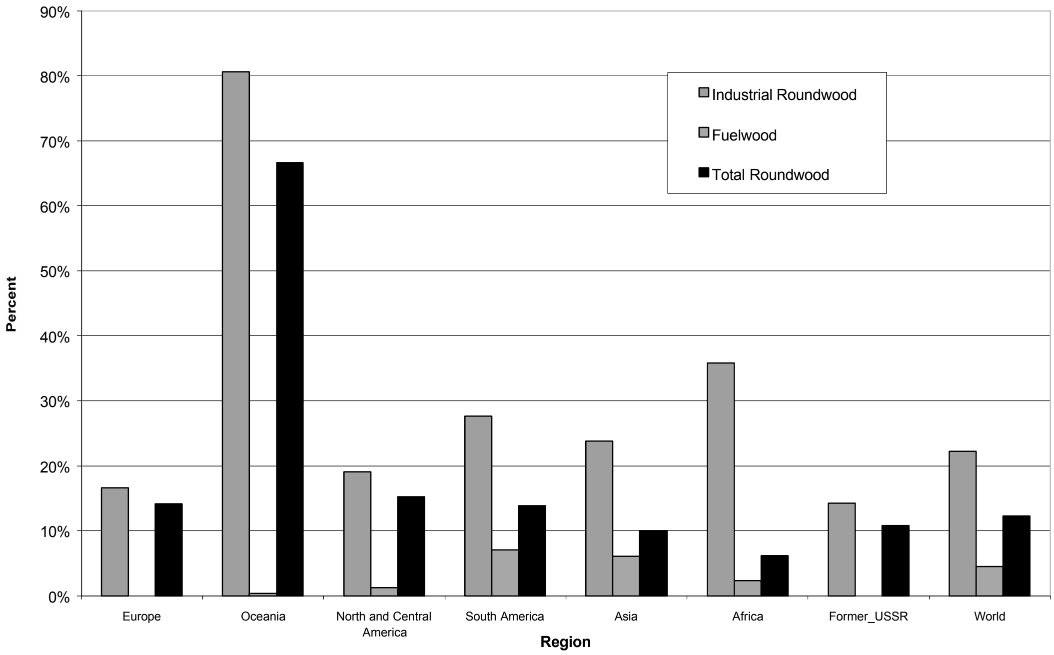
Current annual industrial roundwood production from forest plantations is estimated to be 331 million cubic metres, based on mature age-class production potential. Fuelwood production is estimated to be 86 million cubic metres (Brown, 1999).

Figure 5 shows an estimate of current industrial and non-industrial forest plantation harvests as a percentage of the total harvest of natural forest and plantation-grown industrial roundwood, fuelwood and total roundwood. A number of interesting features are evident from the graph. The "bottom-line" shows that current plantation production for industrial and fuelwood purposes could[1] be supplying around 12 percent of the world's total roundwood harvest. The harvest from forest plantations designated "industrial" constitutes, however, a far greater proportion of reported industrial roundwood production, than does the proportion of non-industrial plantation relative to fuelwood production. Industrial forest plantations are estimated to contribute 22 percent of global industrial roundwood production, compared with non-industrial plantations' 4 percent share of fuelwood production. It is important to note that these estimates are for over bark standing timber. Delivered mill-gate volumes of industrial roundwood may be significantly lower.

Forest plantation production for industrial roundwood is particularly important in the Oceania region, where 80 percent of industrial roundwood is plantation-grown. Africa (35 percent), South America (27 percent) and Asia (23 percent) also have above average proportions of industrial roundwood produced in plantation forests.

[1] That is, the global plantation age-class structure under the assumed national harvesting profiles would suggest that 417 million cubic metres of plantation-grown roundwood had reached maturity (i.e. its assumed rotation age) in 1995.

Figure 5: Estimated forest plantation wood supplies as percent of total roundwood harvest – 1995



Sources: FAO (1997), Brown (1999)

Production from forest plantations in a handful of countries in each of these regions – Australia, New Zealand, Chile, China, Japan and South Africa – is sufficiently large to put these regions ahead of the global average.

Future Forest Plantation Harvest Scenarios[1]

Comprehensive modelling of production, consumption and trade in forest products has been carried out as a core component of the Global Forest Products Outlook Study (GFPOS)[2] using the Global Forest Products Model (GFPM), a price endogenous linear programming system. Three scenarios for future wood supply from forest plantations have been modelled as part of the subsidiary GFPOS Thematic Study on Plantations, but independently of the GFPM analysis. The three forest plantation scenarios are:

Scenario 1 provides a baseline forecast, by assuming that forest plantations are not expanded beyond their current area and that all areas are replanted after harvesting.

Scenario 2 assumes that new planting will increase the forest plantation area at a constant rate of 1.2 million ha per annum in total (equal to 1% of the current area of forest plantations).

Scenario 3 assumes that the annual rate of new planting estimated in 1995 (4.71 million ha in total) is maintained until the year 2010, after which it is reduced by 940,000 ha at the start of each of the following decades (i.e. until it declines to zero in 2050).

The implications of these Scenarios in terms of plantation establishment by region and for major countries are shown in Table 2.

Scenario 2 is notable for requiring only relatively modest, and seemingly plausible, increases in plantation areas. For example, the 27.1 million hectares proposed for China in 2050 under Scenario 2 is markedly less than the 40.35 million hectares currently planned in China to 2050. Scenario 2 implies a 55 percent increase in current plantation forest areas.

[1] Note the assumptions behind the modelling and a more detailed discussion are found in Brown (1999).

[2] Results are published in Shushuai et al (1998).

Table 2: Industrial forest plantation areas under new planting scenarios (million hectares)

Country	Area 1995	Area 2050 Scenario 1	Area 2050 Scenario 2	Area 2050 Scenario 3
North and Central America	**18.9**	**18.9**	**29.3**	**43.2**
United States	*18.4*	*18.4*	*28.5*	*41.2*
South America	**5.4**	**5.4**	**8.4**	**13.6**
Asia	**41.8**	**41.8**	**64.8**	**119.5**
China	*17.5*	*17.5*	*27.1*	*68.3*
India	*4.1*	*4.1*	*6.4*	*11.7*
Japan	*10.7*	*10.7*	*16.6*	*12.4*
Oceania	**2.7**	**2.7**	**4.2**	**5.7**
Africa	**3.6**	**3.6**	**5.6**	**8.9**
Europe	**8.7**	**8.7**	**13.5**	**15.3**
Former-USSR	**22.2**	**22.2**	**34.4**	**28.0**
Russian Federation	*17.1*	*17.1*	*26.5*	*21.1*
WORLD	**103.3**	**103.3**	**160.2**	**234.2**

Source: Brown (1999)

Plantation development is, however, unlikely to be uniform across countries. Countries such as Chile and New Zealand have, for example, achieved isolated increases in forest plantation areas of 5-10 percent in a single year. Other countries have gone for extended periods with little or no forest plantation establishment. South Africa, for example, is not encouraging further afforestation, with a preference to maximise water yields from catchments. Conversely, Australia has targeted the development of a 3 million-hectare plantation estate (a trebling of the current) by 2020. The impacts of subsidies and other incentives could play a major role in distorting competitive advantage in forest plantation establishment away from current patterns.

The areas implicit in Scenario 3 also seem to be generally achievable in physical terms. Institutional and policy constraints may, however, play a highly significant role in limiting planting below the indicated levels. Two notable cases are China and the United States, both of which would be required to maintain rates of plantation establishment higher (or for longer) than seems likely at present. Some of this "excess" planting could, however, be spread across other countries without markedly affecting the results of Scenario 3.

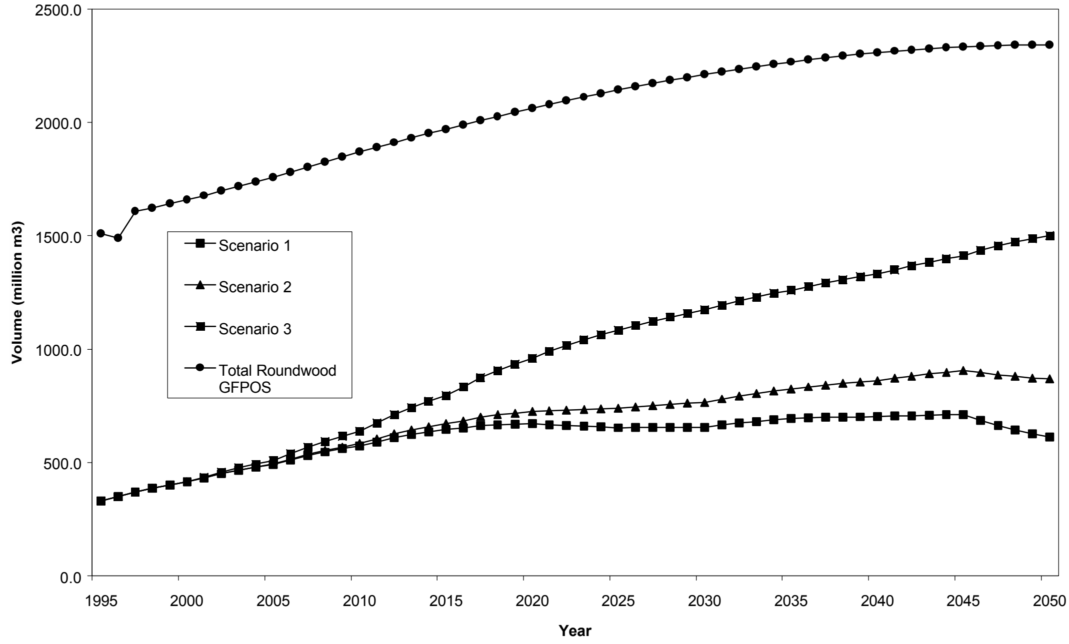
Several issues are likely to be of substantial importance in determining actual rates of plantation establishment. Perhaps most important will be the suite of government policies that impact on plantation establishment. A key change over the past 30 years has been national policy shifts away from centralised government planting programmes, with governments taking less direct means of encouraging tree planting.

A variety of incentive policies, privatisation, management devolution and government promotions, have contributed to this change in a variety of countries. An important future trend, in at least some countries, may be a form of "private sector devolution" whereby forestry companies take a lesser role in plantation establishment, and outgrower-type schemes assume much greater importance.

Future Forest Plantation Wood Production

Future wood production from industrial plantations under each of the three scenarios is compared with a forecast of industrial roundwood consumption derived using the GFPM until 2010 and long-term trend analysis, beyond to 2050 in Figure 6.

Figure 6: Comparison of projections for industrial roundwood production with three plantation scenarios



Source: Brown (1999)

Several Points of Interest Can Be Noted From The Graph

1. There is little difference between the three forest plantation scenarios until 2010. This is because trees already in the ground will determine production over the next decade.
2. The heavy weighting towards the youngest age-classes in the global distribution means that even Scenario 1 (zero new planting) shows a significant increase in wood production from forest plantations. Scenario 1 shows an increase in production from 331 million cubic metres to 712 million cubic metres. Note, however, this growth in plantation production would be insufficient to keep pace with the forecast growth in roundwood consumption, and additional new sources of wood or fibre would need to be found to supply additional new demand.
3. Scenario 2 increases at approximately the same rate as projected new demand for roundwood. Scenario 2 shows an increase in plantation wood production to 906 million cubic metres. Note, however, that current levels of harvesting in natural forests, recycling, etc. would need to be maintained if no other new fibre sources are found, or efficiency is not significantly improved.
4. Only Scenario 3, with its relatively large landuse implications, would enable forest plantations to substitute for wood production from natural forests. Scenario 3 expands plantation production to 1.5 billion cubic metres, approximately equal to current levels of global industrial roundwood consumption. Under Scenario 3, the industrial forest plantation share of industrial roundwood production is estimated to increase from the current 22 percent, to 64 percent in 2050.

The long-term production forecast from forest plantations is very sensitive to the assumptions made about future forest plantation establishment rates. Consequently, much is likely to be determined by the future availability of land for new planting and perceptions of supply-demand balances for wood and fibre. In general, it should be expected that plantations will supply a high proportion of feedstock to fibre based industries and for the production of utility sawntimber (particularly, outside Europe). High quality hardwood timbers, especially, are likely to continue to be sourced from natural forests, although plantation grown teak can be expected to become increasingly important.

Priority Areas For Forest Plantation Research

The analysis to this point highlights a need for continued focus on forest plantation research. If future supply shortfalls are to be avoided, or harvesting in natural forests be reduced, then forest plantation areas are likely to need significant expansion or plantations will need to come significantly more productive. The following offers a brief suite of potentially rewarding research topics.

Data deficiencies: Problems relating to incomplete, inaccurate and obsolete plantation inventory data have already been highlighted. Currently, data weaknesses have significant implications for the accuracy and reliability of production modelling and forecasting. In turn, doubts over the reliability of modelling create uncertainty in public policy setting and for the private sector.

Silviculture and management: Silviculture and management have considerable room for improvement in many countries, particularly in terms of mortality and general neglect. Broader dissemination of best practice techniques for various species and continuing site-specific experimental trials could lead to extensive improvements in productivity.

Species-site matching: Significant improvements in productivity could also be achieved through greater attention to matching species, provenances and clones to sites. Often successful plantings of a particular species or provenance are merely extended across a range of sites, where varying the species selected or testing other provenances could improve harvests. At the same time, a primary driver of species selection should be intended end-use. The species that grows best may not necessarily yield the highest financial returns or have a recognised use or market.

Genetics: The broad field of genetics offers substantial opportunities for improving forest plantation productivity, though activities such as genetic modification (small scale in forestry) are fraught with controversy. Much work may be required to secure acceptable levels of risk to the environment and allay public fears over controversial activities.

Tree-breeding: There is considerable potential for increasing wood yields though tree-breeding and other fields of biotechnology, though effectively translating the results of laboratory or small-scale research plots to the field is doubtless a major challenge. In view of this, it is distressing that still today, seed for planting in the tropics is generally procured or purchased from the most readily available sources, due to lack of information on consequences and potential losses, due to lack of knowledge of within species diversity and its adaptation to varying environmental conditions, and due to unavailability of quality seed, stemming from institutional weaknesses and lack of technical knowhow in seed collection and handling in many countries which possess these valuable genetic resources (Palmberg 1989). Even more disturbing is the fact that countries, at times, will embark on tree breeding programmes based on haphazardly introduced genetic materials, sometimes of unknown origin and genetic base. Such action can only lead to disillusion and economic losses. Amidst excitement over potential improvements in yields and uniformity of products, sight must not be lost of the dangers posed to forest plantations by climatic variation, abiotic factors, pests and diseases.

Issues of wood quality: Plantation grown timbers are often perceived as being inferior to natural forest timbers, particularly in high value applications or for applications where strength or elasticity are important. In some instances this may be more a marketing issue. From a research perspective, many of these issues may be overcome by applying (or developing new) wood engineering techniques. For example, the development of laminated veneer lumber enables plantation grown timber to be used in high load bearing applications where ordinary sawn beams are insufficient.

Wood utilisation: Much small dimension roundwood is produced in forest plantations, as thinnings, top-logs, or due to economics of short rotations. Much of this timber is used for low value purposes such as posts and poles, low quality sawn timber or pulp. Recovery rates for solid wood processing of small logs tend to be low, and often the wood or fibre is of low quality. In many areas utilisation could be improved by better distribution, or by introducing new processing techniques or technology.

Tree-growing in low forest cover countries: Far greater attention needs to be applied for experimental trials in low forest countries, particularly those where there is a weak "forest culture". Considerable strengthening of research into social, policy and legislative issues, as well as strengthening technology transfer and information dissemination may be required in a number of countries.

Revitalising degraded land: Plantation forests are often proposed as a means of rehabilitating or utilising degraded lands. Further attention needs to be given to species-site matching in this regard, as well as more study of the economic and/or environmental efficacy of such rehabilitative efforts. The need for Environmental Impact Assessments to be carried out prior to implementing afforestation projects on "wastelands" should be noted.

Forest plantation sustainability: Considerable controversy continues over the long run sustainability of forest plantations. While most research indicates that plantations meet "narrow sense" definitions of sustainability (notably maintaining productivity across multiple rotations), considerable further work is required to demonstrate that plantations meet broader sustainability criteria. These will be a key consideration if extensive increases in plantation forest areas are to be achieved. Activities that, for example, promote greater biodiversity in plantations may provide fruitful areas for research. Similarly, attention to multifunctional uses of forest plantations can enhance their social and environmental values.

Policy-related: On-going study and research across a broad spectrum of topics will be required to support national plantation policy development. Diverse issues such as land availability, effectiveness of incentive policies, appropriate ownership structures, social impacts of plantation establishment, and mechanisms for carbon offset schemes require study or monitoring.

Conclusions

The analysis suggests a central conclusion that the role of plantation forests in meeting future wood and fibre demands will increase during the next 30 years, irrespective of future rates of plantation establishment. Forest plantation wood supplies for the next decade are already largely determined by trees in the ground and, in many countries, a considerable increase in areas of plantation forests reaching harvestable age is expected. Thus, by 2010, the annual yield of plantation grown industrial roundwood is estimated to increase from the current 331 million cubic metres to around 600 million cubic metres. Production of plantation-grown fuelwood is expected to double from the current 8 million cubic metres.

Beyond 2010, plantation production forecasts are increasingly dependent on assumptions of new planting rates, and on assumptions of improvements in annual increments. There is scope, depending on policy decisions and markets, for forest plantations to play a dominant role in industrial wood and fibre supplies. A more likely scenario is probably that the proportion of forest plantation-grown wood will increase, but natural forests will continue to supply a modest majority of industrial roundwood.

The question of where future plantation forest development is most likely to occur remains unclear. At present, many governments remain active in plantation forest establishment, either directly, through state planting programmes, or indirectly, by providing incentives to the private sector. In some instances plantations realising non-market values can justify incentives. In other cases the incentives are merely maintaining wood supply capacity. In any event, under these circumstances, competitive and comparative advantages are not clearly emerging.

The most significant forest plantation increases in the immediate future will be in countries where specific public planting programmes are in force, most notably China and India. In Europe, plantation establishment is likely to be mainly dictated by the life span of incentive policies. Europe is largely self-sufficient in terms of wood-fibre volumes and development of a larger than present plantation-based export trade seems a relatively unlikely development.

South America and Oceania are likely to continue to expand forest plantation areas under the perception that real competitive advantage in plantation growing is held in these regions. The extent to which forest plantations increase in these regions is likely to be dictated by the extent to which this perception is sustained. If plantation revenues are unsatisfactory then afforestation rates in these regions are likely to slow.

Plantation profitability in the southern countries is likely to be determined by conditions in North American and Asian markets and by wood and fibre supplies from forests in these regions. Similarly, if the current trend toward increasing regulation of natural forests increases then forest plantation establishment in both North America and Asia is also likely to accelerate. Of key interest will be natural forest wood supply trends in the US Pacific-Northwest, Canada, Indonesia and Malaysia.

Plantation forest establishment in the former-USSR and Africa seems unlikely to accelerate in the immediate future. In the former-USSR countries, economic difficulties are likely to mean plantation investment will be of relatively low priority, particularly given the extensive natural forest resource in several of these countries. In Africa, the absence of strong infrastructure is likely to remain a significant competitive disadvantage for many countries. It is difficult to see true competitive advantage in plantation investment emerging in many countries, even those that have important industries based on natural forests.

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Forests and Society Needs:

Non-Wood Products (NWP)

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Production and Utilization of Bamboo, Rattan and Related Species: Management and Research Considerations

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Abstract

Non-wood forest resources particularly bamboo, rattan and other related species, form a very important source of livelihood for the rural folks, especially those who are at the bottom of the economic level. This is particularly true for large segments of the population in many Asian countries. In the last few decades, the accelerated rate of forest conversion and logging has led to a decimation of these non-wood resources, sometimes to the point of their disappearance. Despite their importance in the socio-economic and cultural contribution to the marginalised people, little effort has been given to manage these resources on a sustainable basis through proper harvesting, restocking, and artificial propagation. The lack of scientific knowledge of these non-wood forest resources especially the taxonomy, silviculture, technological properties and processing methods, has partly resulted in their desultory development. With more concerted efforts, backed by deeper scientific investigations, it should be possible for industries based on these underdeveloped resources to supersede the timber industry in several parts of the Asian region. There is considerable opportunity for further development in furniture manufacturing and other novelty items. This paper presents a summary of some of the important findings and the ongoing research efforts, with particular reference to production and utilization of some selected non-wood resources and products in Peninsular Malaysia.

Key words: Non-wood , Management , Research , Developmental considerations

Introduction

Malaysia is one of the twelve "megadiversity" countries of the world. These countries together contain 60 percent of the world's known plant and animal species. The flora of Malaysia, for example, is conservatively estimated to contain between 12,500 to 15,000 species of flowering plants, more than 1,000 species of ferns and fern allies. The fauna composition comprises more than 100,000 species. Both flora and fauna of the country are mostly located in the natural forest, wherein are found the important non-timber resources .

The most important non-timber forest resource in Malaysia (and also several Southeast Asian countries) is rattan, with bamboo next. These two groups of plants have received attention (in terms of silvicultural management) by the scientific community around the region. The forests in this region have the greatest concentration of rattan in the world with 12 genera and about 600 species. In this respect, there is great potential for value added processing of rattan. Trade in rattan has been on the increase especially in the furniture industry.

Bamboo has often been termed the **Poor Man's Timber** or **Friend**. Bamboo has been harvested from natural stands for constructional purposes and other uses such as flooring, walls, frames, shingles, doors and in other components of the house. In modern living, bamboo is found as curtains, paneling, picture frames and in a host of other products. Bamboo shoots are eaten in many Asian countries. Management of this resource is important in order to sustain the productivity and the industry.

Apart from rattan and bamboo, there are also other non-timber resources that are being used by the village community for their daily needs or to supplement their income. Amongst them are forest species producing oil bearing seeds, resins, medicines and fruit. The forests of Southeast Asia are extremely rich in such species.

Past and present activities such as logging or conversion of forests to agriculture or other non-forest uses can permanently destroy the non-timber resources. Exploitation or harvesting of non-timber resources is seldom strictly managed or controlled. This is mainly due to the difficulty in enforcing regulations in the forest. This will in the long run result in total depletion of the resources. There is little available information on non-timber resources, especially on the technical aspects related to their management and silviculture. Information on the available species and their distribution is also scanty. Hence, basic research must be undertaken to provide the much needed information so that these resources could be managed in a sustainable manner.

Non-Wood Forest Resources

Non-wood forest resources as defined in the FAO Forestry Paper No: 97 (1991) refers to market or subsistence goods and services for human or industrial consumption derived from renewable forest resources and biomass, bearing promise for augmenting real rural household incomes and employment. The products include the use of plants for food, beverages, forage, fuel and medicine (Table 1); animals, birds and fishes for food, fur and feathers (Table 2); and the services of land for conservation and recreation (Table 3). The area covered is so wide that the list can be endless. This shows the importance of non-timber forest resources which can give cash earnings and "intangibles" to each country having "forest" that produces wood and other goods.

Status of Current Resources

The current and potential plant resources of the forests are many. They range from timber to other minor forest products such as rattans, dyes, gums and resins. They are being exploited depending on the location and the people surrounding the forests. The most notable forest products that are being harvested/collected are rattan and firewood. There is, however, no large scale organised efforts in their extractions as compared with timber. The fast rate of disappearance of the tropical vegetation underscores the need to study the forests in more detail, especially into the potential of the forests as a source of major and certain minor forests products. The following section highlights some of the important resources exploited and found in the tropical forests and discusses the status of the resources in some of the countries.

Table 1: List of non-wood forest products according to category

Food -	wild, domesticated, semi-domesticated plants, usable weeds, fungi, etc. and their edible roots, tubers, bulbs, stems, leaves, shoots, flowers, fruits, seeds, etc. to provide cereals, vegetables, edible fats and oils, spices and flavorings, salt substitutes, sweeteners, rennet substitutes, meat tenderizers, beverages, cordials and infusions, thirst quenchers, etc.
Forage -	food for livestock and wildlife, including birds, fishes, and insects such as bees, silkworms, lac insects, etc.
Pharmaceuticals -	drugs, anesthetics, slaves, ointments, lotions, purgatives, etc. for both human and veterinary use.
Toxins -	for hunting, ordeal poisons, hallucinogens, pesticides, fungicides, etc. (Note: some may have a pharmaceutical potential, especially as anesthetics.)
Aromatics -	essential oils for cosmetic and perfume industries (international market highly specialized and vulnerable), unguents, incense, etc..
Biochemicals -	non-edible fats and oils, naval stores, waxes, gums and latex, dyes, tannins, biochemicals for plastics and coatings, paints and varnish industries, etc.
Fibre -	cloth, matting, cordage, basketry, brooms, stuffing for pillows, cork, etc.
Wood -	wood for handicrafts.
Ornamentals -	aesthetically pleasing plants for horticultural and amenity planting, cut- and dried-flower trades, etc.

Source: FAO Forestry Paper No: 97 (1991)

Table 2: Faunal Non-wood forest products

Wild animals -	meat, hides, skins, fibre, horn, bone, pharmaceuticals, etc.
Birds -	meat, eggs, feathers, edible nests, guano, etc.
Fishes -	food, fish oil, feed protein, etc.
Reptiles -	food, hide, skins, shell, toxins, pharmaceuticals.
Insects -	edible insects, plant exudates (manna), honey, wax, propolis, silk, lac, insect pests, etc.

Source: FAO Forestry Paper No: 97 (1991)

Table 3: Forestry Services

Range -	grazing, browse, shade and shelter for domestic livestock and wildlife, etc.
Soil improvement and protection -	green manure, humus, N-fixation, soil stabilization, shade, shelter, hedges, etc.
Parks and reserves -	for conservation of flora and fauna, tourism, recreation, hunting, shooting, fishing, photography, bird watching, bug collecting, etc.
Aesthetic -	scenic or historic sites, etc.

Source: FAO Forestry Paper No: 97 (1991)

Rattan

Rattans are spiny climbing plants belonging to the palm family. There about 600 species in the world, of which 106 species are found in Peninsular Malaysia. Based on the third National Forest Inventory (1990-1993), the estimated rattan resource was about 825 million sticks (Note: each stick is 3 m length). If the data is true, then Peninsular Malaysia will face a shortage of raw material supply by the year 2020. Based on another report (Kiew & Hood 1990), the supply of manau and sega are much lower. Rattan harvesters have to track deeper into the forest to collect rattan.

The planting of this resource, mainly that of *Calamus manan*, is conducted by the government and private sector. To date more than 31,000 ha have been planted. Out of this, 7,000 ha have been planted in rubber plantations throughout the country (Aminuddin & Salleh 1994, Abd. Latif & Aminuddin 1996). Other large plantations in Sabah are planting mainly *C. caesius* and *C. trachycoleus*. So far more than 10,000 ha have been established. Other rattan species that have been looked into include *C. scipionum* and *C. palustris*.

Indonesia is one of the countries in the region rich in rattan, providing about 80% of world's rattan supply. Indonesia with about 300 rattan species, has about almost 50% of the known total number of rattan species worldwide. Most of the rattan supplied (90%) to the market are obtained from the primary forests. The rest comes from rural small holdings and plantations. There has never been an inventory of rattan resources for the country but the natural rattan resources are fast dwindling.

Bamboo

Bamboo is next to rattan in terms of economic importance especially in Malaysia. It is one of the non-wood resources found growing wild in the forests. Many Asian countries have a long tradition in the use of bamboo for the manufacture of a wide variety of products such as blinds, chopsticks, mats and baskets, farming implements etc. Other uses include scaffolding, houses and bridges. In some countries like India, bamboo is one of the important raw materials for pulp and paper making. In Malaysia, bamboo has not been utilized as extensively and its use is limited to the production of poultry cages, vegetable baskets, utensil products etc. In Asia, there are 320 species (Liese 1985). Fifty species are known to be found in Peninsular Malaysia but only 13 species are being utilized commercially (Aminuddin & Abd. Latif 1994).

Bamboo usually occurs in significant quantities in disturbed situations such as logged-over forests, wastelands or in marginal localities fringing the forest. So far, there has been no report on the inventory of bamboo resources in any country in the world. However, Abdul

Razak and Abd. Latif (1988) estimated that bamboo covers an area of about 320,000 ha in Peninsular Malaysia with an estimated standing stock of about 7.0 million tons, of which 6,000 tons valued at RM 3 million are of commercial species.

Other Non-wood Forest Products

Besides rattan and bamboo, there are other non-wood forest products that are being exploited. That they are being dealt with less comprehensively here does not necessarily indicate their lack of importance. It only reflects the infant stage of the related industries.

Medicinal Plants

The forest has been the source for man's medicinal needs since time immemorial. This fact is well documented in a number of early publications detailing the uses of various plant parts for numerous ailments (Tavera 1892, Brown 1921, Burkill 1966). The use of plants for medicine has been clouded by superstition and magic, but the basis of the pharmaceutical properties lies in the alkaloids present in the plant tissues. Currently there is a renewed interest in seeking cures for various diseases using active compounds present in plants. The World Health Organization (WHO) has established 21 collaborating centres worldwide to strengthen research and development effort on traditional medicine. The United Nations Industrial Development Organization (UNIDO) has agreed to undertake the task of developing guidelines to assist developing countries in achieving improved supply of medicinal plants.

Systematic screening programs have been initiated since the fifties. In countries like Malaysia, Indonesia, Thailand and the Philippines, thousands of species were examined and screened leading to the detailed studies of promising species (Santos 1957, Kiang *et al.* 1964).

Chemicals from Wood

A large number of chemicals, present in various parts of plants, have found commercial application. A good example is latex from the rubber tree which has demonstrated its commercial importance. The bark of certain mangrove trees like *Rhizophora mucronata* contains a high percentage of tannin and is used in the tanning industry. *Caesalpinia sappan* (kayu sepan), produces a red dye in the wood, which was once extensively used to colour foodstuffs and to dye mattings and fabrics (Burkill 1966). The demand for natural dyes has gradually diminished with the development of synthetic substitutes. Resins are collected from old and new wounds on the tree trunks of some of Dipterocarpaceae especially *Dipterocarpus* and *Shorea* species. The limited supply coupled with the availability of synthetic resins have reduced the trade.

Fruit Trees

In most villages in this region we can find domesticated fruit trees like *Nephelium*, *Mangifera*, *Sandoricum* and *Eugenia* being grown (Wee & Rao, 1980). They have been domesticated through the centuries from wild forest species. Their progenitor and relatives still exist in the forest. Many are known and the fruits are collected and sold in rural markets. A good example is *Baccauria*. *B. motleyana* is an established fruit tree of village gardens. The other two species *B. macrocarpa* and *B. puberula* are known but not properly grown. Of the many species of *Mangifera*, *Durio* and *Garcinia* that exist in Southeast Asia, only a handful are grown in rural orchards, although many more species with edible fruits exist in the forest. Another fruit tree that is known to many in Peninsular Malaysia is *Parkia speciosa* (petai). Petai can be found in encroached forest, logged-over forest, shifting cultivation areas and cultivated agricultural land. In such habitats and management systems, the number of pods produced per tree per year varies. It ranges from as high as 873 pods in encroached forest to 136 pods per tree per year in cultivated agricultural land. This shows that the nature of land uses affect productivity.

Status of Current Utilization

At present, the most important non-wood resource that is being harvested heavily is rattan, followed by bamboo. In countries where bamboo is more prominent such as India and Bangladesh, the reverse is true. Nevertheless, these resources are being depleted and steps are being taken by the respective government agencies of countries in the region to plant them on large scale. In this section, utilization of the important resources are discussed with reference to Peninsular Malaysia.

Rattan

The rattan furniture industry for Peninsular Malaysia is quite dynamic. There are about 700 rattan mills and 525 are engaged in manufacturing activities, with about 13% of the latter being export oriented (Abd. Latif & Aminuddin 1996, Abd. Latif 1997). The rest are mainly cottage and small-scale industries. The rattan industry requires about 12 million 3m-length sticks of the prime cane species *Calamus manan*, and 45 million 6m-length sticks of the small diameter cane *C. caesius*, annually (Appanah *et al*., 1998). Shortages of these high-quality canes are being felt. Other canes of lesser quality are also being used by the industry. While the widely dispersed rattan processing mills tend to be concentrated in the state having large forest areas where rattans are commonly found, the manufacturing industry is predominantly located in the west coast areas where large market and basic amenities are readily available (Aminuddin & Abd. Latif 1991a, Abd. Latif & Aminuddin 1996). Peninsular Malaysia has an abundant supply of raw rattan. The total gross value collected could amount to over RM 5 million a month. The value can increase to more than 21-25 times if the manufacturers concentrate on downstream processing as in furniture or semi-processed products such as ropes and binds which are traditionally imported from Singapore, Hong Kong, Indonesia or Taiwan (Abd. Latif 1989b, Abd. Latif & Aminuddin 1996). Since the ban on the export of raw rattan and the imposition of high import duty for the semi-processed products in 1989, a shift from the traditional practice of exporting the raw and semi-processed products to more value-added finished products has increased the foreign exchange earnings as well as the employment opportunities in the rural urban sectors.

Bamboo

As reported by Aminuddin and Abd. Latif (1991b), there are 1,032 bamboo-based industries of various sizes in Peninsular Malaysia but only 104 mills have appropriate machines producing products such as skewers, chopsticks and toothpicks (32 mills), furniture (2 mills) and craft (70 mills). While these 104 mills are categorised as medium and large-scale, the remaining 928 mills are classified as cottage and small-scale enterprises. Although the bamboo industry in Peninsular Malaysia began in 1950's, activities were confined to traditional handicrafts, while the machine intensive industry was introduced only in the last decade.

Cottage industries making handicraft items are mainly found in the west coast states of Peninsular Malaysia, whereas industries making poultry cages and vegetables baskets tend to concentrate around vegetable plantations around Tapah in Perak . The local market for bamboo products is worth about US$3 million annually (Aminuddin & Abd. Latif 1994). Lately, there has been an increased utilisation of bamboo by the industries. This could probably be associated with increasing level of difficulties in gaining commonly used timbers from the forest, hygienic concerns especially for cheap disposable items used in contact with food; and the awareness to sustain the healthy surrounding green environment within the society. The popularisation of bamboo as an environment friendly material (fast growing, high yielding renewable resource and a secondary forested species) has also resulted in the resurgence of bamboo industries (especially those machine-intensive) from its seven static years in 1988 to 1995. The domestic demands for machine-intensive products such as skewers and single chopsticks, for example, have considerably increased to about US$5 million in 1996 onward compared to the average of US$3 million per annum within those static years (Abd. Latif 1989, Abd. Latif & Abd. Razak 1994, Abd. Latif & Abd Razak 1998).

Fruit tree

In Southeast Asia there are 130 species of domesticated fruit trees belonging to 29 genera and 17 families. Almost all of them have their wild or nearest relatives in the forests. Because wild fruit trees have scattered occurrences, about less than 10 trees per 40 ha, their existence can only be detected with intensive search over a long period of time. The trade in wild fruits in the local markets appears to be tremendous but there is a lack of quantitative data on non-wood resources. In one study on Petai, the magnitude of the trade is fairly large in the domestic markets. The trade can be between RM 336,000 to RM 900,000 per annum depending on the locality (Woon *et al.* 1995). It is therefore necessary to look at evaluating other non-wood resources which will eventually lead to a fair assessment of its economic value.

Non-Wood Forest Resources Management

International funding agencies are willing in their own way to work on these resources but national programs must lead the way. Priority therefore should be given to the further development of non-wood resources that provide socio-economic benefits at the domestic levels. Multi-purpose tree species must be managed at all levels. A selection of the specific non-wood resources is described in general terms.

Rattan

In order not to rely so much on the supply from the wild, large scale planting of the resource is deemed necessary. This is supported by the fact that for *Calamus manan*, Peninsular Malaysia required about nine million 3-m length sticks per annum and this requires planting of about 5000 ha per annum. For other commercial species, planting is also needed in order to supplement its requirement as an alternative material for the highly sought after species. If such activities are not carried out, supply in the near future will be difficult. Planting can be either in the logged-over forest areas or in rubber plantations. Assistance can be provided by the government to provide incentives in other aspects of the plantation management.

Bamboo

In countries where the demand for bamboo is large, silviculture management of the species already exists. This is practically so in countries like China and Taiwan where monopodial bamboo is dominant. In Peninsular Malaysia where most of the bamboos are sympodial (clump-forming type or so-called pachymorph) and wild, management of the natural stand as a plantation crop is imperative in order to ensure continuous supply of the raw material demanded by the industry. It is understood that for *Gigantochloa scortechinii* (the highly sought after bamboo species in the country) which is abundantly found in the northern part of Peninsular Malaysia, about 12 - 15 culms (of age classes less or equal to three years old) per clump should be left behind and the harvesting should be systematically practiced. The optimal number of clumps per hectare should also be maintained between 220 - 250 clumps (Abd. Latif & Abd. Razak 1994).

Fruit trees

For management purposes, it is essential to zone the potential producing areas depending on the fruits. This will provide data for long term management purposes. Intercropping of the fruit trees with other crops to maximise the land-use is another approach to contribute for the higher income generation of the species. In a study by Woon *et al.* (1995), petai and durian land use option provides the highest net present value (US$ 11,173.85 per ha) compared with primary forest (US$ 70); and petai and banana (US$ 262). Planting of some of the fruit trees should be encouraged as the increased income generated will be significant.

Quantification of Non-Wood Forest Resources

There is a growing awareness on the importance of forest and the services it can provide either for conservation or recreation. In terms of non-wood resources, several items listed below can be considered to have tangible benefit and shows that the forest is an important resource to be preserved and conserved by mankind.

Recreation

At present there is almost one forest recreation area in one district but it is difficult to quantify the significance of the area. There has been some studies indicating the number of visitors going to the place (day trippers, campers, etc.), facilities available and so on, but there is no attempt to relate this recreational area to monetary values. Questionnaires and fees charged to people using such facilities could probably provide some information whether such facilities are useful.

Hydrology

Hydrological studies have proven that water production from forests is greatly affected by deforestation and quality. There has been no attempt to look at the economic impact of water in the forest.

Problems and Prospects

Rattan

Peninsular Malaysia has an abundant supply of raw rattan. Abd. Latif (1989a) reported that the total gross value of raw rattans collected amounts to over US$ 1.3 million a month. The value can increase to more than 21-25 times if the manufacturers concentrate on downstream processing as in furniture or semi-processed products such as ropes and binds which are traditionally imported from Singapore, Hong Kong, Indonesia or Taiwan (Abd. Latif 1997). Since the ban on the export of raw rattan and the imposition of high export duty for the semi-processed products in December 1989, a shift from traditional practice of exporting the raw rattan to semi-processed and finished product has resulted. This has increased the foreign exchange earnings as well as the employment opportunities in the rural-urban sectors. There was in fact a significant increase in the export value of rattan products from Malaysia in 1990 (almost 200%) as a result of the total ban. The Federation of Malaysian Manufacturers projected that revenue from the export of rattan furniture would reach RM 150 million (US$ 40 million) before the 21st century.

Rattan has the potential for industrial development especially in the form of finished products (Abd. Latif 1991). Therefore, Malaysia should exploit these resources fully. Concerted efforts, however, must first be spearheaded towards overcoming immediate problems encountered by the industry such as inadequate supply of skilled and trained workers, unavailability of original contemporary designs, technological improvements, know-how such as low-cost automation and mechanisation, lack of quality control and insufficient operational capital. Besides giving incentives such as soft loan and sales tax reduction, establishment of an information and service centre for better marketing strategies, business opportunities and design trends should also be given immediate attention (Aminuddin & Abd. Latif 1991b). The establishment of village industries or service centres at district level focusing on the economic support of complementary activities will highly benefit many traditional entrepreneurs as these could also serve as training centres for new entrepreneurs to learn basic production techniques. With government support to develop the industry, there is no reason why it should not succeed. With careful planning and cooperation among the industrialists and government agencies, rattan entrepreneurship should continue to develop and the industry will eventually become competitive with those from the rest of the exporting countries.

Bamboo

There are several problems that need immediate attention if the bamboo industry is to be developed further. The misconception that bamboos are weeds interfering with the growing timber and regeneration of trees (Ng 1980) or free goods of nature has to be redefined. Bamboo plantations should be established to ensure a continuous supply of high quality raw material and at the same time exploit the possibility of growing bamboo for shoots and commercialising them. Commercially utilisable bamboo species grow mainly in northern Peninsular Malaysia, in logged-over forest, and on river banks and hillsides. The large areas of bamboo forest within this region need to be designated as bamboo estates, and leased out to private sector agencies to manage on a sustained yield basis. With intensive and careful management, these natural bamboo resources can be gradually converted to equivalent plantation stand. With proper silviculture treatment and harvesting practice, sustainability of bamboo supply can be ensured.

A reliable estimate of total bamboo areas and production especially the magnitude of useful bamboo species available within the country (especially Sabah and Sarawak of East Malaysia) should be carried out thoroughly in order to facilitate planning for development of the industries. Only with a continuous and regular supply of the raw material would the industry be able to develop properly. To a certain degree, drastic steps should also be taken to revise the current institutional systems and procedures pertaining to bamboo resources. This also means that the current policy of issuing permit for bamboo extraction should be retailored to include the provision for the licensees in managing the natural bamboo stands within the given area.

More attention should be devoted towards training-cum-production centres. In such centres, besides ensuring all the government funded facilities remain in good condition, the maintenance of machines used on a rental basis could easily be handled by the selected industrialists.

Concerning employment of foreign skilled workers, an incentive for lower levy should be introduced. This is particularly importance with the current serious shortage of workers in both the plantation and industrial sectors within the country. Besides obtaining various knowledge on manual artistic skill work from foreign sources to be delivered to the interested local work-force, more diversified value-added products integrated from different cultures could also be expected.

Information on the technological properties of Malaysian bamboos particularly in relation to their industrial application should also be expanded. Since many bamboo species remain unutilized, research effort is needed to determine the properties of such species and develop their appropriate utilization technology. Emphasis should also be given to encourage locally fabricated machines designed to process local species not only to achieve higher recovery rate but also to reduce the cost of imported machinery. There is also a need to provide a team of industrial designers to produce new and attractive designs (either in combination with other materials such as plastic, metal or less popular cultivated woody species) which can maintain and upgrade the products without sacrificing its original identity as well as to sustain the interest of the buyers. Furthermore, to extend the utilization of bamboo, consideration should be given to promote or upgrade the existing research and development institutions involved in patronizing the small-scale bamboo industries.

Another aspect that could help improve the industry is by reducing its processing waste. The range of wastage (28 - 47%) generated by the industry is very high. If the industry cannot avoid the high labour and other material costs, the waste generated should be reduced by utilizing the waste for other products such as pulp and paper, flooring and advanced materials (for instance the particle and thermoplastic fibre board) which could tremendously increase the profit margin (Abd. Latif *et al*. 1988, Abd. Latif & Liese 1995).

Priority Research Areas

To enhance the importance of non-wood forest based resources to the economy and improve the utilization and production, an intensified research and development programme should be initiated and expanded.

Inventory

There has been no serious attempt to quantify the non-wood resources of any country. The only serious attempt is done by Forestry Department of Peninsular Malaysia in their National Forest Inventory which conducted every 10 years. The National Forest Inventory in 1981-1982 and 1990-1993 indicated that clusters of commercial rattan species appear to be located in the north-west of Peninsular Malaysia. In the south, there seems to be less canes available in the forest probably due to over exploitation. The report by Abd. Latif and Shukri (1989) further revealed that rattan processing mills are concentrated in states having bigger forest areas and better infrastructural facilities, in the west coast states. Stocks of rattan species harvested and the amount required by the industry are well reported by Tan (1989) and Abd. Latif *et al.* (1990a) , respectively.

There has been no attempt to quantify the bamboo resource using the data available from the inventory. The only serious attempt was done for the state of Kedah revealing there are about 179 tonnes and 185,000 tonnes of air-dried bamboo for *Gigantochloa* spp. (Betong type) and for the other bamboo species (non-Betong), respectively. There has also been no attempt to inventorize the stocking of other non-wood resources in Peninsular Malaysia probably due to budget constraints and inadequate inventory techniques. Thus, in addition to rattan industrial survey, bamboo and *Pandanus* are the only two non-wood resources inventoried so far (Abd. Latif *et al.* 1990a; Abd. Latif *et al.* 1990b).

Silviculture and Management

The cultivation of rattan is imperative to sustain the depleting resource. The growth rate of several rattan species was monitored and four important exotic species were planted and studied. The feasibility of planting 'manau' under rubber and forest plantations has been established (Aminuddin & Nur Supardi 1986; Aminuddin *et al.* 1990).

Since propagation of bamboo using seeds is not practical due to its rare phenomenon of flowering and fruiting, vegetative propagation from culm cutting of selected *Gigantochloa*, *Schizostachyum*, *Bambusa* species and *Thrysostachys siamensis* has been initiated. The growth and yield of these species using rhizome offset on degraded soil, and response of bamboo regeneration to harvesting intensities and fertilizer application have also been investigated (Aminuddin & Abd. Latif 1994).

Properties

The usage of non-wood forest resources has long been exploited traditionally. However, further research on the utilization of waste derived from processing and manufacturing processes either for furniture, parquetries and panels (Abd. Latif & Hilmi 1991) is required involving studies on their physical, mechanical and anatomical characteristics. Studies have and are still being conducted to determine optimal harvesting age of bamboo and rattan, in relation to anatomical, chemical, physical, mechanical, and processing properties. These data are important as they help the harvester in selecting suitable material for its intended end-use (Abd. Latif *et al.* 1990c, Abd. Latif & Liese 1995, Abd. Latif & Liese 1998a, 1998b).

Analysis of chemical composition of bamboo, particularly starch and total sugar content, and in relation to fungal and insect attack, was reported by Abd. Latif *et al.* (1990d). The effect of bleaching on mechanical properties and colour quality of bamboo and bamboo products were investigated (Abd. Latif *et al.* 1989). Further studies on the properties of bamboo, particularly on its absorption and retention characteristics (Abd. Latif *et al.* 1990e) and high pressure sap displacement preservative treatment (Choo 1989) were also envisaged to encourage/promote its life-service. Studies on the usage of bamboo for pepper-vine support (Choo 1989), engineering application for soil embankment in highway construction (Low 1990) and soil stabilizer (Abd. Razak 1989) would certainly improve their commercial application.

While some bamboos are commercially utilised, there is still an abundance of other species yet unexploited. The use of less popular species of bamboo for furniture, chopsticks and machine intensive products charcoal and vegetable basket and lesser known rattan species for semi-processed products such as cores, ropes and binds will surely be beneficial to local industrialists. Published Guidelines on selection, preparation and factors related to rattan products quality (Abd. Latif 1991) will definitely be appreciated by entrepreneurs in this field.

Innovation

The development of innovative technology in the non-wood forest based industry in Malaysia has been very encouraging. Research is now being directed towards upgrading the quality and productivity by means of low-cost mechanization and_automation. At present, 47 machines on diversified usage of rattan, bamboo and *Pandanus* have been fabricated, of which 12 of them were registered for patents. A series of jig and mould for mechanical testing of rattan and bamboo were also made (Abd. Latif *et al*. 1996).

Dissemination of Information

With financial support of the Canadian-based International Development Research Centre (IDRC), the Rattan Information Centre (RIC) was established in FRIM in March 1982 with the aim of setting up a comprehensive depository of rattan literature, document and retrieval system, publishing quarterly news bulletin and disseminating information to interested parties (Kong 1989). FRIM will respond to any request for information pertaining to all aspects of rattan biology, silviculture and utilization. The production of the Bamboo Bulletin since 1992 has also contributed to the dissemination of bamboo resources within the country.

Training and Extension

The Small-scale Entrepreneurs Development Unit (SSEDU) for non-wood forest based industries was officially established in June 1985 with the financial support from the World Bank and Malaysian Government. Its main objective is to encourage the involvement of Malaysians in industrialization. The unit also functions as a technical agency by providing industrial guidelines, technical and advisory services and to assist newly established entrepreneurs and to the public.

Since 1985, the unit has conducted training programmes involving 1500 rattan and bamboo entrepreneurs and more than 75 series of entrepreneurship lectures. As a result of intensive training and services to the industry, the unit was able to initiate the establishment of a commendable number of factories. They include 13 bamboo mills, 24 rattan and 3 palm-based industries (Abd. Latif *et al*. 1996).

Besides the SSEDU, the Bamboo and Rattan Agroforestry Unit of FRIM has also conducted several courses on the planting of rattan. Seven series of technology transfer seminars on rubberwood, rattan and bamboo to the rubber small-holders have also been initiated in various states since 1992.

Future research considerations for upgrading the non-wood forest based industries

A summary list of some of the future research priorities in upgrading the related industries:

A. Inventory of Resources

- techniques and methodologies
- species, availability, distribution
- supply and demand
- phenology and taxonomy
- potential areas to be developed

B. Plantation/ Cultivation/ Harvesting

- management and silviculture techniques for natural stand
- selection of potential and suitable species
- planting techniques
- control of harvesting - regeneration and growth performance of cultivated rattan and bamboo on degraded land and tin-tailing areas
- improvement of harvesting methods

C. Properties

a. Anatomical - schedule/key/method of identification
  - fiber dimensions, rations and particle geometries

b. Chemical - extractives, polysaccharide and medical aspect

c. Mechanical - strength, gluing, acoustical and combustibility

d. Physical - moisture, specific gravity, dimensional stability and movement

D. Preservation

- natural durability
- seasonal influences on carbohydrate and chemical contents; susceptibility to borers and fungal attack
- table of fungi, pest and diseases

- cost effective method – traditional and chemical
- resistance to indoor, outdoor and marine use
- determination of permeability or fluid flow law for monocotyledon.

E. Drying/Seasoning

- cost effective method – traditional and advance such as high frequency0, kiln- and forced air- drying
- schedule of drying
- effectiveness of drying methods against defects

F. Processing and manufacturing

- criteria of selection
- machining, workability and rate of recovery
  for both commercial and less popular species
- *operational manual on machineries and methods of processing*
- cutter tool technology - suitability of metal and alloy for efficient processing
- diversification of product design
- bill of costing
- jointing and binding technology
- mould, jig fabrication, low cost mechanization and automation

G. Boiling of rattan

- standardization of method and medium
- rationale of different preliminary processing practices
- effects of boiling and boiling medium on technological properties, durability, quality

H. Finishing
- cost effective methods and materials
- effect on strength and quality
- adhesive and absorption properties
- resistance to environmental stresses
- type and combination of finishing materials and components

I. Grading

a. Processed and semi-processed products (especially rattan)
- table of grading guidelines
- uniform grading rules based on agreeable parameters such as species, length, appearances, allowable defects and strength

b. Finished products
- furniture testing
- wear resistance
- hardness
- jointing

J. Products development

- waste utilization
- polymerization of less popular species
- modification and advancement of materials forthermoplastic composite, hybridization and filler
- panel, wall, flooring, ply, flattened and laminated
- engineering application such as reinforcement, piling, structural and acoustical purposes.

K. Inventory

- impact of the industry on the socio-economics
- inventory on the industries - profile, status,
  distribution
- rate of consumption and production
- market outlets/strategies in relation to products quality, design and acceptance
- employment generation potential

L. Dissemination of information to industries/public

- via non-wood forest products information centre
- homepage and entreprenews

Institutional Responsibility for Non-Wood Resources

Non-wood forest products have been in the limelight for quite sometime. There are various international agencies that are involved, or have taken the lead, in promoting these resources. These include agencies like IDRC, INBAR, ICRAF, IPGRI, UNESCO, UNIDO and WHO. They collaborate with the relevant national programmes in conducting selection and propagation for either agroforestry work or other kinds of plantings. Their responsibility depends on the specialists involved in promoting the resources. It may range from ethnobotanist right through to processing technologist. The action to be taken by the respective experts may include collection of herbarium specimens, communication, liason with other relevant experts and of course analysis.

Approach to Development of Non-Wood Resources

The development of non-wood resources must be a multi-disciplinary approach carried out by appropriate experts in the national programmes and the funding agencies. This kind of collaboration is essential as it creates awareness on any shortcomings that might happen within any research activity.

Another approach is to look at the three necessities, namely food and beverage, forage and medicine. Product development must therefore be geared towards these necessities as it would be expected to benefit a wider range of people. Products that promise to increase rural incomes and employment as well as provide for these three basic needs should receive highest priority.

The stages of development of a product must be coordinated at every level. New product development can then be identified from within a larger project. Collaboration with other departments or agencies can give/provide a better guide in the process. This can only be done if the present status regarding the product is known pooling information not only from within the diversity of the plants or animals involved, but also that related to the sustainable management of the resources. There is also a need to educate the people to be more appreciative of the value of their own natural resources by strengthening some of the training and research facilities.

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Managing National Forests Of The Eastern United States For Non-Timber Forest Products

by
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Abstract

Over the last decade, there has been a growing interest in the economic and ecological potential of non-timber forest products. In the United States, much of this increased interest stems from drastic changes in forest practices and policies in the Pacific Northwest region, a region that produces many non-timber forest products. The forests of the eastern United States, however, also produce many non-timber forest products. This analysis focuses on the status of non-timber forest products in management plans of the national forests in eastern United States. Of the thirty-one national forest plans examined for coverage of non-timber forest products, only seven plans addressed the management of these resources. A review of national legislation that affects national forests reveals that non-timber forest products are not recognized as a management objective. But, they are considered as "special products" in key policy documents. There is legislation under consideration that could significantly change how these products are managed. This paper identifies and discusses key issues that could affect decisions to manage for non-timber forest products.

Keywords : Non-timber forest products, Eastern United States, U.S. forest service, Forest management.

Background

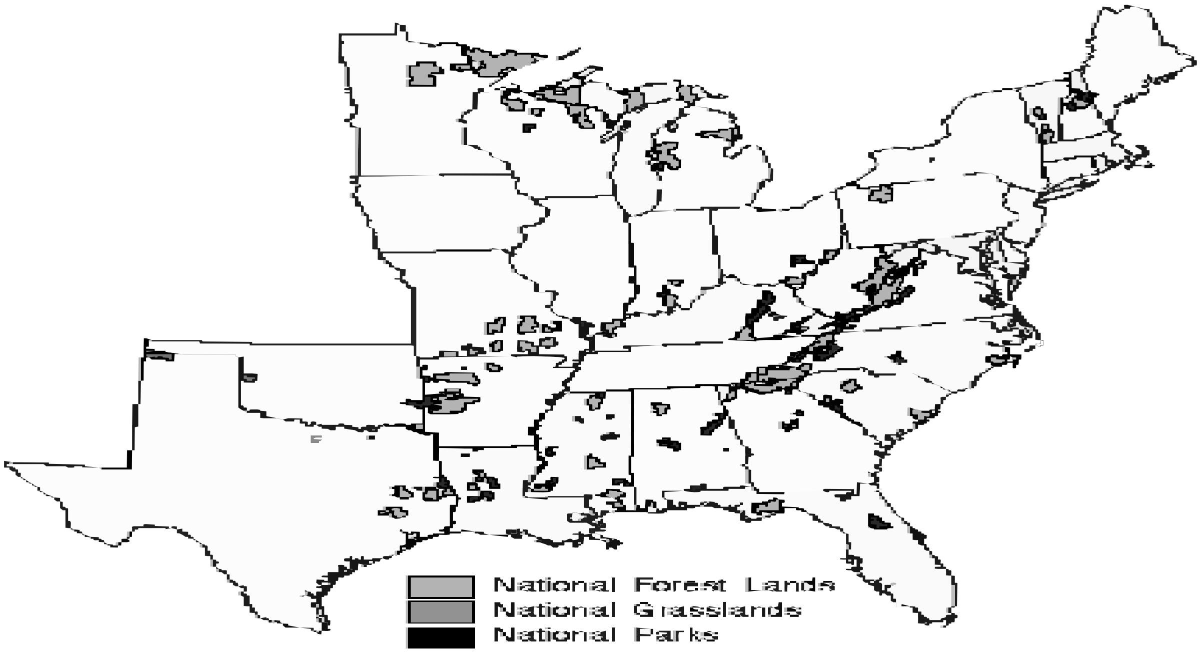
The early inhabitants to the eastern United States brought with them the tools and resources (food, seed, and medicine) needed to sustain their lives. When these stores were depleted, the settlers turned to the forests as the source for many of these essential items. The forests of eastern U.S. are still an important source for many non-timber forest products (NTFPs). Many of the species from which NTFPs are harvested, grow only in the region.

Concern for the management for non-timber forest products has increased, in-part due to the changes in forest policies and practices on the national forests in the early 1990s. With a decrease in logging on national forests, and an increase in demand for many non-timber forest products, there are tremendous possibilities to realize the economic development potential of these resources. At the same time, demand on the forest resources could exceed the capacity to supply non-timber forest products, which could have unfavorable economic and ecological impacts.

The Forests of Eastern United States

The eastern United States has not been the focus of much of the dialogue concerning non-timber forest products, even though the region includes more than 50 percent of the U.S. population and more than half the states. Eastern U.S. hardwood forests are one of the most extensive forests of this type in the world (USDA Forest Service 1984). The biological diversity of some forests of eastern U.S. may surpass that found in tropical and temperate rainforests. The broadleaf forests of the Appalachian and Blue Ridge Mountains ecoregion form one of the most biologically rich temperate forest regions in the world (Ricketts et al. 1999). According to Constantz (1994) "no other region in North America hosts so much living diversity than Appalachia." Figure 1 illustrates the region defined as eastern United States. It includes 33 states, from Minnesota south through Texas and east to the Atlantic Ocean.The eastern states are the source of many forest resources. Most of the eastern States have a high percentage of forest cover and a low percentage of rangelands (USDA Forest Service 1980). All but four of the states have more than 25 % of the total land area in forest.

Figure 1. Eastern United States with National Forests and National Grasslands identified (Adapted from USDA Forest Service 1997)



More than 60 % of the states in the East have more than 50 % forest cover. While the region has low a percentage of land in range, the eastern U.S. forests produced 100 % of the wild-harvested ginseng in 1998, and eight states in the region supplied approximately 85 % (25,739 kg.) of total harvest (Robbins 1999).

Non-Timber Forest Products

Many important products are harvested from eastern forests that are not timber-based, but are plant or fungal based. Various terms have been used to describe these products, including non-traditional, secondary, minor, non-wood, and special or specialty. In many cases, NTFPs are neither minor nor secondary. The collection and sale of NTFPs may be a major source of income for some rural inhabitants. Often, NTFPs are not specialty products, but move through distribution channels as commodities. Many non-timber products have as long of a tradition in human society as do timber products. Hunters and gatherers were collecting edible products from the forest long before they had the technology to cut timber. Some wood-based NTFPs have an important niche in the craft and specialty furniture industry.

Non-timber forest products are plants, parts of plants, fungi, and other biological material that are harvested from within and on the edges of natural, manipulated or disturbed forests. Plants may include fungi, moss, lichen, herbs, vines, shrubs, or trees. Many different plant parts are harvested, including the roots, tubers, leaves, bark, twigs and branches, the fruit, sap and resin, as well as the wood. NTFPs can be classified into four major product categories: culinary, wood-based; floral and decorative, and medicinal and dietary supplements (Chamberlain et al. 1998).

Culinary non-timber forest products include mushrooms, fruits, saps and resins, ferns, tubers and herbs. In many parts of the region, local economies are improved and enhanced by the marketing of edible forest products. Wood-based forest products are considered non-timber if they are produced from trees or parts of trees, but not from commercially sawnwood. For example, burls, twigs, branches, and cypress knees are processed directly into handicrafts, carvings, turnings, utensils, containers, furniture, tools and musical instruments. Floral and decorative products are used in flower arrangements, for wreathes, swags, garlands, roping, as well as in the landscape industry. Plant-derived medicinal products that have been tested for safety and efficacy, and meet strict U.S. Food and Drug Administration standards may be marketed as medicines, otherwise they are legally considered food items and are marketed as dietary supplements.

Eastern United States is the source of many non-timber forest products, some of which are found only in the region. Figure 2 illustrates the geographic distribution of *Cimicifuga racemosa* (Black Cohosh) and *Hydrastis canadensis L.* (Goldenseal), two important medicinal plants (Small and Catling 1999). Though *Acer saccharinum L.* (Sugar Maple) is widely distributed throughout the eastern U.S. (Harlow et al. 1991), the major source of syrup is New England. *Taxodium distichum* (Baldcypress), the knees of which are harvested for woodcarving is distributed throughout the coastal plains of southeastern United States (Harlow et al. 1991). Some states (e.g., Florida) are the primary worldwide sources of important products, such as *Serona repens* (saw palmetto).

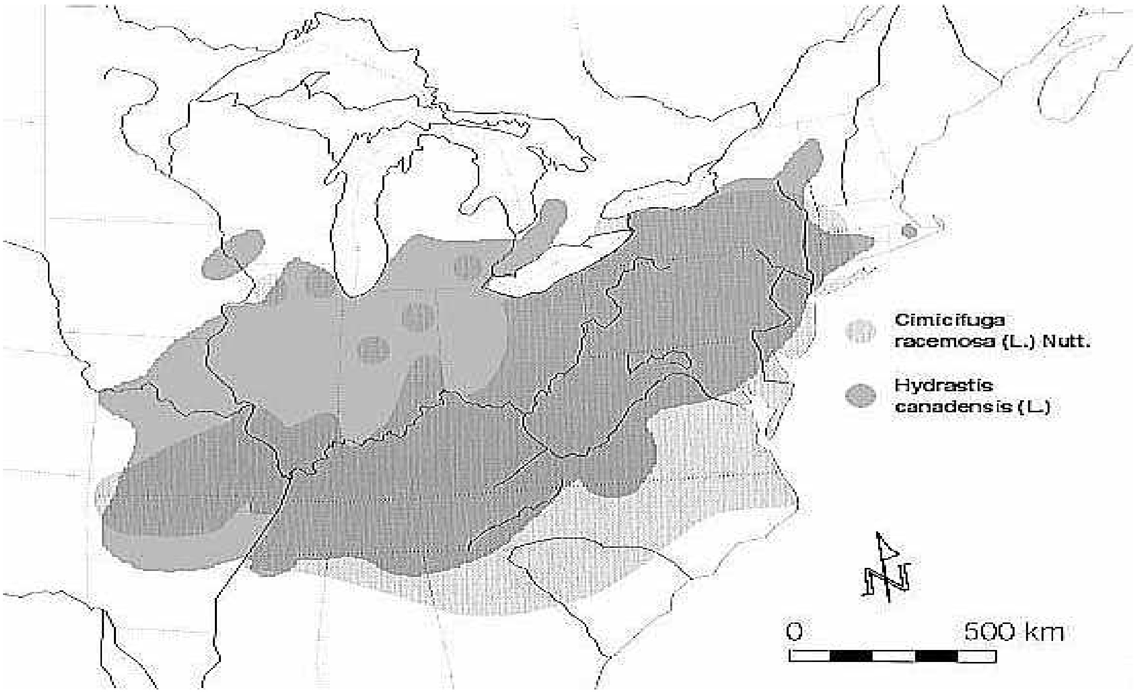
Many species are valued for their therapeutic qualities. Foster (1995) identifies more than 25 tree species, 65 herbaceous plants, and 29 shrubs that have been listed by the U.S. Pharmacopoeia for their medicinal values. More than 500 plant species with medicinal value have been identified in eastern and central North America (Foster and Duke 1990). TRAFFIC North America, a division of the World Wildlife Fund (1999), identified approximately 175 medicinal plants native to North America that are marketed in the United States, many of which are found in forests of eastern United States. Krochmal et. al. (1969) identify more than 125 medicinal plant species that grow in the Appalachian region of the eastern U.S. As the demand for medicinal NTFPs and other products expands, there is potential to realize greater economic benefits, but also potential for increased pressure on the resource base

In the early 1990s, a series of major factors helped spark an increase in interest in non-timber forest products. As a result of major forest fires, bumper crops of edible mushrooms appeared on many National Forests in Oregon and Washington (Freed 1994). Perceiving the potential for economic development and increased revenues, the federal and state forestry departments as well as private companies commissioned market studies on the opportunities for non-timber forest products (Mater Engineering 1992, 1993, 1994).

The findings of medical research also helped to increase market demand for non-timber medicinal forest products (Eisenberg 1993, Le Bars, et al. 1997, Stix 1998). The 1996 estimated value of the global markets for herbal medicines was approximately $14 billion (Genetic Engineering News 1997). Europe was the largest market representing one-half of the global trade. Asia commanded approximately 36 % of the global market. In 1998, the total retail market for medicinal herbs in the United States was estimated at $3.97 billion, more than double the estimate for North America in 1996 (Brevoort 1998, Genetic Engineering News 1997).

The mass-market segment for herbal medicinal products, which constitutes approximately 17% of the U.S. market, is growing at an annual rate of over 100% (Brevoort 1998). The growth in exports of forest-harvested ginseng from 1993 (69,000 kg) through 1996 (191,500 kg) is illustrative of the trend in demand for many medicinal NTFPs (USDA 1999). Though exports of forest-harvested ginseng decreased in 1997 (144,000 kg) and 1998 (109,000 kg), demand for other species continues to expand (USDA 1999). For example, the estimated growth in the mass market for St. John's wort and black cohosh, for the 52 week period ending July 12, 1998, were approximately 2,800 % and 500 %, respectively (Brevoort 1998).

Figure 2. Geographic distribution of two popular medicinal non-timber forest products (adapted from Small and Catling 1999)



Management Agency for National Forests

As steward of the national forests, the U.S. Forest Service has a responsibility to manage for all natural resources found on national forest lands, to meet the public's needs without degrading the environment (USDA Forest Service 1999). Under the National Forest System (NFS), the U.S. Forest Service manages 155 national forests and 20 national grasslands and is the steward of more than 192 million acres of public lands (USDA Forest Service 1999). The NFS is partitioned into 9 divisions, including Wildlife, Fish and Rare Plants, Forest Management, Recreation, Heritage and Wilderness Resources, Range Management, Minerals and Geology Management, and Watershed and Air Management (USDA Forest Service 1997).

The U.S. Forest Service divides the eastern United States into two regions. U.S. Forest Service Region 8 – The Southern Region – includes 13 states (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia). The U.S.F.S. Eastern Region (Region 9) includes 20 north-central and northeastern states. In Region 8, the NFS contains 35 National Forests and 2 Grasslands. These are organized into 17 forest land management planning units (USDA Forest Service 1984). The National Forest System in Region 9 includes 16 National Forests that are organized into 15 management planning units (USDA Forest Service 1983).

No fewer than 82 laws affect Forest Service activities on national forests (Floyd 1999). Four laws provide the main direction on which, and how, the natural resources will be managed. The practice of forest management of the national forests was initiated by the Organic Administration Act of 1897 (U.S. Code 30 Stat. 35). The act directs that forests be established to improve and protect the resources to secure water and to furnish a continuous supply of timber (Organic Administration Act of 1897, U.S. Code 30 Stat. 35). More than thirty years later, the Multiple-Use Sustained Yield Act (MUSYA 1960) authorized and directed the Secretary of Agriculture to manage the national forests to ensure the multiple-use and sustained yield of the renewable surface resources of the forests. MUSYA defines the purposes for which the national forests are established and administered: "outdoor recreation, range, timber, watershed, and wildlife and fish" (MUSYA 1960).

The Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974 institutionalized land and resource management planning in the Forest Service (RPA 1974). The legislation requires the Secretary to prescribe land and resource management planning regulations that incorporate standards and guidelines which are fully integrated into each national forest management plan. In particular, the legislation directs that plans to address recreation and wilderness, range, timber, watershed, and fish and wildlife.

The National Forest Management Act (NFMA) of 1976 amended the RPA to provide additional statutory direction on preparation and revision of Land and Resources Management Plans (LRMPs). The NFMA restated that such plans include "coordination of outdoor recreation, range, timber, watershed, fish and wildlife, and wilderness" (NFMA 1976, section 6 (c)(1)). Plans "determine forest management systems, harvesting levels and procedures in light of all of the uses set forth in subsection (c)(1)" (NFMA 1976, section 6(c)(2)). The LRMP provide management direction through a combination of activities for the use and protection of the natural resources within the bounds of the national legislation. To accomplish this, forest plans: 1) establish goals and objectives for a 10-15 year period; 2) Prescribe standards and guidelines, prescriptions, resources needed, and; 3) monitor and evaluate management impact (White Mountain NF LRMP 1985).

The stimuli for this research are the growing interest in non-timber forest products, and the fact that the forests of eastern U.S. are a major source of many valuable NTFPs. With the full support of the USDA Forest Service, this research is designed to improve our understanding of the status of NTFPs in the management of national forests. The objectives are to determine the extent that NTFPs are addressed in the forest management plans and, to examine policies and legislation that affect management of national forests, for opportunities and constraints to include NTFPs in forest management.

Research Methods

This research adapted a methodology developed to analyze the contents of newspapers, presidential speeches, and other printed material (Holsti 1969, Carney 1972, Krippendorff 1980). The content analysis focused on the forest management plans for the national forests in eastern United States, and measured the area in square centimeters (cm^2) devoted to the management objectives or problem issues identified in the LRMP. Measurements were limited to the discussion (text) devoted to each objective or issue. Measurements were not made of tables and figures, because of the potential to bias the analysis by giving more attention to an objective that required more figures or tabular data. For example, the analysis of timber management requires a large number of volume tables and figures. Also, the units of measurement of tabular data vary tremendously between management objective, making comparisons problematic.

The area of text was measured for three general categories: 1) Natural resources mandated by national legislation; 2) Management objectives identified in the Forest Service Manual (USFS FSM 1998) or as a major public issue, and; 3) Non-timber forest products. Legislation mandates that national forests be managed for certain natural resources: timber, range, minerals, recreation and wilderness, water, and fish and wildlife. In addition, national forest plans address other management objectives as identified in the Forest Service Manual (USFS FSM 1998). These include transportation (e.g., roads), special uses (e.g., power lines, military installations), protection (e.g., fire management, pest control), and facilities (e.g., buildings). Major public issues might include ecosystem management, biodiversity conservation, and old-growth forest. As a management objective, non-timber forest products include discussions about one of the four major product categories.

The research first examined the forest management plans for 31 national forests in eastern United States. Plans that addressed NTFPs to some extent were selected for more in-depth analysis. Forest plan revisions also were examined for coverage of NTFPs. The investigation examined current and proposed legislation and policy analyses that impact national forests management.

Findings

Non-Timber Forest Products in Forest Management Plans

Non-timber forest products are not recognized in national legislation as a natural resource to be included in multiple-use management. In the 1980s when the first forest plans were developed the management of non-timber forest products was not a public issue. Though the markets for many of these products were established, demand on the resources was not sufficient to raise public concern. Even though management for these products was not identified as an issue, seven out of thirty-one national forest plans addressed them to some extent. This section summarizes the extent of coverage afforded to NTFPs in the seven forest plans.

Approximately 23 % of the national forest plans in eastern United States address non-timber forest products to some extent. Seven of the thirty-one national forests in Regions 8 and 9 addressed the management of forest resources for non-timber forest products. Of these, six were located in the eastern region (R9). The only national forest plan in Region 8 (Southern) to address NTFPs at some level was The National Forests of Florida (Florida LRMP 1985).

Table 1 describes the extent of coverage for each of the management objectives addressed in the seven national forest plans that included non-timber forest products. Percent coverage was based on the area devoted to a management objective relative to the total coverage. Overall, the amount of attention afforded to non-timber forest products is insignificant compared with other natural resources. No national forest plan provided NTFPs more than one percent coverage. The amount of coverage provided to legislatively recognized management objectives exceeded 68 %, with the exception for the Hoosier National Forest Plan. Problem issues commanded more than 26 % of each plan. All plans, except for the Hoosier LRMP, addressed management of rangeland resources even though range is a relatively minor resource.

The seven national forest management plans that addressed NTFPs varied in extent of coverage. In general the coverage focused on the recreational opportunities and the research needed to better address these products. Berry production and collection were identified in all but one management plan as a management opportunity. While all seven national forest management plans provide general forest-wide guidance for NTFPs, only three have prescriptions for maintaining or enhancing NTFP production.

Chequamegon National Forest Plan: This plan for this forest, which is located in Wisconsin, devoted approximately 0.4 % of its coverage to non-timber forest products. The primary focus of the coverage was on research needed to better manage NTFPs. The specific coverage dealt with how to restore wild rice beds to their former abundance (Chequamegon NF LRMP 1986). These resources were recognized for their wildlife habitat and for recreational opportunities, but not as a revenue generating natural resource.

Additional coverage was provided to non-timber forest products in the management prescriptions for five management areas. The desired future condition in four management areas was to provide increased access to the collection of NTFPs (Chequamegon NF LRMP 1986, p. 4.108, p. 4.128). One purpose of management area 8.1 was to “create and/or maintain a berry crop” (Chequamegon NF LRMP 1986, p. 4.162). The desired future condition of this management area was to provide for more berry-pickers. The plan recognizes berry picking as an opportunity along with bird watching, hunting, fishing, and trapping.

Table 1. Percent coverage for each management objectives addressed in national forest plans.

Management Objectives	Chequamegon NF (Wisconsin)	Finger Lakes NF (New York)	Florida NF (Florida)	Green Mountain NF (Vermont)	Hoosier NF (Indiana)	Nicolet NF (Wisconsin)	White Mountain NF (New Hampshire)
Legislated							
Timber	25.60%	19.19%	19.32%	17.43%	6.29%	23.46%	15.72%
Fish & Wildlife	12.24%	13.35%	10.41%	12.95%	2.44%	20.19%	12.41%
Water	3.60%	8.86%	7.31%	6.33%	8.45%	3.46%	4.32%
Recreation & Wilderness	24.31%	16.96%	24.67%	21.61%	16.18%	21.57%	34.07%
Range	0.87%	6.11%	3.52%	0.64%	0.00%	0.42%	0.23%
Minerals	3.05%	8.27%	6.66%	9.64%	7.16%	3.02%	4.51%
Total Required	69.66%	72.74%	71.89%	68.59%	40.52%	72.11%	71.25%
Non-Timber Forest Products	0.40%	0.64%	0.08%	0.49%	0.54%	0.54%	0.16%
Not Legislated							
Lands	4.26%	2.94%	9.87%	8.12%	9.83%	6.12%	2.18%
Transport (Roads)	10.52%	5.41%	0.79%	6.73%	6.58%	10.02%	8.72%
Protection	4.67%	7.96%	10.78%	8.82%	7.21%	8.25%	2.40%
Facilities	0.53%	0.70%	4.66%	1.56%	2.53%	0.15%	4.42%
Special Use	0.19%	2.11%	1.25%	1.88%	2.14%	0.12%	0.32%
Public Relations	0.48%	2.70%		0.34%	1.32%	0.38%	0.52%
Research	0.60%	0.44%		0.55%			0.42%
Economics	2.80%						0.84%
Cultural	0.36%	2.07%		1.34%	4.00%		1.10%
Environmental Mgt.	5.37%					1.28%	
Energy	0.16%						
Vegetation Mgt.		2.00%		1.58%	9.21%	0.57%	
TE&S Species		0.28%			1.51%		0.78%
Human Resources			0.70%		2.49%	0.45%	0.29%
Ecosystem Mgt.					0.54%		
Visuals					6.72%		4.17%
Biodiversity					4.87%		
Firewood							2.40%
Total Not Required	29.94%	26.62%	28.03%	30.92%	58.95%	27.35%	28.58%
Total Coverage	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

The Finger Lakes National Forest: This small (13,200 acre) national forest is located in New York state (Finger Lakes NF LRMP 1986). The primary focus of the coverage devoted to NTFPs (0.64 %) was to provide for the recreational collection of blueberries. The plan provided a vision for the management of these resources, as well as prescriptions on how that vision would be achieved. Supply and demand analysis for blueberries provided the general context by which the prescriptions were developed. The major research question defined for this resource was how to keep a desirable mix of blueberry varieties productive with prescribed burns. The plan directed that 5 acres of blueberry patches be provided annually for recreation purposed (Finger Lakes NF LRMP 1986, p. 4.09) and acknowledges the benefits of managing the blueberry resource for forest wildlife. Management prescriptions focused on maintaining and promoting fruit production, including apples. The plan provides forest-wide standards and guidelines for management of this natural resource in accordance with national legislation.

National Forests of Florida: The management plan for the national forests in Florida includes four national forests (Apalachicola, Choctawhatchee, Osceola and Ocala) and covers approximately 1.1 million acres (Florida NF LRMP 1985). The management of NTFPs is afforded approximately 0.08 % of the plan's discussion. The major focus of the coverage was the research needed to develop a way to deal with the expected increased demand for NTFPs, particularly Christmas trees, firewood, and berries (Florida NF LRMP 1985, p. 2-19).

The Green Mountain National Forest: Located in Vermont, the Green Mountain National Forest covered about 325,000 acres in 1986 when the plan was adopted. An explicit goal for the national forest was to "maintain existing areas that provide blueberries for picking and valuable habitat for wildlife" (Green Mountain NF LRMP 1991, p. 4.07). The plan established forest-wide standards and guidelines for the management of fruit and berry production and prescribes eliminating vegetative competition, pruning and fertilizing to maintain productivity. To maintain and increase blueberry production, the plan prescribes burning 1/3 of each patch every 3 years. The plan calls for maintaining 2/3 of each patch in vigorous growth (Green Mountain NF LRMP 1991).

The Hoosier National Forest: This forest is located in Indiana and covers approximately 196,000 acres. During the development of the forest plan environmental pressure on how the Hoosier National Forest was to be managed grew substantially. The well-organized and motivated environmental community was instrumental in directing how the forest resources were to be managed. The low amount of coverage afforded to timber management (6.3 %) is a result of these efforts. At the same time, substantially more coverage is afforded to problem issues in the Hoosier plan (58.95 %) than any other plan.

The original plan (Record of Decision – 1985) for the Hoosier National Forest was significantly amended in 1991 (Hoosier NF LRMP 1991). The amount of coverage afforded to non-timber forest products, in the amended plan, was approximately 0.54 %. The plan recognizes management of mushrooms and berries as an issue of public concern. The discussion professes an abundance of edible forest products on the forest and suggests that some areas have been managed for NTFPs, particularly blackberries. Yet, NTFPs are not addressed in the management areas nor accompanying prescriptions.

The Nicolet National Forest: The forest plan for this 655,000 acre national forest in Wisconsin was accepted in 1986 (Nicolet NF LRMP 1986). The plan provides approximately 0.54 % of the management discussion to non-timber forest products. The major focus of the coverage is forest-wide standards and guidelines that deal with sensitive species. Throughout the forest, "harvesting of ginseng without a permit (Form 2400-14) is a violation of 36 CFR 261.6(h)" (Nicolet NF LRMP 1986, p. 62). District Rangers are directed not to grant permits for harvesting ginseng. Embedded within a table, and therefore not measured as part of the coverage, is a proposed activity to manage 50 acres of blueberry annually.

The White Mountain National Forest: The plan for this 750,000-acre national forest, in New Hampshire, was accepted in 1986 (White Mountain NF LRMP 1985) Non-timber forest products are addressed in the discussion (0.16 %) of forest-wide standards and guidelines. The general direction provided for "other forest products" in the plan is to consider applications for collection on a case-by-case basis. The plan recognizes maple sap, Christmas trees, and evergreen boughs.

Forest Plan Revisions

The National Forest Management Act requires that all forest plans be revised "when the agency finds that conditions on a forest have significantly changed, or at least every 15 years" (NFMA, section 6(f)(5)). Following this legislation, all national forest plans in eastern U.S. should be revised by 2002. Only 13 national forests in regions 8 and 9 have submitted a "Notice of Intent" to revise the forest plan prior to August of 1997 (USDA Forest Service 1999a).

Of the seven national forest plans that addressed NTFPs, four are in the process of, or have completed the plan revision. The plan for the national forests in Florida, the only completed revision, has forest-wide standards and guidelines for special forest products. It designates the District Rangers as the responsible party for establishing appropriate restrictions on the collection of seventeen recognized special forest products (Revised Florida NF LRMP 1999). The Chequamegon and Nicolet National Forests, which are combining efforts to produce one plan for two forests, have the most comprehensive "Analysis of the Management Situation" for special forest products (USDA Forest Service 1998). It summarizes current outputs and activities, assesses demand for special forest products, and recognizes the need to "manage these resources" (USDA Forest Service 1998, p. 10).

1995 Resource Planning Assessment

The 1995 RPA program identifies ecosystem management as the strategy by which the Forest Service can reach the goal of sustainable forest management by 2000. This new strategy will require the Forest Service to "move beyond traditional approaches to include a broad range of values" (USDA Forest Service 1995, p. ES-1). Four fundamental elements (ecosystem protection, restoration, multiple benefits, and organizational effectiveness) are identified as necessary for the success of the strategy (USDA Forest Service 1995).

All of the fundamental elements have direct implications on how forest resources are managed for non-timber forest products. A greater diversity of ecosystems creates potential for greater diversity of forest products. Conserving species before they are protected under the Endangered Species Act helps to assure productive populations of harvestable NTFPs. The use of native species in restoring ecosystems suggests that the gene pool for NTFPs could be conserved. Accelerating natural processes could help to restore NTFP species that have been extirpated from certain forests. For example, Forest Service research efforts to restore the pine/bluestem ecosystem in the Ouachita National Forest may prove beneficial to *Echinacea spp.* (purple coneflower), a plant harvested and marketed for medicinal purposes (Guldin 1999). A priority management activity of developing a system to charge fees for harvesting and using the natural resources that is based on fair market value could significantly change the permit system for collection of NTFPs. Further, an emphasis on restoring and sustaining strong and diversified rural economies could lead to greater assistance to NTFP harvesters.

In the 1995 RPA special forest products are a main concern under the priority management area "economic action programs" (USDA Forest Service 1995, p. III-31) and are identified as compatible with sustainable forest management. The Forest Service uses the term "special forest products" to describe products derived from biological resources, collected from forests, grasslands, and prairies for personal, commercial, and scientific uses. Special forest products exclude sawtimber, pulpwood, cull logs, small round wood, house logs, utility poles, minerals, animals, animal parts, insects, worms, rocks, water, and soils (National Strategy 1999). The RPA commits the Forest Service to "develop these products to strengthen rural communities" (USDA Forest Service 1995, p. III-31).

"One of the most important ways the Forest Service can contribute to special forest products is to collect information" (USDA, Forest Service 1995). This includes identifying and describing the ecosystems and habitats from which NTFPs are collected. Information is needed on defining what materials are collected, the methods of collection, and how much is collected. More economic and market information on NTFPs is needed. Finally, the

RPA recognizes the need for management strategies that include NTFPs to protect the health, diversity and productivity of forest ecosystems.

National Strategy for Special Forest Products

The Forest Service is developing a "National Strategy for Special Forest Products" (National Strategy 1999) that recognizes the need to manage for special forest products. The principles and priority areas set forth in the strategy are intended to provide "a solid conceptual foundation for an action plan" (National Strategy, p. 3). To guide and direct management of the renewable resources that produce special forest products, the strategy establishes five strategic goals: 1) availability within ecosystem limits; 2) integration into forest management; 3) consistent and effective policies and plans; 4) inventory and monitoring of resources; and, 5) collaboration with stakeholders.

National Legislation for Special Forest Products

In February of 1999, the U.S. Congressional Subcommittee on Forestry and Public Land Management convened a hearing to explore opportunities and constraints on increased harvesting of non-timber forest products on national forest land. In October of 1999, there was national legislation in front of the President that could drastically change how the US Forest Service manages national forests for non-timber forest products. The Bill (H.R. 2466) provides for establishment of a pilot program to charge fees for the harvest of "forest botanical products" from National Forest System lands (H.R. 2466, Sec. 339). Forest botanical products are defined as mushrooms, fungi, flowers, seeds, roots, bark, leaves, and other vegetation that grow on NFS lands, but does not include trees. The Bill requires the Secretary of Agriculture to determine sustainable harvest methods and levels and to establish methods to ensure that revenues from the issuance of permits for collecting these products reflect the fair market value.

Though the first round of forest plans did not, in general, address management of NTFPs, there is potential that these resources will receive greater attention in the future. The 1995 RPA provides explicit direction to the Forest Service concerning non-timber forest products. The national strategy on special forest products contributes to the institutionalization of management for NTFPs. The legislation that is under-consideration could provide further acceptance of these products in forest management.

Issues and Implications

Based on this review of forest management plans and polices, a number of key issues are identified that could significantly affect how the national forests are manage for non-timber products. Societal pressures on how, and for what purposes, national forests are managed continue to intensify. Economic issues are driven by demand for the products and include questions of macro and micro scale. Environmental concerns range from the impact that harvesting has on the species to the impact on the ecosystem from where the products were collected. There is a wealth of knowledge on how to mange for timber, wildlife, recreation, and water resources, but in general there is a lack of technical information and expertise for managing for non-timber forest products. How to incorporate NTFPs into the ecosystem management paradigm remains an issue. Institutional barriers must be removed to allow NTFPs to be well managed.

Social

For the most part, the collectors of NTFPs are under-represented stakeholders in the planning process. They are not organized nor represented by any group, but are individuals who may be apprehensive of getting involved in government activities. They may not want others to know how much is collected nor the collection location. But none-the-less, the collectors are stakeholders in how the national forests are managed, as management decisions can drastically affect these people's livelihoods. For some collectors the income gained from the sale of NTFPs could be a major portion of their annual income. Certainly, for many collectors, income generated from NTFPs is "extra money" and is an important component to the overall household budget. A ban on collection of NTFPs, or an increase in permit costs could have significant impact on the collectors' lives. Special efforts are needed to identify the collectors and to get their input. The sustainable management of NTFP resources will require understanding of how these people view and use the resource.

Economic

Unlike timber, the economic value of non-timber forest products, in general, is not well defined. Though the overall value of some sectors (e.g., herbal medicinal) is documented, little information is available on forest-harvested products (e.g., forest-harvested medicinal plants). Defining the value of non-timber forest products at the forest and district levels is necessary to determine sustainable management levels. Though demand figures for some products (e.g., ginseng) are available, in general very little is known about the demand for most products. As a whole, very little information is available on the supply of non-timber forest products. Forest inventory data for NTFPs is generally non-existent. Without accurate information on the supply and demand for non-timber forest products, it is difficult to determine sustainable economic harvest levels.

Environmental

The environmental issues, if not addressed, could result in a management strategy based on protection of the NTFP resources and not conservation or utilization. If the population of a NTFP species degrades to a level that initiates the statutes of the Endangered Species Act the Forest Service would be required to pursue a protection strategy. To manage for conservation and utilization the status of NTFP species can not drop to the level that requires management under ESA. The effect that harvesting has on local plant populations, as well as the impact on the associated ecosystem is an issue that truly affects how the Forest Service manages these resources.

Institutional

To address the issue of technical management of the NTFP resource will require creating new information through research, broadening horizons beyond traditional forestry, and expanding the expertise involved in management. The research needed to develop the knowledge on how to manage for NTFPs is boundless. In general, there is a lack of information within forestry on how to manage the NTFP resources. But, expanding the inquiry to include knowledge of herbal medicine and gardening could provide valuable information on reproducing some NTFPs. The technical management of NTFPs will require more information on the status, characteristics, and requirements of the habitats and species. To include NTFPs in forest management will require developing the expertise to understand the ecology (biological and social) and botany of the natural resource.

From an institutional standpoint, the economics of management must be defined to determine the investment needed to ensure sustainability of the resource. Over the last decade revenues from timber sales, as well as appropriations from the U.S. Congress have decreased. The decline in fiscal support has put tremendous pressure on the Forest Service to deal with the most important issues. The issue of "below-cost" management could impede Forest Service efforts to manage the NTFP resources. At this point, the costs of managing NTFPs may exceed the revenues generated from the sale of collection permits. To incorporate NTFPs into forest management will require either additional fiscal support or a shift of funds from other management objectives.

National legislation is being considered that would lead to increased revenues from the sale of collection permits and development of sustainable harvest levels. But, until NTFPs are recognized as a natural resource, "more important" issues will subsume the amount of effort devoted to managing them. Legislation that recognizes NTFPs as a management objective for national forests, along with those identified in current legislation, would institutionalize management of non-timber forest products.

Conclusions

In the 1980s, when the first round of national forest plans were developed, non-timber forest products, in general, were not recognized as a management objective nor as a issue of public concern. A few national forests identified NTFPs as a resource and incorporated them into management plans. Still, the coverage devoted to NTFPs was insignificant compared to other management objectives. Much of the coverage focused on recreational collection and research needed to conserve the resource base.

Over the last decade, interest in, and concern for, NTFPs has increased drastically. Today, NTFPs are receiving a great deal of attention in natural resource policy dialogue. The U.S. Forest Service is leading the way on defining how national forests will be managed for non-timber forest products. A great deal of research, analysis and support are still needed to have NTFPs fully integrated into national forest management plans and practices.

Non-timber forest products are economically and ecologically important. The collection and sale of NTFPs from the forests of eastern U.S. have local, regional, national and international economic impact. Collection of these products also, may have significant impact on the health of the forests of the region. To realize the maximum economic benefits and to have the minimum ecological impact, the natural resources that produce NTFPs need to be managed.

The Forest Service strategy of managing national forests as ecosystems can not be fully realized until NTFP resources are sufficiently integrated into management plans. The goal of sustainable forest management will remain elusive if NTFPs are not managed as a natural resource. Certainly, the paradigm of multiple-use management needs to be expanded to include these forest products. Perhaps, the ecosystem management paradigm needs modification as well.

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Hiccups/Problems with Inequitable Distribution of Profits from Non-Wood Forest Products and Their Remedies

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Abstract

The nonwood products, or nontimber forest products (NTFPs), have become important forestry outputs as their economic significance is being perceived by forestry experts and policymakers at large, all over the world. For example, some US$ 90 billions worth of NTFPs are extracted worldwide every year. And, more than 300 million people, specially tribal and underprivileged, are dependent primarily upon them for earning their livelihood. This has initiated, and enhanced where initiation had already taken, the process of commercialization of NTFPs. Commercialization has augmented the values of NTFPs on one hand but has also added to the rapid extraction of NTFPs on the other. The enhanced process of extraction of NTFP resources has thus generated large profits for large corporate companies but at the same time have heightened the concerns about subsistence and livelihood for a large poor tribal and low income earning population. The commercialization of NTFPs has thus engendered more inequity and has raised concerns about the sustainable use of the resource in the future.

In the wake of this unequal and unsustainable development, the policy questions that loom large are: How should we develop this resource and how can we benefit the most poor and unprivileged people of the world? Are there some remedies on hand or need to be invented? This paper would attempt to answer these questions and highlight the issues of commercialization of NTFPs and its impact upon the distribution of profit between poor tribal population and the large profit-seeking enterprizes. The paper would delve into various aspects of inequity generated as a result of commercialization and its implications for social welfare. One of the various remedies that can be proposed to attenuate the escalating inequity is to promote NTFP-based small-scale enterprizes in the rural areas. The paper hypothesizes that small-scale enterprises generate income and employment in the local village economy and thus reduce poverty, unlike large companies which export jobs from villages to cities and big business centers of the country or world. The small-scale enterprizes thus generate economic growth with equity, and are also sustainable in terms of scale of operation, and have spill-over effects in promoting entrepreneurship skills among tribal people. The paper would emphasize upon the development of NTFP-based small-scale enterprises, document their characteristics and constraints, and finally list the benefits and costs of developments of small-scale economic institutions. The study would identify various types of constraints and discuss ways to relax them in order to promote small enterprise development, and would explain how to promote entrepreneurship skills among tribal people in rural areas. The study would be based upon the cross-country review of various enterprises and data. Various countries that would be reviewed are India, Pakistan, Indonesia, South Africa, countries covering the Amazon region, Malaysia, and others. Finally, the paper would provide a framework to develop NTFP resource without jeopardizing the welfare of tribal and underprivileged people in rural areas of much of the Third World countries.

Keywords: Non-wood products, Non-timber forest products, Small-scale enterprise, Sustainability

Introduction

During the last 10-15 years, the world at large has discovered the economic significance of non-wood forest products (NWFPs) which were in the past belittled by identifying them as “minor forest produce”. Several studies around the globe now confirm the significance of NWFPs. For example, in India, the recorded revenue from sale of NWFPs was about Rs100 million (US$2.5 Million) per annum in 1958-59 and it has now increased to Rs 20000 million (US$500 million) in 1990s (Shiva, 1998, 35). Further, NWFPs constituted some 13% of total exports of India in 1990-91--one of the major categories of foreign exchange earning commodities (Shiva, 1998, 36). The Indian trade in NWFPs is now estimated to be around US$1000 million (Freese, 1998). In terms of employment, some 500 million people living in and around forest in India depend on NWFPs for their sustenance and supplemental income (Tewari, 1994). Likewise, in Pakistan, the Northwest Frontier province abounds in NWFPs, especially honey and mushroom; and, about US$ 1 million worth of NWFPs are annually harvested (Iqbal, 1991). Large quantities of NWFPs are harvested in Nepal and Bangladesh too. Some US$ 529000 worth of NWFPs are exported into India from Nepal every year (constructed from Edwards, 1993). In Bangladesh, some US$250 million worth of NWFPs are extracted annually from Sundarban region which employs some half a million people every year (FAO, 1999). It is believed that, in the Indian subcontinent alone, the total value of NWFP harvested every year is estimated to be more than US$ 2000 million (personal estimate).

In Southeast Asia, including Indonesia, Malaysia, and other neighbouring countries, the trade in rattan alone is estimated to be more than US$3 billion per annum (World Watch,1991). In Brazil, exports of palm heart and Brazil nuts generate some US$20 million per annum (World Watch, 1991). In the Western United States, several NWFPs are commercialized and play a significant role in the economy. For example, the value of maple syrup production in 1995 was estimated at US$ 25 million, and the value of mushroom production in Oregon, Washington and Idaho was approximately US$41 million (FAO, 1999). In the Eastern United States, the Applachian region abounds in NWFPs; the total recorded value of NWFP industry in Virginia has been estimated at US$ 35 million (FAO, 1999).

In overall, the NWFPs have become a big business around the globe. It is estimated that some US$ 90 billion worth of NWPS are extracted every year (Pimental et al, 1997). Further, some US$ 11 billion worth of NWFPs are internationally traded, and $55 billion worth are traded within the national economies of the world, and the rest one-third is consumed in the local village economies of the world (Tewari, 2000). In terms of employment, NWFPs support more than 300 million people in the world, most of whom belonging to underprivileged and tribal populations (FAO, 1998). These estimates are, however, believed to be rather conservative, the real size of world NWFP economy is believed to be larger than above. The multiplier impacts of the same are hence to be much larger and significant than otherwise thought. The World Health Organization estimates suggest that some 80% of the population of the developing world use NWFPs for health and nutritional needs (Vantomme, 1999).

The wheel of commercialization has augmented the value of NWFPs and made them more profitable to big companies. This has brought mixed sets of results. On one hand, there are large soaring profits that big businesses are enjoying. On the other hand, this is adversely affecting the original user population, i.e., the tribal or indigenous population which primarily depends upon NWFPs for their food, medicine, and income. In turn, it has heightened the concerns about their subsistence and livelihood. The trade–offs are very large. The commercialization of NWFPs has thus engendered more inequity and more poverty and more unsustainable use of NWFP resources.

In the wake of this unequal and unsustainable development, the policy questions that loom large are: Is “big business” approach to develop NWFPs the right one? How should we develop this resource otherwise? Are there some remedies on hand or need to be invented? In the past several studies on NWFPs have expressed concern over the “big business” syndrome among the NWFP sector (Tewari, 1994, Tewari and Campbell, 1995). However, a comprehensive understanding and analysis is lacking. This study aims at fulfilling this gap. The major objective of the study is to throw light on the inequities created by the “big business” syndrome and suggests remedies to thwart the impending dangers. More specifically the study aims at:

1. Understanding the process of “big business” syndrome in the NWFP sector;

2. Discussing the impacts of "big businesses" and concerns of original users of NWFPs;
3. Suggesting some remedial policy measures to thwart the "big business" syndrome;
4. Recommending some operational policy guidelines to promote equitable and sustainable use of NWFP resources.

The Big Business Syndrome

The process of commercialization and formation of big businesses in the NWFP sector are intricately related. The original consumers of NWFPs are the forest dwelling population -- tribal/indigenous in nature – who lived in a subsistence economy. Formal health care was more or less absent and people resorted mainly on to indigenous medicare which used NWFPs intensively. In addition, NWFPs also provided various other forms of food such as wild fruits/berries, etc. and thus, ensuring food security to the tribal population. The NWFPs thus met the personal or household needs of tribal population; resource in general was well protected as there were no opportunities for personal gains in this subsistence economy, finally ensuring the sustainable extraction of NWFPs. For almost many centuries, the cycle of subsistence economy remain undisturbed and exploitation of NWFPs went on a sustainable basis. But things began to change as trade in NWFPs increased around the world. Increasing trade led to the enhanced demand for the NWFP resources. This opened new markets for NWFPs and thus a new alternative to generate income by selling in local and faraway markets emerged. The process of marketization went on over the years and brought three significant changes in the business of NWFPs.

Firstly, the product which were once used by indigenous population are now being demanded in the faraway places in the regional, national and international economies. Most of this demand for NWFPs originates from the developed world including U.S.A., E.C., and Japan. Some 60 percent of annual imports of NWFPs originate from the above three regions (Iqbal, 1995). For example, Brazil produces some 42 thousand metric tons of raw brazil nuts per annum at an estimated value of US$ 34 million; of this total, approximately 80% is exported to USA, Canada, U.K., Australia and Germany (Lafleur, 1992, 1-22). It is believed that some 150 NWFPs are of major commercial significance in the international trade (Iqbal, 1995, 3). Many more would be of commercial significance in the national and regional economies. In other words, the center of consumption has moved from local village economy to faraway national or international economy. Thus, to meet the needs of distant urban consumers, changes in the product quality and information systems were necessitated. Changes in product quality demanded new techniques and strategies for product processing, transport, and storage. Similarly the new information systems which can cover large areas and multiple consumers, producers, and traders were also needed.

Secondly, as the demand for NWFPs increased, the pressures on the resource increased and sometimes reached the threshold of economic extinction. Therefore, to meet the extra demand, some of NWFPs are required to be cultivated or domesticated; thus, a shift in production from natural stands to the domesticated production is happening. A large number of NWFPs are now being domesticated.

Thirdly, during the last 15 years, the world has been swept by many macro changes such as rising wave of privatization or promotion of free enterprise economy, more freer trade and trade liberalization and so on. These changes have imparted more control of resources in the hands of individuals, firms, and other marketing entities, leading to a sophisticated marketing system in the global economy. The marketization of NWFPs has enabled the original user population to harvest the resource for personal monetary gains resulting a shift from local economy to a regional/national/international economy. The change-over to market economy has thus promoted the big businesses to take over the command of NWFP economy. The size of market economy is much larger than subsistence economy thus requires a larger volume of NWFPs to maintain a sustainable profitable business. This leads to the enhanced extraction of NWFPs, often pushing the system toward the threshold of un-sustainable extraction. Various studies done lately confirm this conviction (Tewari, 1999; Singh, 1999; Parameshwarappa, 1992).

Impacts of Big Business Syndrome

As the business in NWFPs grew over time, the small businesses were replaced by large ones because of their better access to national and international markets and better co-ordination of information. This brought a variety of changes which can be classified primarily into two categories; 1) people-related changes, and 2) resource-related changes.

The people-related changes refer to those that affect the people or tribal collectors primarily. People can be impacted in various ways such as by income and employment transfers created by big businesses, promoting migration from centers of production to centers of consumption of NWFPs, reducing food security to local villages, heightening the income differential between rural and urban people, and so on.

Various studies confirm that NWFPs generate income and employment for tribal or indigenous collectors as the business in NWFPs grows (Tewari, 1999; Pimental et al, 1997). This happens primarily by increased labor absorption in collection of NWFPs. The income and employment generation potential is increased tremendously when NWFPs are processed and value is added. Most times this is done in big cities, far away from areas of collection of NWFPs. It is believed that income and employment generation potential through value added activities is many times greater that from sheer collection of NWFPs. The value addition in places distant to rural areas (where raw NWFPs are collected), also exports jobs and incomes to cities. This displacement of income and employment has thus far-reaching effects on rural areas.

Lack of adequate employment opportunities in villages drive people out in cities, contributing to the congestion and more pressure on municipalities. Marketization of NWFPs has also reduced the food security to village people. Prior to takeover of NWFPs by big businesses, ample quantities of wild fruits and berries were available to meet the needs of hungry village people. However, with increased access to market, villagers now sell everything that is available in the forest and try to make as much money as possible. Since the NWFPs are common property resource and tribal collectors do not pay any price for it, the resource is extracted too soon from the forest, and very little is left to meet the needs of hungry people.

Commercialization of NWFPs has also brought a change in the collection strategy. For example, in subsistence economy, individual families harvested plants for domestic use only. But, with market economy, the incentive to collect maximum is high and now 2 to 4 households group together to collect maximum possible for monetary gain (Singh, 1999). Further, people now start harvesting early and end it late, thus stretching the collection period. This finally damages the resource, in particular, its regeneration capacity (Singh, 1999). Besides above, the monetization of NWFPs has widened the gap between rich and poor. The capital-rich large businesses can take advantage of this natural resource whereas the capital poor tribal people can only get a meager income.

The resource related changes entail the over-exploitation of resource and thus has raised concerns for the its sustainability per se. Some of the trends are not fully visible at this time but would be recognized a few years from now and by then most of the damage would have been already done. Many studies confirm this conviction; for example, increased demand for NWFPs has led to the increased pressure on extraction, and, as a result, many NWFPs are on the verge of economic extinction. For example, Salai (Boswellia serrata) gum trees in north Gujarat are diminishing rapidly. During 1970s the average extraction of Salai gum was about 4000 quintals and the total population of economically yielding trees of Salai gum was about 80000. In the late 1990s, the average annual extraction had declined to 1500 quintals and the number of Salai gum trees per hectare declined from 100 to 38 (Tewari, 1998). Kadaya (Sterculia urens) gum trees met a similar fate. During the 1970s, some 2000 to 3000 quintals per annum of Kadaya gum were extracted from north Gujarat. But by the 1990s, there was no collection of Kadaya gum at all and the population of economically yielding trees was basically nil.

Other examples include the extensive loss of Gulmavu (Machlus marcarantha) trees in Coorg and Malanad districts in karnataka, India, due to unscientific or over-exploitation (Parammeshwarappa, 1992). In central India, Mahua trees (Madhuca indica) are burnt repeatedly in order to harvest petals-- this kills the regenaration. As a result, young Mahua trees are getting scarce and believed to be extinct by 2200 (Wasteland News, 1992). Evidence also exist that most medicinal plants in different parts of the world are over-exploited (Joshi and Edington, 1990; Cunningham, 1991; Farooquee and Saxena, 1996).

Remedies : Small is Sustainable and Beautiful

The NWFPs collected by the rural poor are sold out to middlemen or government agencies which sell them in the national or international markets at high prices. Only a small proportion of final price goes to the original users of the NWFP resource. This happens for three possible reasons. Firstly, some NWFPs are bulky and they are transported in raw form to distant markets/collection points; since transportation costs are high, it finally reduces net price to the tribal collectors. Secondly, most collectors have very little knowledge of access to improved processing technologies, which gives high margins to middlemen (Poffenbergen et al, 1990). Thirdly, in many developing countries, the NWFPs markets and marketing channels are not well developed. As a result, the marketing margins are very large for those who indulge in this business. This finally translates into low price to NWFP collectors; but, at the same time, it promotes exportation of jobs and income to far away places.

To boost income and employment in local economy, we need to reverse the process by promoting value addition activities in the local village economy. This would give (a) higher net prices to collectors, (b) stop the migration of rural people to urban areas in search of jobs, (c) improve quality of life in village economy, (d) provide security in terms of food and income. Bringing value addition activities in local economies would also be consistent to sociocultural values of people; for example, recruitment of wood-carvers from far-away places for an urban-based small scale NWFP-based enterprise in Java (Indonesia) did not take the progress too far, mainly because of chronic absenteeism (Karr, 1991).

The best way to initiate value addition activities in local village economy is to promote the small-scale enterprises. Processing adds a considerable value to the raw NWFPs. For example, from experience in West Bengal, it has been noted that Sal leaves grow in value and become ten times more valuable when stitched into plates and pressed with polythene inserts. In the absence of value addition villagers sell raw products at 5 to 20% of market price (Poffenberger et al, 1990). Likewise, Cashman (1987) found that palm oil small-scale processing enterprises, among various income generating activities such as selling cola nuts, fruits, vegetables, meat and fish, maize, locust beans processing and soap making, were the most profitable activity in southwest Nigeria. Also, processed NWFPs fetch higher export prices as well; for example, the value of rattan re-exported from Hong Kong was found to be 17 times higher than the price of raw rattan exported from Indonesia (Business News, 21/10/81). The forest-based small-scale enterprises (FBSSEs) are thus considered to be better for value addition for their efficient handling of collection, processing, and marketing of NWFPs, as opposed to large-scale enterprises.

In the collection and processing of NWFPs, the large-scale enterprises do not have comparative advantage due to their higher private cost of collection and processing; and, at the same time they cause large environmental costs to the society as well (Campbell, 1991). This is because NWFP resources are scattered and hard to reach, thus mass extraction and transfer costs are high, and extraction of NWFPs is less likely to be sustainable. The FBSSEs are seen by local indigenous people, who gather or collect NWFPs, as part of their livelihood strategies. The major objective of FBSSEs is hence to provide a steady or supplemental income and help meet subsistence need of the indigenous people over the long run. On the contrary, large enterprises are interested in short -run profit maximization and may have less or no concerns for sustainable extraction of NWFPs. Large scale enterprises require a large amount of NWFPs in order to break-even, or their minimum scale of output is very large. In addition, the large scale enterprises have a greater propensity to move in and out of the market thus induces instability in the market and uncertainty to tribal collectors.

The higher mobility potential of large scale enterprises also mitigates against the sustainable extraction. As opposed to large business firms, the local people are less inclined to move to other occupations and can operate with small outputs of NWFPs, without destroying the regeneration capacity of the forests. For example, indigenous rattan collectors in Indonesia have been collecting and processing raw rattan out of dense local rain forests for hundreds of years to feed the growing non-wood industry (Campbell, 1991). Similarly, Sal-leaf plucking in West Bengal and in Madhya Pradesh, India, has been found to be a sustainable practice (Deb, 1990). It has been also found that women are more concerned about the sustainability of leaf production than men. For example, women are found to pluck leaves, not to break twigs, so as to preserve the leaf renewal capacity.

Small-scale enterprises are also more efficient in serving local markets, particularly when certain market infrastructures such as roads and other fast communication channels are absent. The small-scale enterprises do well as they have cheaper means of accessory market information and can quickly respond to demand signals received from the immediate processing or manufacturing units. For example, small scale splint and veneer producing enterprises in southern India provide a reliable supply of intermediate goods to thousands of small enterprises scattered within the region. The Sal leaf plates making household industry in West Bengal is mainly run by women and is found to be meeting demand very cost-effectively (Dutta and Adhikari, 1991). The wood carvers and rattan crafts people in central Java (Indonesia) are able to claim a large market share which large mechanized furniture factories could not do (Campbell 1991). This however should not be mistaken to mean that FBSSEs have always got a competitive advantage over large-scale enterprises. For example, the traditional umbrella making industry in Indonesia has become less viable compared with cheaper factory-produced plastic substitutes from Taiwan. Many NWFPs have been marginalized by chemical and synthetic substitutes, and this potential threat may exist for many NWFPs.

Case studies from India, Indonesia, and Latin America and African countries reveal that FBSSEs have some common characteristics. The most common characteristics are their small size and based in household; they are frequently seasonal in nature, providing seasonal employment and supplementary income to local people. All of FBSSEs are labor-intensive and based on simple technologies. In addition, they have low capital requirements. That is why they are accessible to low income and socially disadvantaged groups and are most often managed by women (Campbell, 1991; FAO, 1987).

The small-scale enterprises do not always perform well as they face various types of constraints. It is imperative to take cognizance of these so that a proper environment can be created for them. Various constraints can be classified into six categories: (1) diminishing supplies of NWFPs, (2) problems with access to institutional finance and lack of tax incentives, (3) highly market environments and poor infrastructural support systems, (4) income-sharing problems, (5) poor management capabilities, (6) poor availability of appropriate technology and skills. Knowledge of these constraints is one step towards improving the FBSSEs in the industry (FAO,1987).

As the demand for the NWFPs is rising with increasing trading opportunities, the impacts are being felt on the stocks of NWFP resources too. Some of the NWFPs are being over-exploited. Unlike, in the past, extraction of NWFPs is no longer a part-time activity of many tribal collectors; rather it has become a major source of income to some people and it is a part of a more formal, market oriented enterprise, competing with major forest products such as timber. For example, the Indian match industry is finding it increasingly difficult to meet raw material demand from these timbers also used to produce fuelwood. Similarly, rattan collectors in Indonesia find themselves helpless in fighting against large timber extracting companies which destroy the NWFPs resource base. The long-term survival of FBSSEs depends on well-balanced management plans which limit removals, focusing on growth and regeneration strategies which increase production rates instead.

Although investment in FBSSEs is small, the rural poor have very few assets to keep as collateral, a prerequisite for getting loans from any institutional source of finance. This is because banks are very risk-averse when it comes to financing FBSSEs. Banks should rather use the productivity or income generation potential as collateral and extend loans to the FBSSEs. Tax incentives are also important policy instruments for promoting the small businesses in NWFPs. Any easy access to finance and tax incentives could produce very promising results. For example, the small-scale sector of match industry in India has been very successful on account of government's tax incentive policies (Campbell, 1991).

Markets faced by small-scale enterprises are local, small and uncertain. FBSSEs hence need to be diversified, or swings in demand can destroy their existence because of their very low risk-bearing capacity. Despite instability in demand, they face competition from international markets and from the manufacturing sector in terms of innovating and producing substitutes. Adaptability to new market situations and diversification of activities is therefore essential for improving the risk-taking capacities of small enterprises. For example, due to its adaptability the carved wooden furniture industry in Indonesia has been able to recognize new demand and new designs and has survived. On the other hand, the traditional umbrella and craft industries in Indonesia have given way to plastic substitutes.

Income-sharing within FBSSEs depends upon who owns them. A concentrated ownership is not of much advantage. For example, the ownership of medium match factories in India is concentrated in the hands of 18 families who hire women and under-aged children at very low wage (Campbell, 1991). The lack of government support forces this to continue. The share of NWFP-gatherers in consumer's rupee is very small; a large proportion goes to intermediaries. The NWFP gatherer's share can be increased by checking the exploitation by intermediaries and increasing extraction efficiency through improved harvesting, storage, transport, processing of NWFPs (Wickens, 1991).

The poor management skills are a big constraint and this results into a failure of business; up to 80% of small enterprises go out of business; within five years due to poor management (FAO, 1987). The major reasons for failure is that most times FBSSEs are run by one person as owner-cum-manager who has to deal single handedly with all activities, ranging from creation of enterprise, identification and procurement of inputs, organization of production, finding markets and then marketing, planning future course of action, etc. Also, unlike large enterprises, FBSSEs do not have hard market data, and planning very much rests on intuition and causal understanding of market factors. A large number of FBSSEs (up to 10 workers) do not use machinery and depend upon simple tools (El-Namaki, 1987). As a result, their labor productivity is very low, which in the long term hampers the growth of FBSSEs.

Required Policy Initiatives

From the above discussion, it is obvious that promotion of FBSSEs would meet the objective of securing more equitable distribution of profits and also sustainable extraction of NWFPs. The major concern hence is to outline policy measures which would promote the development of small-scale enterprises. A five-pronged strategy is suggested. This would certainly require initiatives and efforts from governments of respective countries. The strategies include: (1) transfer of management and organization skills to the collectors of NWFPs; (2) promotion of value addition activities at the local and regional level; (3) improvement in marketing channels so as to pass benefits on to collectors of NWFPs; (4) exploring the regional and national markets; and, (5) strengthening the local institutions.

The first and foremost strategy for regenerating the FBSSEs is the development of skills among the rural people. Many collectors who pursue the small-sale enterprises do not have the skills required for running a business; these include skills of organization, marketing, and bookkeeping and so on. This is because many of these collectors are iliterate and not exposed to the outside world. The non-governmental organizations ot NGOs can fulfil this role .

The second most important task is to promote the value addition activities in local village or regional economy, thus saving the exportation of jobs and income to faraway areas. This also gives a higher net price to the local collectors. The value can be increased by sorting produce by quality grades or by performing simple value adding operations such as separation of dirt, pulverizing, powdering, and making tablets and so on. For example, the Gujarat State Forest Development Corporation (GSDFDC) in India enforced the standardization and grading of NWFPs and thus passed on large benefits to tribal collectors. It is interesting to note that price differential between lowest and highest grade of of NWFPs varied from Rs 55 per quintal in the case of Doli (seeds of Madhuca indica) to the highest of Rs 1383 per quintal for Musli (Cholorophytum tuberosum) (Tewari, 1999). Similarly the GSFDC undertook various simple processing operations on NWFPs of medicinal value and at times this resulted into as high as 4000% increase in the value of raw NWFP through simple technology (Tewari, 1999). Another good example is the efforts of Kalahan Educational Foundation (KEF) in Philippines. In 1980, the KEF members started a food processing center and began making jam and jellies from forest fruits, with an intention to capture 10% of the high-end market in Manila. By 1995, the center was providing cash incomes to some 150 local families (Rice, 1995). Several such success stories exist and teach us that local processing is a key to the sustainable management of NWFPs.

The third important change is to revamp the marketing system. Currently there exist many middlemen in the marketing chain from collectors to final consumer. This finally reduces the net price to the NWFP collectors as marketing margins constitute a big proportion of consumer's price. The higher marketing margins can be associated with high risk involved but they can be exploitative if middlemen use their bargaining power to their advantage. In these circumstances, the co-operative or community-based enterprises have worked better. For example, the trade in medicinal plants in Nepal is very large to the tune of US$10 million per annum but large benefits from this in the past had gone to the middlemen and least to the collectors. So much so that some of the species are believed to be locally extinct. An important herb , known as Jatamasi (Nardostachys grandiflora) was saved by a concerted action by local people with the assistance of a non-governmental organization. The locals took control of the market by processing it locally and thus cutting the large margins charged by middlemen (Taylor, 1999).

The fourth most important strategy is to explore the regional and national markets. International demand alone is likely to yield short-term benefits unless the product in question is well-established. Search for regional and national markets can be more rewarding, for it is cost-efficient and hassle-free. Regional markets can thus serve as key to the NWFP trade (FAO, 1995). For example, Amla (Emblica officinalis) a fruit tree which grows in the forests of Gujarat, India, is an important NWFP; tribal collectors sold its raw fruits at a very low price as they could not store it long. But, once they learn to dry the fruits, the prices climbed up. Thus, simple processing allowed them to store it long and also to sell their produce throughout the province of Gujarat (Tewari, 1998). Neem (Azadirachta indica) is another example; previously Neem seeds were purely crushed for oil but when their insecticidal properties were later discovered, a large regional market was exploited. Similarly, in Cost Rica, traditionally the bitterwood (Quassia amara) was used for medicinal uses; later it was found to be a source of a bio-insecticide and strong demand existed for this in the region. But, its extraction was found to be unsustainable for the export purposes (Taylor, 1999). In Thailand, the extraction and processing of catechu (Acacia catechu) flourished well when they found a regional and export market in India(Wanida et al, 1993).

The fifth most important strategy is to provide a set of local institutions which can help the change to take place in the rural setting. The strong local institutions and supportive national policies are crucial for making small-scale enterprises a success. Strong community-based traditions are a plus factor which augur with the success of local businesses. These can be in terms of some collective and co-operative venture.

Summary, Conclusions and Guidelines

Non-wood forest products have become an economically important output in terms of their economic significance and trade. It is estimated that some US$ 90 billion worth of NWFPs are extracted every year and some $13 billion worth of products are traded internationally. However, the commercialization of NWFPs have benefitted more the big companies than the poor collectors who depend on NWFPs for their livelihood and food security, and medicine. The rights and privileges of these collectors are hence encroached by big companies and no mechanism exits for resolving this issue. Commercialization has thus engendered more inequity and more poverty and more unsustainable use of NWFPs. These symptoms-- inequity, poverty, and unsustainability-- are part of, what I would define as, the Big Business Syndrome. The big business syndrome is characterized by increasing value addition away from the center of production, increasing monetization of the resource, and increasing poverty and inequity in the local village economy, increasing unsustainable extraction of the resource as such.

The forest-based small-scale enterprises are suggested to be a solution to counter the impacts of big business syndrome. For various reasons the small-scale enterprises are considered to be more efficient than large scale enterprises and they are also found to be using the NWFP resources on a sustainable basis. However, they are besieged with various constraints such as access to credit, poor management capabilities, uncertain markets, and so on. But they can be made effective if sufficient policy initiatives are taken. A five pronged strategy is suggested to increase the share of small-scale enterprises in the profits from NWFPs and manage them on a sustainble basis. These include: (1) transfer of management and organization skills to the collectors of NWFPs; (2) promotion of value addition activities at the local and regional level; (3) improvement in marketing channels so as to pass benefits on to collectors of NWFPs; (4) exploring regional and national markets, and (5) strengthening the local institutions.

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Non-Timber Forest Product-based Enterprise in Forest Conservation and Community Development: India's Evolving Institutional Context

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Abstract

Non-timber forest product-based enterprises have been viewed as possible vehicles for reconciling the livelihood needs of forest dependent populations with the larger societal goal of sustainable forest management. In India, village-initiated efforts and state-sponsored programs for collective forest protection during the past decades are reconfiguring the context and institutional landscape for such enterprise. Increasingly, local institutions for forest management are becoming focal points for village development and resource governance. Proceeds from NTFP sales, fines and fees from a variety of products from village protected forests are also creating pools of common funds which are becoming significant sources of liquidity and investment capital for rural enterprise.

Despite their appeal and considerable promise, experience in India and other countries has shown that relatively few conservation-oriented NTFP enterprises have become viable. It takes time and in most cases, subsidies, especially during the early years for an enterprise to achieve viability. Fewer still have demonstrated significant equity and poverty alleviation impacts and for many, their conservation benefits remain unproven. In many cases, economic success has resulted in resource over-exploitation since generally low levels of capital and skills requirement often make them contestable. High returns tend to invite new entrants and increase pressure on NTFP resources unless rights of access are clear and enforceable. For these enterprises to achieve their multiple goals, complementary developmental inputs and strong policy support are essential.

Keywords: NTFP enterprise, Conservation, Collective action, Cooperatives, Community and economics

Introduction

The potential of non-timber forest product (NTFP)-based enterprise to reconcile the livelihood needs of forest-dependent populations with the larger societal goal of sustainable forest management has been the subject of much discussion during the past decade. Reasons often cited for their potential derive from the observation that many NTFPs: involve non-destructive harvesting of annually renewable plant parts; depend on intact forest systems for their continued viability; tend to be small-scale, spatially and temporally dispersed; and usually engage people from the poorest socio-economic groups (FAO 1995; Perez and Arnold 1995). The growing recognition that knowledge of NTFPs is integral to local cultures and to the character of local ecosystems has also raised interest in patterns of resource use that are at the same time economically profitable, empowering for local people and affirmative of their cultural heritage (Gupta et al 1995; Malhotra, 1998). This thinking has developed in tandem with the idea that forests need to be sustainably managed for both timber and non-timber products to satisfy the needs of multiple users. It fits comfortably with the two-decade-old paradigm of participatory, decentralized management of common property natural resources at a time when greater market liberalization worldwide holds out the promise of significant economic returns (Isaak, 1999). Moreover, it intersects an on-going shift in international development thinking, namely, the refocusing of developmental goals from poverty alleviation to sustainable livelihoods and asset creation (Jazairy et al 1992; Robinson and Tinker 1998; Granfelt 1999). In this reformulation, particular attention is paid to a class of intangible assets such as institutions and social networks, which provide poor people with instruments of empowerment and expanded economic opportunities, thus enabling them to collectively improve their livelihoods and better manage their natural resource base (Bebbington 1999). Within this conceptual landscape, conservation-promoting, NTFP-based enterprises that can be managed profitably and sustainably by local communities and forest-dependent households find a very hospitable niche.

However, while recognizing the attractive features of the concept of inter-linking livelihoods and conservation through enterprise, a number of concerns have been raised about the possible adverse implications of commercializing NTFPS, especially those that are key inputs to household production. Commercialization and the prospect of increased returns could attract more powerful groups into NTFP-based activities at the expense of women and disadvantaged groups (Dove 1994; Perez and Arnold 1995). For many NTFPs, the long-term outlook may not be optimistic because of competition from lower cost synthetic products or higher quality substitutes. Demand and market sizes for some NTFPs may fall as consumption standards or incomes rise if the products are considered "inferior goods". On the other hand, NTFP-based activities with good prospects for growth and returns often require levels of skills and capital investments that the poorest segments of the community may not possess (Arnold and Townson 1999). Local markets for NTFP products tend to be thin, while markets farther away, including international "green" markets, tend to be volatile and unreliable (Hyman 1995). Sustainability is an amorphous concept that is not easily marketed to final consumers who, in most cases, are unwilling to pay price premiums for conservation (Rice and McLean 1999).

Given that the bulk of NTFPs traded worldwide are still collected from the wild, questions are increasingly being raised about the validity of the implicit assumption underlying conservation-promoting NTFP enterprise, i.e., that NTFP stocks are sufficiently abundant to withstand increased harvesting. The ecological and genetic diversity impacts of long-term harvesting especially when the enterprise involves collection of roots, fruits, seeds or whole plants are issues of concern (Godoy and Bawa 1993; Peters 1997). Several authors have noted that even in the absence of destructive harvesting, the collection of commercial quantities of fruits and seeds can cause notable changes in the structure and dynamics of a plant population (Hall and Bawa 1993; Peters 1994; Murali et al 1996; Muraleedharan et al 1997; Muraleedharan et al 1999). Data showing that in the case of some species even small-scale harvesting of foliage and twigs can lead to regeneration failure if done continuously over a long period of time (Singh 1998), lend credence to some of these questions. The numerous cases of failed conservation-oriented enterprises have prompted others to call for a rethinking of the concept (Oates 2000).

Indeed, available evidence suggests the difficulty of simultaneously meeting livelihood and conservation objectives through enterprise. Results from two recently completed cross-country studies indicate that many factors determine the economic viability and conservation outcomes of NTFP enterprises. A multi-dimensional analysis of NTFP enterprise cases from nine countries showed that resource conservation goals can be achieved only under certain circumstances. Successful outcomes tend to be associated with: positive state-sponsored regulations that offer clear and well-known rights to people; a harvesting intensity and/or technique that does not put excessive pressure on the resource; a transparent market; well-organized gatherers; and the existence of external support groups (Perez and Byron 1999). Similar conclusions were drawn from the Bio-diversity Conservation Network's seven-year experiment with twenty projects on bio-diversity conservation through enterprise development in seven countries in Asia and the Pacific (Salafsky and Margoluis 1999; Salafsky et al 1999). Their results indicated that an enterprise strategy can lead to conservation, but only under limited conditions, and never on its own. Factors that influenced enterprise viability included: good book-keeping skills; working in markets that are established but not too competitive; good market research; and focusing on simple enterprises that used skills local community members already possess. Their findings showed that local involvement in the enterprise and effective conservation were strongly associated and that cash incentives may not be as important as non-cash benefits as initially supposed. Among the major lessons learned was the importance of providing complementary development work and environmental education to enhance enterprise viability and conservation success. That an enterprise strategy may need to be subsidized yet still create a net gain for conservation was another important lesson.

Over the past decades, attempts have been made in India to promote conservation-oriented, collective NTFP enterprise schemes that included developmental elements to varying extents and with varying degrees of success. While initial efforts were organized around state-initiated cooperatives with a pronounced focus on livelihood generation, later efforts increasingly involved non-governmental organizations (NGOs) as facilitators and intermediaries between local communities and state agencies within collaborative forest management arrangements. This paper discusses the evolving context of collective NTFP enterprise in India and emerging opportunities for more effective linkage among economic empowerment, community development and sustainable forest use. It highlights a few enterprise cases and draws wider implications for policy.

Context of NTFP Enterprise in India

The collection, processing and trade of diverse NTFPs has been an important, although until recently, largely unrecognized sector in India's economy. The NTFP sector is estimated to contribute more than 50 % of total forestry output value and 70 % of export earnings. It generates over 1600 million person-days of employment annually, mostly through household or small group-based NTFP collection from public forests and trading involving mainly women and forest-fringe dwelling tribal populations (Khotari et al 1998). Earnings from NTFP enterprises contribute from 5 to almost 60 % of total household income (Shiva and Mathur 1996). As in other countries, NTFP enterprises are a key component in Indian rural households' multiple sourced livelihood strategies. The income they provide, though meager, is critically important especially during lean agricultural periods and times of famine. NTFP enterprises are typically seasonal, small-scale, undertaken within complex, usually conflict-ridden conditions of resource access, dependent on individual or household labor, use relatively simple technology, mostly oriented to local markets, and generally non-remunerative (Tewari and Campbell, 1995). They are usually labor intensive and have limited overhead costs, fixed assets or raw material inventories. With labor as the most significant input, NTFP enterprises tend to be contestable. High rates of profit invite new entrants and increased pressure on the resource unless there are effective institutional safeguards and clear, enforceable rights of access.

Out of the 16,000 recorded plant species in India, 3000 yield NTFPs. Except for NTFP species of high commercial value, most (about 60 %) are consumed locally. Those that are traded are mostly sold or exported in their raw form with little, if any, value adding processing (Shiva 1998). There is considerable scope for increasing NTFP utilization and for adding value to already traded products. But lack of access to capital, markets and market information; weak technology and extension support; inadequate storage and transport facilities; and depleting or unreliable raw material supplies have been serious constraints. In the absence of alternative means, most NTFP collectors and entrepreneurs are locked into highly exploitative relations with middlemen who are often their only source of inputs and their sole gateway to more distant markets. NTFP collectors' share in their products' market value typically ranges only between 10 and 20 %, even much lower in the case of perishable commodities (Shiva and Mathur 1996; Verma 1998). The lion's share goes to middlemen, mostly in the form of monopoly profits. These iniquitous arrangements, in turn, have encouraged resource over-harvesting especially when combined with pervasive policy-induced insecurity in NTFP access rights and strong competitive pressures from other collectors.

Ostensibly to protect both collectors and NTFP resources from over-exploitation, state governments have organized NTFP enterprise around the idea of cooperatives and have taken over the marketing of the most commercially important NTFPs. Between 1970s and 1980s, the Indian government nationalized key NTFPs such as mahua (*Madhuca indica*), tendu (*Diospyros melanoxylon*) leaf and sal (*Shorea robusta*) seeds, making trade in these and other nationalized products a monopoly of the state. Regulations on processing and transport were also put in place for some products. State forestry development corporations (SFDCs) were created to manage NTFP collection, marketing, resource conservation and development and to help ensure fair prices for collectors. In addition, the SFDCs were supposed to provide training in resource management, credit and other inputs. To harness the unified strength of NTFP collectors, the government encouraged the formation of NTFP collectors' cooperative societies and apex organizations and the adoption of a system of cooperative governance of NTFP resources at the village level. Since the mid-1980s, many tree growers' cooperative societies were also created for watershed rehabilitation and afforestation on degraded lands to satisfy local fuel, fodder, small timber and other NTFP needs. Cooperatives could bid for SFDC contracts to harvest nationalized NTFPs. Contractors would then pay state governments royalty on the NTFPs they collect. Through this system, in theory, cooperatives could generate employment for their members, have a ready buyer for their harvests, and in some cases, receive bonuses based on the values realized from NTFP sale.

Although notions of democracy, autonomy, self-governance and self-reliance are often thought to permeate the cooperative ideal, ironically, in practice, instead of being voluntary, member-led institutions, many cooperatives in forestry are state-funded, bureaucratically controlled, inefficient and non-transparent set-ups with little accountability to their members (Jain and Coelho 1996; Singh and Ballabh 1996). Participation by members is often limited to merely serving as hired laborers. Through a system of patronage and sub-contracting to private agents, state monopoly has generally translated into private monopolies by influential individuals. Except in a few states, the system of state monopoly and NTFP cooperatives has proven to be largely ineffective from the standpoint of both livelihood enhancement and resource conservation.

Evolving Institutional Landscape

Village-based efforts and state sponsored programs for collective forest protection initiated during the past decades, however, are now slowly reconfiguring the Indian institutional landscape and the context for rural enterprise. The numerous self-organized village-based forest protection groups that have emerged to counter severe forest products shortages, while far from ideal, are probably the closest approximation of the cooperative concept. Their membership tends to overlap with that of village level NTFP collectors' and other forestry-related cooperatives. They are estimated to number in the tens of thousands, with at least 10,000 in the state of Orissa alone. In some states, they have begun to federate for purposes of conflict mediation and policy advocacy on behalf of their members, often with the support and facilitation of development-oriented professionals and NGOs. In Orissa, they are demanding ownership rights over state forests which they have been protecting for decades (Mahapatra 1999). Some are venturing into livelihood augmenting activities, such as collective NTFP marketing and trading.

A similar pattern of evolution is becoming increasingly apparent among village institutions set up during the 1990s in the context of collaborative forest management programs, notably Joint Forest Management (JFM) in degraded forests and Eco-development (ED) in protected areas. JFM and ED have been the main vehicles for implementing the concept of people's participation in forest management articulated in India's National Forestry Policy of 1988. Both programs involve a formal agreement between state forest departments and village-based groups which protect degraded public forest lands from fire, grazing and unauthorized use in exchange for usufruct rights to non-nationalized NTFPs and, in the case of JFM, a share in timber harvests. Currently, there are an estimated 35,000 JFM groups protecting 7 million hectares of degraded forests. Many of the JFM and ED groups have benefited from the assistance of NGOs in group formation, leadership training, resource management planning, basic book keeping and organizational management, and in forging links with government agencies and external partners. Where NGOs are absent, foresters have often performed some of these functions.

In some locations, neighboring groups have federated and are beginning to carve out niches in the NTFP economy (Raju 1998; Mahapatra 1999). For example, in Gujarat, SAKSHAM, a state-wide federation of 12 federations consisting of village forest protection groups and tree growing societies, has been formed to advocate the cause of grassroots institutions engaged in forest protection and management. With a combined membership of 49,000 men and women protecting nearly 53,000 hectares of forest and wastelands, and a strategically designed program for peer learning, capacity building and advocacy, SAKSHAM is becoming an increasingly important force for the political and economic empowerment of its members (VIKSAT 1999). High on SAKSHAM's agenda is a campaign for greater share in the NTFP economy through increased contracts for member-federations to become SFDCs' NTFP collection agents. Through federation-formation, it is becoming increasingly possible for forest protection and NTFP collectors' groups to achieve economies of scale in production and marketing and to improve the efficiency of technology access and application. Albeit still limited, public and private research and development efforts have yielded a wide range of technologies that can be adapted for NTFP processing (Shiva and Tangri 1996).

Where collective action has been effective, degraded forests and wastelands have begun to regenerate. From 1972 to 1995, the area of regenerating forests nation-wide increased by 14 % or about 7.82 million hectares (CSE 1999), largely due to village-based protection. Participatory monitoring of vegetation changes conducted by villagers and NGOs in several states indicate generally increased availability and diversity of NTFPs in different types of forests. Effective village forest protection, self-regulation and management are also contributing to increased liquidity and savings in rural areas, thus, helping to somewhat relax the credit constraint on entrepreneurship. In many states, village funds are being accumulated from fines, penalties and sales of timber and NTFPs. Investments made using these common funds have not been limited to forestry, but have included road construction, school building, drinking water facility installation and other village development projects (ETS 1999).

In many villages, self-help savings and credit groups (SHGs) which mobilize members' savings for revolving loans have also been formed to complement JFM and ED programs. For example, in Andhra Pradesh, all 115 villages covered by the ED program in and around the 11,000- hectare Srisailam Tiger Reserve have at least one SHG. The 362 SHGs operating in the area serve around 5500 members and together have accumulated net savings of Rs. 2,040,530 (US$48,600) (AP SFD 1999). These pools of funds represent significant resources in a country where per capita income is only Rs 11649 (US$ 277) per year. SHG funds are usually deployed for emergency needs or invested in individual assets and small businesses, including NTFP enterprises. Although SHG savings tend to be limited and often unable to provide enterprise capital requirements beyond a small scale, through these funds, villagers are increasingly able to qualify for matching funding from the formal banking sector under the Indian government's various livelihood-oriented loan programs. Hence, they are widening the space for NTFP enterprise and other more profitable activities. In addition, they are facilitating empowerment through enhanced financial autonomy especially for women. Building on these institutional and technical possibilities, a number of innovative enterprises designed for mutually advantageous, resource conserving partnerships between the business sector and grassroots federations are now in the process of development (Boaz 1999; Phansalkar 1999). Recent legislation that vested village assemblies in predominantly tribal areas with ownership and management authority over NTFP resources, if implemented, could further expand the scope for such enterprises in the future.

Enterprise Cases

The increased supply of NTFPs from regenerating forests, more effective local institutions for forest resource planning and management, stronger leadership and organizational capacity, expanded networks and alliances, growing pools of investable funds, and increased access to technical, financial and marketing support are making NTFP-based enterprise increasingly feasible. But whether or not they would also result in greater resource protection remains an open question. Previous experience with state-initiated and NGO-facilitated NTFP-enterprises has shown that it takes time and, in most cases, subsidies, especially during the early years, for a collective enterprise to reach economic viability. An enterprise can be economically profitable and provide enhanced employment and income, yet fail to mitigate, and sometimes even encourage, resource depletion. The ability of groups to effectively manage their common resources and enforce their rights in the face of increasing contestation crucially determines outcomes. This, in turn, depends to a large extent on the policy environment and their web of alliances that could be mobilized in times of need. While early state-initiated efforts tended to be paternalistic in their approach, NGO and private sector efforts that have come up in recent years have tended to emphasize capacity building to enable communities to better manage their resources and interface with the market. This difference in approach is illustrated in the following cases which also underscore the difficulty of meeting multiple goals of economic viability, resource conservation, equity and empowerment.

Kerala Tribal Cooperative Societies. After the state of Kerala granted its tribal population exclusive rights over NTFP collection in 1978, Tribal Service Cooperative Societies were established to ensure that collectors receive fair prices for their products. In 1981, a federation of cooperative societies was formed and entrusted with the right of monopoly procurement and sale of all NTFPs collected by the societies. All decisions relating to collection, allotment of territories to be harvested, setting royalty payments and purchase and selling prices of collected NTFPs, are made by a committee chaired by the state's Chief Conservator of Forests. Acting on the instruction of the committee, the federation's branch managers and the State Forest Department's Divisional Forest Officers award collection contracts to cooperative societies which in turn employ tribal people to harvest specified types and quantities of NTFPs.

Although the cooperative societies merely act as collection agents with no resource management authority, collectors have nevertheless benefited through increased employment and income and improved product prices (Thomas 1996). Total quantity of NTFPs collected and marketed by the federation increased from 3 to 24 million kilograms between 1982-83 and 1997-98. Data from the Kerala Forestry Research Institute's long-term socio-economic and ecological monitoring in two forest divisions indicate a similarly increasing trend of collection and marketing for many individual NTFPs within individual cooperative societies, as well as a fairer distribution of proceeds from NTFP sales. Payments received by collectors for different NTFPs on a per kilogram basis increased by as much as 190 to 4200 %. However, because of high rates of inflation, collectors' real incomes rose only up to 239 % [Muraleedharan et al 1999]. While the federation has not been immune to unexpected price fluctuations, which have caused losses from certain products in some years, it has generally been able to make profits from NTFP marketing.

However, rising NTFP prices and market demand have led to dramatically increased harvesting not only by authorized tribal collectors but also by illegal, non-tribal private collectors. The lack of members' participation in the functioning of their cooperatives, their inability to fend off illegal collectors, and more attractive procurement prices offered by private traders, have given the latter effective control of about 40% of the market with virtual monopolies in some locations. Only half of the commercially exploited plant species were found to still have reasonably good density and population distributions. Regeneration rate was found to be negatively related to harvest intensity and to be high in vegetatively propagated species, but poor in seed propagated species. The regeneration index of species propagated vegetatively was 100 % even when harvest was as high as 95 %, but in seed regenerated species, a harvest rate of 35 to 50 % would be the sustainable limit (Muraleedharan et al 1997). The combination of intensive commercial harvesting and poor regeneration, especially of species regenerated through seeds, has apparently negatively affected biodiversity in the study areas. A similar scenario can be drawn from detailed analysis of the SFDC and NTFP collectors' cooperative societies in Gujarat (Tewari 1998).

Tree Growers Cooperatives. The National Tree Grows Cooperative Federation (NTGCF) is a national level apex organization established in 1986 to provide technical inputs, marketing and liaison support to village-based tree growers cooperative societies (TGCS) which are its members. It is a non-governmental, membership organization governed by an elected board of directors composed of representatives from state-level TGCS and from the National Dairy Development Board. Through a proactive campaign for environmental education, organization and training, the NTGCF has established over 520 TGCS in six states with total membership of almost 40,250. Together, they have revegetated more than 10,720 hectares of mostly state-owned wastelands leased by the societies for plantation of timber and NTFP species.

Funds for the TGCS are raised through membership fees and issue of shares as well as through loans, donations, subsidies and grants. The NTGCF provides each newly organized TGCS with a loan of Rs. 458,000 (US$ 10, 900) to establish mixed tree plantations. Profits earned by the TGCS from sale of members' produce are allocated as follows: 25 % for its reserve fund; up to 12 % for shareholder dividends; and a certain amount stipulated by law for a cooperative education fund. Out of the remainder, 65 % is proportionally distributed as bonus to members based on the value of products they sold through the society; 10 % as bonus to TGCS staff; 15 % for a soil, water, energy conservation and wasteland development fund; and 5 % for cooperative promotion and publicity. Resource conservation, economic incentives and social responsibility are thus tightly intermeshed in this program which Singh (1999) rated highly in terms of economic efficiency, equity, people's participation and sustainability. However, a typical TGCS will take about 15 years to achieve financial viability and will most likely need subsidies during the initial years. But Saxena and Agrawal (1997) argued that conventional financial accounting does not capture the value of environmental services produced by TGCSs and, hence, provides a distorted assessment of their worth. Using an expanded accounting framework, they showed that a TGCS with a financial net worth of only Rs. 7089 (US$ 170) was in fact worth Rs. 568,000 (US$ 13,525) when the value of its social and environmental services are considered.

Soliga Enterprises. The Vivekenanda Girijan Kalyan Kendra, a community development-oriented NGO working with other NGOs and university-based researchers, established a cluster of NTFP enterprises in the Biligiri Rangaswamy Hills, a 540 sq. km. sanctuary populated by the 4,500-member Soliga tribe in the state of Karnataka. The first enterprise, a 30-ton capacity honey processing unit (HPU) established in 1995, involves collecting and processing honey from wild (*Apis dorsata*) and domestic apiaries. Although operating at less than full capacity, it made profits of Rs. 200,000 (US$ 4,760) in 1997 and Rs 340,000 (US$ 8,100) in 1998. The second enterprise, a food processing unit (FPU) also established in 1995, produces jams and pickles for sale, using *Phyllanthus emblica* and other fruits of forest species. In 1998, it generated over Rs 145,000 (US$ 3,450) in sales. Together, these two enterprises, which are located within the sanctuary, provide full-time employment to 14 people and annual earnings of more than Rs 100,000 (US$ 2380), a considerable sum compared to the Soligas' average annual household income of Rs. 13,000 (US$ 310). The third enterprise, a herbal medicine processing unit (HMPU) located 24 km away, produces and markets herbal medicines using both domestically grown and wild herbs collected from the forests. This unit is only just beginning to become profitable. The enterprises have been supported by strong biological research and monitoring to determine the impacts of enterprise-related extraction and to ensure that harvests are kept within sustainable levels (ATREE 1999). Complementary activities were also in-built to promote community participation, management capacity strengthening and equitable benefit sharing.

The Soligas have now taken over management of the HPU and the FPU. The enterprise manager, also a Soliga, reports to a managing committee consisting of NGO and Soliga community representatives. The Soligas decide profit distribution. For example, they decided to distribute 30 % of the HPU's 1998 profits to NTFP collectors and enterprise shareholders within the community. The HMPU is gradually increasing Soliga participation and adopting profit-sharing mechanisms to support community development programs. Although the enterprises are now performing well financially and the Soligas are increasingly sharing in the benefits, determining sustainable harvest levels continues to be a challenge. Over-all rates of NTFP extraction remain high. For example, average levels of *Phyllantus emblica* fruit removal per tree range from 87 to 95 %. These high levels of fruit harvest appear to be an opportunistic response to uncertainties in the entire process of bidding, selling, payment and harvesting adopted by the state-sponsored cooperative with monopoly rights over NTFPs in the sanctuary (Lele et al 1998). Harvest rates were significantly lower where NGOs and researchers have undertaken environmental education compared to areas where no education had been undertaken (ATREE 1999). However, despite this hopeful sign, thus far, the conservation benefits from the enterprises have yet to be conclusively demonstrated.

Conclusion

Despite their appeal and considerable promise, experience in India and in other countries has shown that relatively few conservation-oriented NTFP enterprises have been able to achieve their multiple goals. It takes time and in most cases, subsidies, especially during the early years, for an enterprise to become viable. Fewer still have demonstrated significant equity and poverty alleviation impacts. The conservation benefits for many such enterprises have remained unproved. In many cases, economic success has resulted in resource over-exploitation. The generally low levels of capital and skills requirement for NTFP enterprises often make them contestable. High returns have tended to invite new entrants and increase pressure on NTFP resources. The strengthened institutional capacity and new channels for critical inputs being created in rural India present greater opportunities for NTFP enterprises to meet livelihood needs while promoting sustainable resource use. However, unless present restrictive policies and the system of state monopoly and centralized control over key NTFPs are reformed, sustainable resource use would remain an elusive goal. Strong policy support and well-defined and enforceable rights for those most dependent on forests and NTFP resources are essential if these resources are to be effectively and sustainably managed.

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The Potential of Non-wood Forest Products in Sub-Saharan Africa: Towards a Better Assessment of Forest Resources Providing NWFP

by
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Abstract

Rural and urban people in Africa are heavily dependent on non-wood forest products (NWFP) for a wide range of needs including food, medicines and construction materials. Many of these NWFP are important sources of income and employment at the local level, with some being traded at the international level.

In order to determine the sustainable level of any commercial utilization of a given NWFP, accurate information is needed on the status and regenerative capacity of the resource providing the product, in addition to information on the socio-economic and cultural aspects affecting the use of the NWFP.

Practical methodologies for assessing socio-economic and biological factors of NWFP utilization are not widely available. Such methodologies are needed to collect information both at the forest management unit level as well as at the national level.

This paper analyses the factors to be taken into consideration when planning an assessment of the forest resources providing NWFP. It discusses current gaps in knowledge and presents some of the main activities of the FAO Forestry Department aimed partly to fill these gaps at the local and national scale.

Keywords: NWFP, Forest inventory, Assessment methodologies, Africa.

Introduction

A variety of definitions exist for non-wood forest products (NWFP) and the related term non-timber forest products (NTFPs), corresponding to different perceptions and different needs. For the purposes of this paper, the following definition of NWFP is used: "Non-wood forest products are goods of biological origin other than wood derived from forests, other wooded lands and trees outside forests" (FAO 1999).

This definition makes a distinction between the forest resources and the products, which are obtained from these resources through direct human intervention. An assessment of the resources providing NWFP, therefore, will not aim to quantify all biological resources (other than wood) found in a forest but only those which are actively used by people for particular purposes or which have a potential for exploitation. In this sense, assessment of NWFP resources is aimed at assessing the status of exploited resources and evaluating the potential or otherwise of NWFP utilization for economic development at local and/or national level within the framework of sustainable forest management. NWFP can be collected from the wild or produced in plantations, in agroforestry systems or in intermediate systems. The knowledge of the prevailing production system is an important factor in planning a sustainable promotion of NWFP.

This paper deals principally with NWFP which are already used in Africa, and in particular those which are traded. The discussion on assessment methodologies is limited to plant resources providing NWFP.

The last decade has witnessed a steep increase in interest and activities concerning NWFP. There are numerous ongoing projects in African countries and globally to promote NWFP use and commercialization as a means to improving the well being of rural

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populations and at the same time conserving existing forests (FAO 1995, Wollenberg and Ingles 1998, Ros-Tonen 1999).

In order to determine the sustainable level of any commercial utilization of a given NWFP, accurate information is needed on the growth and regenerative capacity of the resource providing the product, in addition to information on the socio-economic and cultural aspects affecting the NWFP use. Although there is often considerable indigenous knowledge for specific NWFP, there is often a lack of documented or scientific information suitable for the determination of sustainable yields readily available to forest users.

At the national level, the full recognition of the socio-economic value of NWFP to people and national economies is still hampered by the lack of good national data on NWFP production, consumption and trade. At the same time, increasing demands are being put on countries to report on the status of forest resources and their biological diversity (which includes NWFP and their use) at the national level as part of reporting requirements under international initiatives, such as for the Convention on Biological Diversity, for initiatives on Criteria and Indicators for Sustainable Forest Management, and for reporting to international agencies like the Food and Agriculture Organization of the United Nations (FAO), World Trade Organization and International Tropical Timber Organization.

Although significant advances in research on both the socio-economics and the biology of NWFP have occurred in the last few years, methodologies for NWFP assessment at the national as well as the forest management unit level are still not widely available in practice. The multitude and variety of NWFP, the multiplicity of interests and disciplines involved in NWFP assessment, organizational and financial constraints, the lack of globally, or even nationally, recognised common terminology and units of measurement (FAO 1998a), all contribute to make the assessment of NWFP and of the resources providing them a difficult task.

According to its mandate, FAO shall collect, analyse, interpret and disseminate information related to nutrition, food and agriculture (including forestry). FAO is mainly concerned with the national, regional and global levels. Within this mandate, the FAO Forestry Department is carrying out a number of activities aimed at addressing gaps in knowledge and field application of NWFP assessment at various levels, so as to contribute towards the achievement of sustainable forest management in its member countries.

Materials and Methods

The results and discussions in this paper are based on information obtained through desk studies, literature reviews and a number of expert consultations in which the Non-wood Forest Products Programme of FAO has taken the lead or been actively collaborating.

Recent activities related to the potential of NWFP exploitation and assessment of resources providing NWFP in sub-Saharan Africa include those outlined below.

The Importance of NWFP in sub-Saharan Africa

A series of international consultations, conferences and workshops have been held in recent years. Those in which FAO has been involved and which are relevant to the current paper include the following:

> The International Expert Consultation on NWFP held in Yogyakarta, Indonesia in 1995 (FAO 1995)
>
> The International Conference on Domestication and Commercialization of NWFP held in Nairobi, Kenya in 1995 (Leakey at al. 1996).

With particular reference to Africa, a Regional Expert Consultation on NWFP for English-speaking African countries was held in Arusha, Tanzania in 1993 (FAO/CSC 1994). The Central African Regional Programme for the Environment (CARPE)-FAO workshop held in Limbe, Cameroon in 1998 specifically addressed the issue of ecological assessment of NWFP, identified gaps in knowledge and recommended actions on a number of priority key species (Sunderland *et al*. 1999).

Assessment of NWFP and Non-wood Forest Resources at the National Level

Within the framework of the EU-FAO Partnership Programme on "Data collection and analysis for sustainable forest management in African, Caribbean and Pacific (ACP) countries: linking national and international efforts", quantitative and qualitative information was gathered during 1998/99 on the exploitation practices and production levels of major NWFP in collaboration with 42 African countries. The preliminary findings were discussed in four regional workshops: East Africa (Kenya, 1998), Southern Africa (Zimbabwe, 1998), Central Africa (Gabon, 1999) and West Africa (Côte d'Ivoire, 1999). The most important NWFP in Africa, on which further development efforts should be concentrated, were also identified during this process and include: gums, mushrooms, forest fruits, bushmeat and medicinal plants.

More specifically, information was collected on a country basis on major NWFP, the plant or animal sources from which they are extracted (and part used), the habitat in which they are found/produced, their destination (subsistence/trade), main uses and economic value.

The data collected under this effort were also used as input to a Special Study on NWFP for the Global Forest Resources Assessment 2000 (FRA 2000), spearheaded by FAO. Methodological work preceding the actual gathering of available information for this study concentrated on the information requirements for data collection of NWFP at the national level.

Assessment of Non-wood Forest Resources at the Forest Management Unit Level

In addition to information obtained from the above activities, this paper also builds on information obtained from the two recent literature reviews indicated below and a number of case studies commissioned by FAO on the assessment and management of forests providing NWFP.

As part of the development of a set of guidelines for the management of tropical forests for the provision of non-wood goods and services (FAO *in press*), an extensive literature search was undertaken. The guidelines, which focus on the tropical moist forests, include a specific chapter on the aspects of assessment of resources providing NWFP at the forest management unit level. Several case studies were commissioned from around the world, including one on the assessment and management of wildlife resources providing bushmeat in West Africa.

In a study commissioned by the Forest Research Programme of the UK Department for International Development (DIFD), Wong (2000, in prep.) analysed 95 case studies on assessment of non-wood forest resources mainly from English language literature. Of these, 28 were from 16 African countries. Based mainly on the results of this review, a detailed structure for quantitative surveys of NWFP is under development and will form part of a new forest inventory manual being prepared by FAO.

Results

NWFP and Their Potential in Africa

Rural and urban people in Africa are heavily dependent on NWFP for a wide range of needs, including food, medicines, construction and shelter materials, fibres, dyes, resins, gums, oils, aromatics and a variety of animal products such as honey, beeswax and bushmeat. Many of these NWFP are important sources of income and employment at the local level, with some being traded at the international level[2].

Various criteria can be used to identify key NWFP. At the aforementioned CARPE-FAO workshop on NWFP for Central Africa, two

[2] An overview of major NWFP in Eastern and Southern Africa is described in a separate voluntary IUFRO paper: "The significance of NWFP for tropical societies: an analysis of statistical data on NWFP utilization in East and Southern African countries", by Killmann et al., 2000.

criteria were used to draw a short-list of key NWFP: firstly and most importantly, those products which are highly valued for domestic consumption, or as a product for the market; secondly, those where the demand for a "high value" NWFP is exceeding supply. Therefore a two step selection process is recommended: step one to identify NWFP with a high value, step two to define those that are intensively harvested and consequently risk unsustainable exploitation. At the local level, resource assessment studies are most urgently needed for NWFP species meeting the above criteria. However, for national assessments, a wider range of products and species may be of importance.

Assessment of Forest Resources Providing NWFP

The above-mentioned activities have provided some useful information on the trade and consumption of the main NWFP for 42 countries in sub-Saharan Africa. However, the study also highlighted the fact that there is a serious lack of data at the national level on the resources providing these products.

The reviews of cases studies and other reports of assessment of non-wood forest resources at the forest management unit level (particularly the above mentioned DFID study) concluded that the range of assessment methods used so far in tropical moist forests has been limited and many assessment methods in use are not biometrically valid (Wong 2000 in prep.).

Discussion: Towards a Better Assessment of Forest Resources Providing NWFP

The discussion below focuses on the biological and technical aspects of non-wood forest resources assessment. The political and legal context of NWFP use (ownership, tenure and access to the resources, legal restrictions), the social profile and welfare of the collectors/users, current and future demand for a given product, market assessments etc., also affect the sustainability of forest resource use. However, such analyses lie outside the scope of this paper.

Information Needs at the National Level

The recognition of the socio-economic value of NWFP to people and national economies requires information on the collection, validation and analysis of national level data on NWFP production, consumption and trade. Increasing demands are also put on countries to report internally on the status of their forest resources and biological diversity (and therefore, incidentally, reporting on the status of resources).

This calls for a two-pronged approach to obtain information on both products and resources at the national level.

<u>Products</u>

Product information needed at the national level are production and trade data (quantities and values) of major NWFP for their inclusion into national and regional level country statistics, including the FAO Forest Products Statistics Yearbook. These data are essential to assess the full contribution of the forest sector to the economy of the country, and may be complemented with other descriptive information on the importance of NWFP for sustaining subsistence livelihoods, particularly their contribution to food security and /or their income generating role.

<u>Resources</u>

At the national level, improved assessment of forest resources providing NWFP require information on:

- the identification, prioritization and knowledge of the plant and animal species from which major products are obtained;
- the extent, frequency and status of the species, based on national inventories; and
- habitats in which the species are found.

The above information should be available, as far as possible, in a standard format to allow comparisons both among countries and products.

Management Information Needs at the Forest Management Unit Level

Abundance, distribution, population structure and growth rate data are among the most fundamental pieces of information required for sustainable management of a given forest resource. Data can only be obtained through quantitative forest inventories combined with growth and yield studies. Such inventories also provide the baseline data necessary to monitor the impact of harvesting and management practices.

Main Factors to be Considered in the Assessment of Forest Resources Providing NWFP

Assessments should concentrate on priority NWFP. Initial screening of NWFP for further study at the local level can be done through a participatory appraisal and may include information from harvesting records, household consumption analysis and market studies. At the national level, information on traded products, e.g. taxation records and/or preliminary information on the status of the resource, can be used for initial screening.

Due to the great variation of NWFP and the settings in which they occur, it is not possible to prepare specific prescriptions, which are valid for the assessment of all the forest resources providing NWFP. However, some general considerations to ensure that such assessments are biometrically sound are presented below.

The discussion is limited to the biological and technical aspects of non-wood forest resources assessment. Other aspects, such as the economic feasibility and socio-cultural suitability of each approach, should be carefully considered in the context of local conditions before choosing a specific approach. Techniques must be refined and adapted to suit location-specific ecological and socio-economic circumstances, needs and priorities.

General Approach for Forest Resources Assessments

Few assessments will have to start from scratch. At the national level, results from previous inventories, recent aerial photos or satellite imagery at a large scale and existing maps may be available.

At the local level, collectors and users often have long-established and detailed knowledge of the resources of which they make use. This may include knowledge of their life history, distribution and abundance, and variation of productivity in time and space and with respect to harvesting practices. Although this knowledge is rarely quantifiable, it can be very valuable if used together with sketch maps drawn by experienced collectors during a preliminary participatory appraisal.

Where possible, the delineation of different forest types should be undertaken based on available information prior to conducting the inventory.

Local users undertake many NWFP inventories at the forest management unit level. In a participatory inventory, techniques must be tailored to the abilities and resources available to the communities.

The methodologies for resource assessment vary according to the type of forest resources in question. Plants and animal resources, more often than not, are thus treated separately. It should be kept in mind, however, that an assessment of plants that are important food sources or habitats for animals might be needed for the sustainable management of the forest animal resources. Likewise, an assessment of the status of animals that are important pollinators and seed dispersers might be needed for successful management of forest plant resources. Although valuable information on plants may be obtained from an inventory of forest animals and vice versa - and should be used as far as possible – few examples exist of successful efforts at combining the assessment of plant and animal resources in, for example, a multi-purpose resource inventory (Lund 1998).

Bushmeat is an important NWFP in sub-Saharan Africa. Yet, the assessment of forest animal resources poses several specific problems due to their mobility, habitat (e.g. tree canopies), life cycle, seasonality (caterpillars/butterflies, migratory birds) and diurnal pattern (many species are nocturnal) and fall outside the scope of this paper.

Resource Assessment Designs

Assessments can either be undertaken as total counts or by sampling. Total counts are expensive and time-consuming and can only be justified if the resource is very valuable and the area relatively small. Most assessments are carried out through some form of sampling.

Several different sampling designs exist. The choice between sampling designs depends mainly on the type of forest and resources to be assessed, the existing information and knowledge of the area and the skills of the assessors. Systematic sampling provides a regular distribution of observations, is easier to lay out and is better for mapping purposes than random samples, but the risk of bias is greater.

In tropical forests being surveyed for the first time and/or for a number of different resources, a systematic sampling design, usually laid out in grid fashion, is generally recommended to ensure that all parts of the forest are covered. Where prior knowledge about different forest types and distribution of desirable species is available, each type can with advantage be sampled independently using a stratified design. This is often combined with random sampling. Particular difficulties are related to the rareness and clumped species distribution, which are characteristics of tropical forest species.

The sampling units may be transects with or without fixed boundaries, plots – usually square or circular, sample points, or measured in time. The choice between these depends on the type of resource(s) involved.

The size of the individual sampling units depends on the size and density of the resources being assessed. Where several different plant resources that vary greatly in size are to be included in one inventory , nested quadrants may be used. For statistical purposes, the optimum sampling unit should contain an average of 10 to 25 individuals.

The sampling intensity employed for sampled counts varies according to the purpose of sampling and the degree of accuracy needed and on the funds and time available. It also depends on the size and abundance of the resource and according to whether information on the local distribution of animal/plant populations is available or not. Where distribution is clumped and the locations known, the sampling may be concentrated at known sites and the overall sampling intensity (sampling area in percentage of total area) may be very low. If the resource is small and abundant, a low sampling intensity may also be used.

Timing of the assessment depends on the type of resource and its life cycle and seasonality. The issue is most critical with regard to ephemeral resources such as flowers, fruit or mushrooms. The inventory should take place, where possible, just prior to the harvesting season or when flowers are available to facilitate taxonomic identifications.

The parameters to be measured depend on the purpose of the assessment, the type of resource(s) and the product(s) to be obtained.

The inventory of forest plant resources at the forest management unit level should provide the following information (Peters 1999):

- a reasonably precise estimate of the density of harvestable plants;
- data on the current population structure or size-class distribution of adult plants; and
- a preliminary assessment of the regeneration status of the species.

What is FAO Doing?

Assessment of NWFP and Non-wood Forest Resources at the National Level

A prerequisite for compiling national level statistics on NWFP of countries for inclusion into the Forest Products Yearbook is the availability of a global, applicable and agreed upon classification system for NWFP. This was initiated by FAO (Chandrasekharan 1995), which continues to work with its member countries to develop further practical mechanisms for countries to report on NWFP production and trade data, including supporting efforts towards harmonization of related definitions, concepts and classification systems (FAO 1999).

Few NWFP are significant at global level, which is one of the reasons why they are not reported in the global forest products statistics published by FAO. The publication of regional forest statistics, where important NWFP at the regional level could be featured, and the identification of low-cost, easy and applicable methodologies to improve the collection of national data on NWFP, are initiatives supported by FAO (FAO 1998b).

The FAO-EC partnership programme mentioned above supports capacity building in participating countries to provide improved statistical data on forestry and specifically NWFP. The information obtained is being used to prepare a regional synthesis on NWFP, while also contributing to 'NWFP country reports' as a Special Study under the FAO "Forest Resource Assessment 2000" programme. In addition, information on the current use of main NWFP and on likely trends will be the basis for the formulation of the NWFP section of the recently initiated Forestry Outlook Study for Africa, which is coordinated by FAO and funded by the African Development Bank.

Within the FAO-EC partnership programme, 'pilot studies' have been initiated in four countries (Uganda, Cameroon, Madagascar and Zimbabwe) to develop and test methodologies for the collection and analysis of data on NWFP. These methodologies should provide reasonable estimates of the production, consumption and trade in NWFP, and should be cost-effective and widely applicable and relevant to other countries in the region. During the pilot studies, all available information related to NWFP in the respective country is analysed and NWFP of major national importance are identified. The coverage of NWFP by national statistics is evaluated and all institutions involved in the collection of statistical data, as well as the methods used for data collection, are identified. Finally, necessary steps to improve statistical data availability on NWFP are suggested.

Assessment of Non-wood Forest Resources at the Forest Management Unit Level

Guidelines for the management of tropical moist forests for the provision of non-wood goods and services have recently been prepared (FAO *in press*). This document provides general guidelines for the assessment and management of forest resources providing NWFP, complemented with several examples and case studies on this subject.

A "Forest Inventory Manual" (working title) is currently under preparation in FAO. This manual aims to provide an overview to natural resources users and managers on inventorying and monitoring techniques, which will enable readers to access other references for details and in-depth studies. The final result will be a "forest inventory package" where single chapters will be set up as inter-linked, self-contained units, which can be updated, reviewed and compiled over time by various individual or corporate authors. This modular format, while potentially also linearly structured, will allow more dynamic access to users, timely modification and revision of the content and closer collaboration of inventory specialists in sharing knowledge and experiences. The NWFP section is structured so as to guide the user to a set of recommendations, which can be used as the basis for a locally specific and relevant protocol.

Within the framework of another and recently initiated partnership programme between FAO and the European Commission, NWFP resource assessment methodologies at the forest management unit level are being tested for important, selected NWFP in each of the major sub-regions in sub-Saharan Africa. The project will develop guidelines that will enable national forestry administrations to implement improved and regular monitoring of the NWFP resource base and develop sustainable management plans in partnership with local and indigenous communities. This endeavour will draw on existing knowledge through the review of ongoing and completed work on NWFP resource assessment.

Conclusions

Rural and urban people in Africa are heavily dependent on NWFP for a wide range of needs, including food, medicines and construction materials. Many of these NWFP are important sources of income and employment at the local level, with some being traded at the international level. However, the full recognition of the socio-economic value of NWFP to people and national economies in sub-Saharan Africa is still hampered by the lack of national level data on NWFP production, consumption and trade.

The assessment of NWFP, and the forest resources providing them, is an essential tool for the sustainable management of these resources.

In spite of recent interest in and research work on the ecology and socio-economics of NWFP, practical methodologies for the assessment of NWFP at the local and national levels are still largely unavailable to the main resource users (local communities) and to the institutions that are responsible for centralized planning, monitoring and national reporting.

Various approaches exist to carry out NWFP assessment: those drawing on indigenous knowledge and ethnobotany, and those drawing on quantitative inventory. However, the range of assessment methods used so far in tropical moist forests is limited and more attention should be given to ensuring that quantitative inventory assessments are biometrically valid.

The mandate for work on NWFP often falls across several disciplines, institutions and land-use categories. While this may represent a constraint in the implementation of inventories, it also presents an opportunity for devising much needed innovative approaches to NWFP assessment, drawing on the experiences of different disciplines and sectors (forestry, agriculture, ecology, social sciences, etc.).

Due to the great variation of NWFP and the settings in which they occur, it is not possible to prepare specific prescriptions that are valid for the assessment of all the forest resources providing NWFP. However, in the forthcoming FAO Forest Inventory Manual, practical information on the main factors that should be taken into account to ensure biometrically sound NWFP resource assessments is included.

The economic feasibility and socio-cultural suitability of resource assessment approaches should be carefully considered within the context of local conditions, and methodologies and techniques should be refined and adapted to suit location-specific ecological and socio-economic circumstances, needs and priorities.

FAO, in close collaboration with other international and regional organizations and institutions in member countries, supports the development, testing, adaptation and dissemination of improved methodologies and practices for the assessment of forest resources providing NWFP through a number of specific activities in sub-Saharan Africa, as well as in other countries.

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The Recreational Functions of European Forests

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Abstract

This paper discusses cultural differences and similarities in forest recreation and other amenity uses between a Northern (Finland), a Central (The Netherlands) and a Southern (Italy) European country. The behavior, meanings and values related to forests for different European populations are discussed in order to understand the future demand on forests and other natural resources for recreation and nature-based tourism. Nature-based tourism is predicted to become one of the major, increasing, uses of forest resources in the future. It is important for a host country to know how it should deal with visitors that have varied cultural backgrounds.

Different types of recreational forest uses are described in terms of participation rates and the intensity of participation in different activities, as well as in terms of time-use patterns and the types of areas used for recreation. Attention is also paid to the differences in meanings and values of forest and nature between countries and regions. The effects of differences in the supply of natural resources for recreation are also discussed.

In the North, there are many natural areas available for recreation, and there is much interest in also providing those resources as a basis for nature-based tourism for other European peoples. In Central Europe, people are interested in increasing the amount of nature in their residential areas. The total participation rate in outdoor recreation is as high in the South as in the North, but people make fewer visits to forests. In Southern Europe, there is a growing pressure to use nature protection areas for recreation, which causes serious problems for the protection of nature.

Keywords: Outdoor recreation, Ecotourism, amenities, Service functions

Introduction

The Aim of the Paper

In many Central and Southern European countries, forests have lost their predominant role of timber production in the last decades. In the Nordic countries, forestry still has an important role in national economies. At the same time, other functions of the forest have come to interest the public, economic operators and governments. These are water and soil protection, biodiversity preservation and recreation. The role of forest in social and cultural life cannot be measured only in economic terms. Many kinds of direct or indirect enjoyment of the forest involve our emotional, psychological and spiritual sphere. In Europe, such non-economic components of forest functions play a great part in people's lives.

This paper analyses the present state of forest recreation in three European countries (Finland, the Netherlands and Italy) which, because of their geographic position and cultural features, are assumed to represent the European situation well. The main purpose of the work is to draft a common European framework for forest recreation, highlighting similarities and differences among the countries, which will allow the formulation of proposals and hypotheses for the future development of forest recreation in Europe from a common perspective.

Forests for Recreation in Finland

Forest areas are abundant in Finland, covering 86 % of the land area. The total area of forests is 26.3 million ha, which means 5.1 ha per person. State owns 33.2 % of the forestland, private families 54 %, and the commercial sector 7.8 %. The national economy is strongly dependent on forest industry, which produces about 29 % of total foreign income. In Finland, all forested areas are available for recreation according to the doctrine of 'everyman's rights', but there are a large number of designated recreation areas as well. The forested land includes 2.67 million ha of protected areas and about 0.2 million ha of urban forests and recreation areas, which are about 10 % of the total forested area. The protected areas include 32 national parks and 7 national hiking areas. The capital area has a concentration of large urban populations (0.9 million persons, 18 % of the population). Of the total population, 36 % live in cities with more then 50 000, and 64 % in smaller towns or in the countryside.

Communities manage most recreation sites which are located close to residential areas. Designated recreation areas are facilitated by trails with signs and information boards, and in many areas with on longer trails there fire rings, camping facilities, shelters, huts, etc. All forested areas are suitable for recreation but the areas most used for recreation are forests in urban fringes, lake and seashore forests (close to summer houses), forested islands in the archipelago as well as lake districts national parks and wilderness areas in Northern Finland. Family-owned summer cottages are an important basis for the recreational use of many timber production forest areas. At the nationwide inventory of the area the listing of recreation areas as well as monitoring the services and the quality of recreation resources are in progress (Sievänen 2000).

Forests in Italy

Forests cover 28 % of the territory in Italy. Almost 8.7 million ha (MAF-ISAFA, 1988), or 35 % are plain forests, 37 % hill forests and 28 % mountain forests. They are very important element from the landscape and social point of view, and less important for economic purposes especially in the last decades. Italy imports about 50 % of the rough timber. The forested areas comprise of forests (71 % in total; high-forests, 27 %; coppices, 44 %), other woodlands (mainly scrubs, 26 %), and plantations such as fruit chestnut and cork oak woods (3 %). The plantations have no recreational function.

About one-third of the wood resources are public forests. At present, around 10 % of the national territory is protected (19 national parks and over 800 protected areas). Forest availability for the population averaged, 0.16 ha per person but the area is not uniformly distributed. While there is about 0.7 ha per person in some alpine regions, it decreases to 0.05-0.10 ha per person in some Mediterranean regions. Almost 47 % of the Italian people live in urban areas with more than 30 000 inhabitants, and 53 % live in small cities (< 30 000 inhabitants) or in the countryside.

Due to its large north – south latitudes, Italy enjoys wide climatic diversity, which determines many different forest typologies on its territory. From the alpine forests of conifers, similar to those of central Europe, they change through the broadleaved woods of the Apennine up to the coastal woods situated in the central-southern peninsula and in the islands, which have a strong Mediterranean mark. Different forests determine different behaviour and recreation approaches. In the North forests are very often the main environmental attractions', the alternatives being in some way linked (and close) to the woods: lakes, rivers, mountains and grasslands. In the Centre and South, the sea and the beach are the most important attractions.

In Italy, at present, there is not really an "everyman's right" or an equivalent tradition of open access, but most forest areas are freely accessible for "low impact" recreational use. Some limitations may apply to the protected areas (permanent or seasonal prohibition to access some zones or to walk outside marked paths). Limitations concerning activities such as hunting, fishing, free camping, out-of-paths skiing and, overall, accessing forest roads with motorised vehicles are quite frequent.

Forests in the Netherlands

The total forested area in Netherlands is 355 000 ha of which 60 % are coniferous and 40 % deciduous. Most of the forests are found in the higher and dryer parts of the Netherlands, located more inland. Together with 141 000 ha of other natural areas, they cover about 11 % of the Dutch territory. Currently 36,700 ha of these natural areas are within one of 10 national parks. Six more (land-based) national parks are being formed. On average, the nature availability is about 300 m^2 per person. Nature availability, however, is not uniformly distributed. When using a 3-kilometer radius, the amount of nature available within this radius ranges from less than 20 m^2 per capita for census tracts located in large cities such as Amsterdam and Rotterdam, to over 840 m^2 per capita in more forested and less densely populated areas.

The three major organisations that own or managed nature areas are the State Forest Agency (220 000 ha), the Federation of "Provincial Landscapes" (80 000 ha) and "Nature Monuments" (78 000 ha). The latter two are private organisations that are primarily dedicated to nature and landscape conservation. These organisations are very popular within the Netherlands. For example, "Nature Monuments" is an association with about 900 000 households as members. Although in the Netherlands there is no "everyman's right", most natural areas are open for recreation (about 80%), although access is often restricted to roads and paths (70 %), and sometimes for members only (Grontmij 1995). Timber production is a minor industry in the Netherlands. For example, the State Forest Agency produces about 300 000 m^3 a year, which is considered a substantial part of domestic production. Another important function, besides nature conservation, bio-diversity, recreation and timber production, is water retention.

Recreational Use of Forest and Other Natural Resources

Forest recreation in Finland

Participation in Outdoor Recreation Activities

Forest recreation is an essential part of the Finnish way of life. According to a recent population study, a preliminary estimate of the total participation rate among the Finnish population is 96 % (Sievänen 2000). The most popular activities are walking, picking wild berries and mushrooms, swimming outdoors, bicycling and studying nature (Table 2). Typically, urban people keep the tradition of picking berries at a family-owned summer cottage, to which about half of the population has access. Berry picking is an everyman's right. Hunting is three times more common among men in Northern Finland than among men living in southern Finland. Hunting is one of the few activities that shows some type of rural vs. urban difference in nature-based recreation. An average number of visits is three to four times a week, each visit lasting about one hour at a time. Finnish people use an average of 4.4 hours per week for recreation and sports according to the national time use survey (People and Pääkkönen 1989). About 40 % of the make a nature trip during each year. A nature trip is defined as a trip, in this the main purpose is to participate in outdoor recreation, and which includes an overnight stay.

Access to Recreation Resources

For the site areas used for day visits (does not include overnight stay), 85 % is forested areas. About half of them or are located by near lakes or seashores. Around 40 % of all day visits are in municipality-managed recreation areas, 5 % on state recreation areas, and approximately 50 % in areas used according to "everyman's right". The average distance to a day-visit area managed by municipality is 3 km, and 25 km to a state owned area. Most people have a forest suitable for recreation within one kilometre of their homes. Three out of four day visit areas have a paved or gravel road for walking and bicycling, and about one out of three has constructed trails and signs (Sievänen 2000).

In areas which are destinations of nature trips, 90 % have forest and almost 80 % are located by the sea or lake, (include smaller lakes or ponds). Majority of nature trips in the countryside(over 80%) and designated for recreation (50-60%); e.g., they are multiple-use areas (Sievänen 2000). About half of the destination areas have constructed trails, signs, information boards and constructed sites for open fire and shelters for visitors. The state-managed areas have a special role in providing recreation opportunities for vacation and weekend leisure time. People travel quite long distances in order to get to some of the state-managed areas. The average distance between a visitor's residence and the state recreation area is about 500 km, (Sievänen 2000). The reason is that state-managed areas are mainly located in northern and eastern Finland, but the majority of the population is in southern Finland. The state managed recreation areas, which are located in southern Finland, the average distance traveled by visitors is between 80 and 90 km (Ovaskainen et al.1999).

Forests are an essential part of the Finnish landscape. Often the forested landscape is fairly dark and closed, dominated by conifers. The hardwood forests, particularly birch forests, are favourite the among and Finnish (Savolainen and Kellomaki 1984). The people give a great value to forest as a recreation and also appreciate fields, meadows and, particularly, water elements in the landscape (Sievänen 1995).

Access to Nature and Some Policy Issues

In Finland, a new forest law (1997) emphasizes also the social sustainability of forest uses, including recreation. The Ministry of Agriculture and Forestry has developed a basic list of criteria and indicators, which should be used to evaluate the sustainable use of forests. Recreation is one of the criteria of social sustainability and recreation research is recognized as the means to provide information and monitoring.

There are several different kinds of national programs and projects, which give new guidelines to forest management. Some guidelines are developed particularly to improve forested environment for recreation and others consider landscape management as an aspect related to recreation. In these programs, integrated forest planning is developed. Such planning includes economic use (timber production), ecological sustainability (biodiversity) and social sustainability (recreation).

Table 1. A summary of forest resources in Finland, Italy and the Netherlands.

	FINLAND	HOLLAND	ITALY
Total country area (land and water areas) (million ha)	33.5	4.1	30.1
Inhabitants (millions)	5.2	15.8	57.6
Forest (million ha)	26.3 *)	0.34	8.7
Forest area per capita (ha)	5.1	0.02	0.7
Public forest area rate (%)	33.2	46.9	33.9
Free accessible forest area rate (%)	99.9	80	n.a.
Protected areas (million ha)	2.7	0.01 **)	3.0 ***)
Timber production (million m^3 per year)	77	1.2	8.5
Timber exported/imported	Export	Import	Import

*) In Finland, also high altitude areas and peat lands with scrubs are included.
**) Figure applies to State Forest Agency only
***) Not only forests. Protected forest area can be estimated as about 0,9 million ha

Table 2. Recreation activities: participation rates and frequencies, on average, during the last 12 months in 1998-1999 among the Finnish population. LVVI-study/ Sievänen 2000 *).

Activity	Participation rate %	Frequency (times or trips per 12 last months)
Walking	68	110
Hiking	19	10
Bicycling	55	46
Jogging, running	16	49
Walking the dog	25	229
Staying in summer cottage	56	30
Camping	18	6
Picnicking	28	7
Hunting	8	21
Picking wild berries	57	7
Picking wild mushroooms	41	7
Cross-country horseback riding	2	28
Studing and enjoying nature	51	7
Swimming outdoors	64	23
Boating	46	23
Fishing	44	24
Cross-country skiing	40	20

*) The first nation wide population survey of outdoor recreation, the total sample is 12 000, respondent rate 84 % (population by 15-75 years old).

In Finland, one of the actual policy issues is to determine how a large supply of recreation services is needed in recreation areas and whether the costs of services should be paid from tax money or from user fees. Funding from the state budget has not developed in terms of the number of areas and services that are to be maintained. There is a discussion about developing a fee system to cover the expenses of recreational services. According to recent surveys, only one in ten Finns clearly supported the introduction of user fees to maintain the current level of recreation services and facilities (Sievanen and Ruuska 1999).

In Finland, rural areas are now looking for possibilities to provide resources and services for nature-based tourism. There are a large number of EU-projects, which support the construction of new facilities such as trails, farm-based accommodation and restaurant services, and program services in rural villages. Village planning is a key method to integrate agriculture and forestry, landscape management, and tourism in a way, which offers possibilities for employment and income in rural communities.

Forest Recreation in Italy

Participation in outdoor recreation activities

At present, a periodical survey of the recreational use of forests in Italy does not exit. So far, only a unique study by Scrinzi et al. (1995) has evaluated, throughout the whole country, the role of the forest in Italian people's recreation demand in quantitative terms. Featuring parameters such as length of events, type of forests and the activities concerned, the study referred above exclusively concentrated on direct exploitation inside forest environments, and did not consider all those kinds of events and activities generally addressed to 'green areas' (attendance of urban parks and gardens, camping, snow-based and water-based activities, etc.) in which, however, the forest plays an important role. Almost all (96%) of Italian people participate in recreation activities involving the forest. The median time from the last forest-related recreational event for the Italian population is about 66.2 days (compare the method of Koch 1978, Koch and Jensen 1988). Each Italian has, on average, about 4 events per year with a mean duration of 3 hours and 45 minutes or about 1.3 days/visitor according to the Schreuder criteria (Schreuder et al. 1975).

Italian forest areas host a total of 170 to190 million events per year (including also the young, the elderly and foreigners), corresponding to 50-58 million days/visitors, 40 % of which involved protected areas. Italian forests are subject to a human pressure of about 20 events per year per hectare (70 events/year/ha in protected areas, 13 events/year/ha in other forest areas) with an average value of about 6 days/visitor per hectare, per year. The time spent on recreation in forests is less than 1 % of total free time and about 5 % of free time spent outdoors (Table 3). Italians have, on average, 4.7 hours of free time per day. Outdoor activities (including sports) take, on average, 0.8 hours per day (ISTAT 1993). Most recreational use (60 % of events) occurs on festive days. An increasing number of events have been recorded during holiday periods (25 % of the total number of events with a frequency ten times higher than in working periods). About 70 % of events occur exclusively on road networks (forest roads, paths, etc.). Users travel an average of 32 km from their starting point (home or temporary residence) to reach the forest site.

Preferred recreation environment

Users prefer “pseudo-natural” forests that are not too intricate, with good visibility on the ground, low-density stands, and even vertical stems of intermediate or big size (Scrinzi et al. 1996). Forestry interventions have the most negative effect on preferences, at least when their consequences are evident (cut or cracked stems, scattered residuals, stumps).

The results also showed that the great impact of users on protected areas (40 % of the total use on 7% of the total area) could cause compatibility problems between recreational use and preservation. Italian forest legislation lacks measures concerning the social function of the woods. The main national forest law (quite outdated, being issued in 1923) focused on soil and water protection including a number of limitations to be respected in forest activities. Management plans are compulsory only for public forests while on private property they are optional and therefore being very rarely an additional cost to the owners. In the absence of a management plan, the law acts according to its most restrictive dictate.

Table 3. Activities, participation rates and recreation use of forests estimated for Italian population.*)

Activity	People practicing the activity (%)	Times the activity is prevailing, %	Time dedicated to the activity, %
Walking (without a specific destination)	40.1	21.9	17.0
Hiking	38.1	21.7	19.7
Picnicking	44.6	16.0	20.6
Mushroom picking	20.9	9.9	10.2
Wilderness watching (incl.photography)	20.9	8.2	8.4
Picking of other products	19.4	6.3	7.7
Bicycling	5.7	2.9	2.1
Tourist facilities, attending	6.9	2.1	2.9
Running	3.9	1.7	1.3
Hunting	3.9	1.7	1.9
Horseback riding	3.0	1.1	0.8
Fishing	2.8	1.1	1.0
Climbing	2.5	1.0	1.1
Free camping	2.4	0.8	1.1
Cross-country skiing	1.8	0.6	0.6
Other activities (not specified)	7.0	3.0	3.5

*) a mail poll questionnaire on a sample of 3000 citizens (18-75 years old) distributed over a variety of demographic criteria and representative of the whole Italian population.

Forest Recreation in the Netherlands

Participation in Outdoor Recreation Activities

Within the Netherlands, nation-wide surveys on outdoor recreation are conducted regularly though Statistics Netherlands. These surveys focus on day-trips of at least two hours in length. Data are gathered by means of a diary (Statistics Netherlands (CBS) 1997). This survey focuses on activities much more than on destinations. About 50 % of the 60 million visitors make day-trips and 30 % of the 40 million cycling day-trips takes place in forests and heath. For walking, over 70 % of the day-trips take place in natural surroundings (besides forests and heath, also beaches and dunes, and along lakes, pools, and rivers). For cycling, agricultural areas are also important as a location (about 30 % of trips).

In the last version of the CBS-survey, conducted in 1995-1996, participation levels were asked for the first time without referring to a minimum of time spent on the activity. The results for activities that belong to the category of outdoor recreation are depicted in the table 4. According to the Social and Cultural Planning Agency (SCP 2000), in 1995, the Dutch people spent on average about one hour a week on outdoor recreation. This is about the same amount of time as they spent on this type of activity in 1975.

Preferred Recreation Environment

Within the Netherlands, forests are generally considered to be the most attractive natural environment (Reneman et al. 1999). From the rank order of 11 different types of natural environment, the forests have a mean score of 9.6 on an eleven-point scale. Sea, beaches and dunes come second, with a score of 7.5. The third place is for lakes and pools (M = 5.9). The lowest scores are for large-scale agricultural landscapes (M = 1.5). The most attractive aspect of a forest is silence (the absence of noise), the second most is alternation with other types of nature. The third most attractive aspect is space (‘large’), the fourth is solitude (‘quiet’, i.e., few other people), and the fifth is being within walking distance from home. Beech, birch and oak forests stands of full growth are considered most attractive. Generally forests with undergrowth are considered more attractive than forests without undergrowth. However, the undergrowth should not be too dense. Variation in overgrowth has a high attraction value (Heytze and Herbert 1991).

Table 4. Outdoor recreation participation levels and frequencies in the Netherlands (based on CBS-survey 1995/’96).

Activity	Participation rate (%)	Frequency (how often in last 12 months)
Walking	74	63
Bicycling	68	46
Touring (by car or motor)	39	21
Jogging, running	16	51
Surfing, sailing, rowing, canoeing	14	11
Horseback riding (outside)	6	30
Visiting playground (large), zoo, attraction park	57	3

NB: frequencies are the average for participants

Access to Nature and Other Policy Issues

In the Netherlands less forested areas are less available, certainly on a per capita basis, compared to the other European countries. One of the goals of the Dutch government is to increase the forested areas by 75 000 ha within the next 25 years. Although forests take a less dominant position in people's life than in Finland, they form a very popular destination for short outdoor trips, as well as for vacations. Together with the small supply, this may be one of the reasons that access can not be taken for granted and is often restricted to roads and paths. Recently the need for 'roaming nature', (i.e., nature areas in which there are fewer restrictions on behavior within the area and one is allowed to walk wherever one pleases), has become a policy issue.

The issue of user fees was on the political agenda a few years ago. Besides problems related to the feasibility of implementing such a measure in a cost-efficient way, also some negative side effects may be expected. Introducing entrance fees has a strong negative effect on visiting behavior to the extent that the expected length of the visit is shorter, the present frequency of visitation is higher, the visitor visits other locations more and the household income of the visitor is lower. There is also a relationship with the mode of transportation: the negative effect of introducing entrance fees is smaller for people that come by car. Presumably these people are used to having to pay for parking. Consequently, parking charges are likely to meet less resistance and have less negative effects on visiting behavior than entrance fees (De Bruin and De Vries, 1997). Nowadays more attention is paid to indirect mechanisms for marketing nature, such as leasing or letting out land. By combining ‘red’ (commercial, man-made) and ‘green’ (resource-based) facilities in this way, the ‘red’ facilities can pay for (their location in or near) the green facilities (see Hansman, Borgstein and Kolkman, 1999).

Within the Netherlands a change in policy has taken place. Until recently nature conservation and ecological policies used to look at recreation as a threat, and adopted a “no, unless” attitude towards recreation in natural areas. This meant it was up to the recreation sector and its proponents to show that recreational use of the area had no negative impact on nature. Nowadays there is more attention to the societal function of nature, such as nature-based recreation.

Recently, the Dutch ministry of Agriculture, Nature Management and Fisheries also has become more output-oriented. As a consequence, the State Forest Agency now has classified all of its grounds according to ‘recreation target type’. Each type has its own level of recreational facilities and intended level of visitors. Governmental financial support depends on the assigned type of the area. The agency has to monitor visits in order to show the ministry that intended levels of visitation are met, to ensure the financial support is maintained at its present level. At present, the tendency is for policy-making to become more integrated and participatory. Among other things, this leads to (more) multifunctional forests and (experiments with) integrated forest management (Van der Jagt et al. 1996).

Discussion

Comparison of recreation opportunities and recreational use of forests

For Finns, the accessability to nature-based recreation services is fairly easy and the supply is evenly distributed among the population. Those who live in the northern parts of the country have better opportunities for activities which demand large forested areas, such as hunting or snowmobiling. The common interest in outdoor activities among urban and rural populations offers an important insight when discussing the preferences and values which people assign to rural landscapes and natural recreation environments. Large forested areas, lakes and rivers, and even wilderness are highly appreciated by the Finnish. Naturally, not all of the forested land has the qualities of good recreation environments but together with the supply of designated recreation areas, the Finnish have ample opportunities to enjoy nature in their leisure time.

Finland can provide high quality recreation opportunities to other Europeans, who are interested in recreation in forested environments, and particularly in snow-based activities. Today, forest planning and management policies include aspects of landscape and recreation issues much more than before. Recently, special efforts have been taken to produce a good information basis for landscape management and the recreational use of forests. It is a future challenge to develop nature-based tourism. Tourism could offer new sources of income and employment to people in rural areas who are dependent on the natural resources.

In Italy, visiting a forest is not a "daily" component of life in comparison with central or northern European countries, but visiting a forest is a annual festive event. Picnicking is the most popular activity, which describes the social character of forest visits in Italian culture (89% of visits being group activities). Picking mushrooms also belongs to the Italian tradition of countryside visits, being a significant economic resource as well. If compared to Northern Europeans, Italian people have much less forest area available, even though there is a great variety of forest environments. Furthermore, people are very interested in visiting nature protection areas. The high recreational pressure is a problem in those areas, which are founded for nature conservation. On the other hand, over the last decades Italian public opinion, aware of the need to safeguard nature, has often identified such needs with an absolute denial in forest interventions for timber production in ordinary timber managed forests. Such cultural and social concerns have caused a very prudent style of forestry action, often based on a low level of interventions. Consequently, though suitable enough for recreation activities from an intrinsic point of view, many Italian forests are not very specialised for such a function. Because of the increasing importance of non-material functions of the forest ecosystem, coupled with a concentration of recreation use in few specific forest areas, a deep revision of traditional forest management criteria is currently taking place in Italy.

In the Netherlands, visiting a forest is not a daily activity. However, it does seem to be an important part of leisure, or of life in general. When the local supply of forested areas is poor, people will go out of their way to visit a forest. The number of kilometers traveled to the most often visited forest site ranges from less than 7.5 in well provided areas to more than 30 kilometers, on average, in poorly supplied areas (De Vries, in preparation). Not surprisingly, many people in these latter areas are not satisfied with the amount of forested areas within their immediate environs. Of desired changes within the own living environment, over 50% have to do with more forests and/or other natural areas within this environment (Reneman et al. 1999). This is often at the expense of industrial and business sites, roads, dwellings and large-scale agricultural landscapes. More nature within the living environment is considered (very) important by about half of the respondents. This almost universal positive valuation of nature seems to justify the use of public finances on securing its societal functions. Given the strong association of nature with silence and quietness, it remains to be seen whether the proposed marketing of nature is not in direct conflict with what makes it attractive: a sphere that is not dominated by people, in whatever way.

Summarizing and comparing the situations in Northern, Central and Southern Europe, forests are important recreation environments in all studied countries, but the supply of forested recreation environment varies greatly. In the North, there are many natural areas available for recreation and there is much interest in providing those resources also as a basis for nature-based tourism for other Europeans. In Central and Southern Europe, particularly in the Netherlands and other places where the population density is high, there is shortage of natural environment for recreation and people are interested in improving their environment by introducing more of nature into their residential areas. Participation rates in outdoor activities are comparatively higher in Northern compared to in Central Europe. The only difference is that natural areas are more commonly used in the North. In the South, participation in outdoor activities in nature is different. The total participation rate is as high in the South as in North, but people make fewer visits to forests and more often use other natural environments, and the activities are more social in character, such as picnicking. In

Southern Europe, there is a growing pressure to use nature protection areas for recreation, which cause serious problems for the protection of nature.

Final Considerations and Conclusions

In European nations where large natural or semi-natural forests still exist, such as Finland, most preservation and protective tasks are not in conflict with recreation functions. On the contrary, in countries where fewer natural forest areas are available, as in the Netherlands or Italy, it is necessary to identify and specialise those sites to be used for recreation in the future. Forest areas of a high importance from a natural and ecological point of view, currently subject to human pressure, could be better safeguarded. In the Netherlands, politicians have started to favour a multiple-use policy, in order to combine nature conservation and recreational use on a limited amount of land. In Italy, the huge public interest in protected areas makes the principle of multiple use a more complicated matter. Other forested areas than protection areas should be developed for recreation in order to shift the recreation pressure from protected areas. In Finland, restrictions of recreational use on protected areas are very seldomly demanded.

Development of forest areas for nature-based tourism has to take into account the ecological and economic peculiarities of those areas. This also means that the neighbouring communities and local people have to be given an active and participatory role in the management of these areas. Policy and legislative actions have to be taken to improve the integration between primary economic activities and other functions in the use of forest resources. Finland has developed methods of multipurpose forest planning, which help in this task. For example in Italy, the conversion of coppices into high forests, provides many benefits: economic (timber assortment), ecological (i.e., biodiversity), protective (side stability, water tapping), and suitability for recreation.

In many European countries, wood does not constitute an exhaustive source of income in rural areas. It is necessary to stimulate rural development where farms are running different parallel activities: forestry, agriculture, breeding, wild products gathering, tourism and recreation services. This may be possible in many regions without changing the farm structures too much. In Italy, an already existing law offers fiscal discounts and contributions for "holiday farms". In the Netherlands, private owners receive a subsidy for opening their forest for recreational use. A desired development should provide recreation services while maintaining the predominant role of primary rural activities. The same type of rural development is an objective in Finland, too, where landscape protection is becoming an important aspect of rural land-use. In most European countries, the present forests are a result of centuries of human action (both in a positive and a negative sense). Forests need to be cultivated and managed by man in a balanced manner and according to the latest criteria of forestry. As a common feature for European people, forest recreation can constitute not only a source of psychophysical relaxation and a way to know the natural environment of other countries, but also a means to get closer to their traditions, cultures and ways of life, becoming a precious instrument for integration. Each European country, in particular those, that have a quantitative and qualitative richness of forest environments, should therefore supply forest recreation services to its own citizens, but also acknowledge opportunities for foreign visitors.

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Social Functions of North American Forests

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Abstract

Forests of North American provide many social benefits and services for people. These range across a wide range of leisure, environmental, amenity, and economic benefits and services including recreation and leisure, water and wildlife, cultural and spiritual, and employment and income services. Resulting from these interests has been intense interest in parks, wilderness, wild rivers and other special places, exploitation of forests for a variety of services, a preservation orientation to counter exploitation, and clashes between interests. The result has been development of a mosaic of land uses and classes to provide opportunity for realizing a variety of services from North American forests and a constant tension among competing interests to have their service needs met. Clearly, North Americans recognize that forests provide many and diverse social and environmental services.

Keywords: Benefits, Services, Leisure, Environment, Amenity, Economic

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Amenity Resources and Other Services of Asian Forests

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Abstract

The various social services provided by the forests of industrialized Japan and Malaysia, a developing country, are discussed. The large population, increasing urbanization, diversity of cultures and geography, distinct national environmental policies and administration in the region have influenced the location of forests and their conservation, their socio-economic uses and recreation preferences and demand. The discussion is based on themes such as types of amenity forests and facilities available, recreation policies, use and demand statistics, growing demands for nature/ ecotourism opportunities, impacts of use and issues arising. Several suggestions are given for sustainable management and utilization of forests for recreation, ecotourism and conservation in light of the socio-political and economic conditions of the two countries. Common trends in both countries are highlighted.

Keywords: Amenity resources; Forest recreation; Sustainability; Ecotourism; Asia

Introduction

Asian forests as well as people are more diverse than other regions of the world. Furthermore, the population density in many parts of Asia is very high. These populations depend not only on forest products and forestlands for economic livelihood but also on recreational opportunities provided by forests. This situation is contributing to the overuse and deterioration of ever decreasing areas of Asian forests. Very often, non-commodity values tend to be neglected as immediate demands such as food and timber supply are given more importance. However, concern over global environmental issues such as biodiversity loss and increases in greenhouse gases emissions has compelled Asian nations to take immediate measures against the further degradation of their forests.

The authors discuss the various social services, in particular, amenity services provided by the forests in Japan and Malaysia. Criteria for comparison include the following: the forest environment, recreation policies, legal instruments, some use related statistics and national survey results, facilities, and recent hot issues. Various suggestions are given for sustainable management and use of forests for recreation, ecotourism and conservation in light of the socio-political and economic conditions of the two countries.

Forest Recreation and Related Services in Japan

Japan's forested areas have been increasing since the 1950s when dependency on fossil fuels accelerated as a result of "energy revolution". Now they occupy over 25 million hectares (Forestry Agency 1999). That means almost 68% of Japan's land area is forested. This percentage is much higher than the Asian average ratio of 18% and equivalent to that of Finland. However, there are several problems from the viewpoint of social services.

Japan's Forests as Amenity Resources

Japan's forests have several characteristics from the standpoint of amenity resources. First, 41% of them are plantations represented by cypress planted in the 1950s. Such forests are not only dark and monotonous but also relatively low in biodiversity. Such plantation forests can be attractive if occasional thinning is done. However, current timber prices are too low to invest money in managing them. Second, the lack of management of wildlife populations, for example, the rapid increase in deer population is causing serious damages to agricultural products as well as plantations.

Third, most forested areas are located in steep mountain areas. These mountainous regions contributed to the protection of Japan's forests which otherwise would be under heavy population pressure. However, steepness makes access from urban areas difficult and expensive. Once developed, both trails and forest roads require intensive care to overcome the damages caused by occasional landslides or erosion. Activities in such areas are also demanding and high risk. For example, Mt. Tanigawa has claimed more than 500 lives of climbers. Fourth, heavy rains accompanying the monsoon make some recreational uses uncomfortable and dangerous. For the same reason, the undergrowth of forest is dense and full of undesirable bugs enough to discourage activities in the summer season except for the alpine zone. For instance, hornet attacks are causing more casualties than elephant attacks in Kenya; every year more than forty lives are lost.

In short, Japan has relatively abundant forests, but their quality and location are not preferable as amenity resources. Still, these natural disadvantages can be turned into attractive factors by various adaptation measures. Indeed, the Japanese developed a sustainable forest culture since the eighth century and have not only been using the forest sustainably for thousands of years, but also have been enjoying it as amenity resources. Such non-commodity values of the forest were recognized by not only the ruling class but also by ordinary people.

Social Issues related to the Forest

Forest culture is diverse and changing from traditional wise use to biodiversity protection and recreation (Ito 1998b). The Japanese have developed a sustainable relationship with the forest after several critical periods (Totman 1989). However, such relations have been getting weaker since the 1950s, and several social issues related to the forest are occurring.

First, because of higher cost of domestic timbers, Japan depends heavily on imported ones; more than 88 million cubic meters (80%) of timber resource are imported annually. Such dependence on imported timber is partially contributing to the increase in biomass in Japan, but forestry is becoming a diminishing industry. The population of mountain villages is decreasing, and plantations are not managed. As a result, traditional forest culture related to wise use of forest resources is disappearing. At the same time, the accumulated deficit of national forest management reached 3.7 trillion yen (equivalent to 34.6 billion U.S. dollars) by 1997.

Second, because of the uneven location and resulting lack of direct contact, urbanites have little real experiences in forests. They tend to believe in forest information supplied by the mass media with little doubt. This is causing serious problems in the understanding of forest conditions among city dwellers. Most Japanese prefer natural forests to man-made forests when asked in questionnaires, but they choose the picture of the latter (Shidei *et al.* 1981). Thus, ignorance of forest and forestry among the Japanese is further compounded by images. This trend is clear from the national surveys on forest and forestry (Prime Minister’s Office 1999). Almost 90% of Japanese have some interests in the forest, but more than one third of them did not visit the forest at all. Even among those who visited, they just enjoyed sightseeing drives and other activities not directly connected to the forest environment.

Third, those with little experience in the forest tend to depend on modern tools and facilities to enjoy forest recreation (Ito 1994). They purchase a variety of camping equipment as advertised in outdoor magazines and carry them in overloaded cars. Then, staying at fully equipped auto camping sites, they enjoy high-tech displays and audio-visual presentations at the visitor centers in national parks or forest parks. Considering the popularity of such overdeveloped facilities, both state and local governments further develop such facilities in the public forest. This situation is narrowing the spectrum of opportunities as described in the Recreation Opportunity Spectrum (ROS). This vicious cycle further isolates visitors with interest in forest environment from the forest itself. In contrast with oversupply of hardware for forest recreation, software such as interpretation is underdeveloped. Considering the rainy climate and rugged topography, certain amount of development is indispensable. However, current gaps between hardware and software development are wide enough to hinder direct contact with the forest.

Fourth, related to forest recreation facilities, the legal system of protected areas is complicated. Over 31% of forested areas (25 million hectares) in Japan are national forests managed by the Forestry Agency, Ministry of Agriculture, Forestry and Fishery. The agency set aside 63% of national forests (4.8 million hectares) from timber management. The nature park system, including 28 national parks, is often overlapping with the national forests. The Environment Agency in the Prime Minister's Office is in charge of these nature parks. That is, the same forest is often managed by these two agencies. Such dual management was inevitable to establish national parks in the 1930s, but it caused serious inefficiencies in management (Ito 1996).

Fifth, the development of ecotourism is encouraged to revitalize rural communities in protected areas and to promote the understanding of natural environment and rural communities. National surveys revealed strong interest in it, but at the same time lack of leisure time appeared as a major obstacle (Environment Agency and Forestry Agency 1999). Already eco-tour operators are active in several national parks. Rich natural and cultural resources often impress participants. However, once they return home to urban areas, environmental awareness boosted by the ecotour is often forgotten (Naito 1999). Renewing such experiences is recommended. However, domestic ecotourism cannot compete with similar experiences overseas because of higher cost.

Possible Measures to Boost Social Roles of Japan's Forest

Thus, there are both environmental and social issues to promote the non-commodity uses of the forest in Japan. The forest environment cannot change over a short period, but social environment can be improved in a relatively short time. Particularly, Japanese society is rapidly aging due to increasing longevity and decreasing birth rate. Therefore, forest recreation and related services are expected to play important roles in promoting public health

Considering access for the elderly, urban fringe forests should play more important roles in forest recreation. Incidentally, recently more people are paying attention to such forests abandoned in the 1950s. Such interest is attributable to three main reasons: biodiversity, recreation and nostalgia. The urban fringe forest intensively managed for fuels and other commodity resources developed a stable ecosystem, and preserved certain species depending on such human interference. Such intensively managed forests without shrubs are ideal for recreation as well. Furthermore, urbanites recognize management activities like thinning or weeding as new forms of recreation with contribution to the forest environment. That is, traditional demanding work for farmers is being revived as recreation for city dwellers. The third reason, nostalgia for the sustainable life might be an escape from our wasteful modern life. However, Aldo Leopold's successful campaign to promote wilderness preservation reminds us of its importance (Ito 1998a).

Greenways, trails on abandoned railway tracks, have been promoted in the United States. The greenway has multiple roles such as recreation and environmental corridors and future sites for railway restoration. Since railway transportation is still active, development of more extensive greenway networks will be possible in Japan (Ito and Matsushita 1997). Such networks should connect not only between urban fringe forests but also urban fringe forests and the wilderness in national parks supplying biodiversity and diverse recreation opportunities.

The Japanese have been separating the urban fringe forests and wilderness or backcountry forests as *satoyama* and *okuyama* respectively. Accordingly, recreational uses were also distinguished. While *Satoyama* was used for common recreation such as cherry blossom viewing for ordinary people, *okuyama,* recognized as sacred space, was used by mountain priests to practice asceticism (Ito 1998c). Such a distinction enabled the Japanese to preserve wilderness next to a big city such as Nara. Such an old tradition for forest culture can be revived as a factor to give diversity to recreational opportunity as well as ecosystem.

Forest Recreation and Related Services in Malaysia

In 1997, the total forested area was estimated at 20.6 million hectares or 62 % of the total land area. Recognizing this rich endowment, the government has set aside 14.32 million hectares as permanent forest estates (PFEs) throughout the country. The PFEs have four main functions: as protection forest, production forest, amenity forest and research and education forest. According to the National Forestry Policy (1978, 1992), these are managed under sustainable principles to maximize social, economic and environmental benefits for the country. Since the 1900s, the country has been establishing a network of protected areas as part of its conservation efforts. In 1992, the country had 2.14 million hectares of conservation areas in the form of national and state parks, wildlife reserves and sanctuaries, nature parks, bird and turtle sanctuaries. In addition, there are also 120 Virgin Jungle Reserves covering 111,726 hectares serving as nature reserves and natural arboreta of the diverse forest types in the country.[1]

Amenity Resources of Malaysian Forests

Public demand for amenity forests became evident as early as the late 1960s. Rapid urbanization, high economic growth, rising incomes and education levels experienced by the population in the last two decades have heightened that demand for outdoor recreation spaces, particularly natural areas. Aggressive tourism promotion in the international market has also attracted more foreign tourists to visit the country's protected areas. To cater for this ever-expanding demand for recreation in natural areas, a total of 85 forest recreation areas (FRAs) have been established in Peninsular Malaysia (Forestry Department 1997). In addition, there are 39 protected areas in Peninsular Malaysia in the form of national or state parks and wildlife reserves (DWNP et al 1996).

[1] Statistics from various sources by the Ministry of Primary Industries, 1998, Forestry Department, 1997 and Ministry of Science, Technology and Environment (MOSTE), 1998.

The number of people seeking recreation in natural areas is increasing. Approximately 1.35 million locals and foreigners visited State / National Parks, Reserves and other natural areas (including islands) in Malaysia in 1994[2]. In a study of 20 FRAs (Willis *et al*. 1998), a total of 2.57 million visits per annum were estimated. Sites closer to urban areas and with better facilities and natural resources (eg. rivers and waterfalls) received more visitors than those which were more rural, remote and less facilities. Wildlife Department records of visitor numbers to the National Park in Pahang – Terengganu showed an increase from 8,200 visitors in 1984 to 58,157 visitors in 1997 with the development of easier access facilities, better accommodation and recreational facilities. When the Forest Research Institute of Malaysia opened its grounds for public use, with opportunities for hiking along nature trails, jogging, picnicking and enjoying nature; visitor numbers (in terms of organized visits) climbed from under 20,000 in 1990 to close to 60, 000 in 1998 (cited in Noor Azlin 1999).

As forests are often considered as public goods, forest recreation is usually unpriced or under-priced. No entrance fees are charged to FRAs and very low entrance fees are charged for visits to National Parks. Respondents involved in the survey of 20 FRAs indicated a mean willingness to pay RM 1.46[3] for access per visit (Willis et al 1998). Willingness to pay for entrance fees to the National Park were estimated at RM 3 and RM 8 per visitor for existing and improved opportunities respectively. The recreational value of existing opportunities at the Park has been estimated at RM 211,939 per annum and with improved opportunities, this value increased to RM 304,086[4]. Although, at present, there are no FRAs within the North Selangor Peat Swamp Forest (NSPSF), it offers numerous recreation opportunities such as bird watching (migratory birds as the main attraction) and recreational fishing. The potential recreation value of the NSPSF is estimated to be worth RM 142,000 per year (Woon et al. 1999a). Sport fishing

[2] Statistics from National Ecotourism Plan Malaysia, Ministry of Culture, Arts and Tourism, 1996. Cited in Assessment of Biological Diversity in Malaysia, MOSTE, 1997.

[3] Fixed exchange rate of USD 1 = RM 3.80.

[4] Case study cited in Assessment of Biological Diversity in Malaysia, MOSTE 1997.

enthusiasts to the NSPSF were willing to pay an average of RM6 per trip, those with higher education and income levels showing a willingness to pay more (Mohd Shahwahid et al 1999). Development of recreation opportunities at NSPSF will help relieve crowding at nearby popular recreation sites as well as ensure the conservation of this unique ecosystem.

Many of the country's natural areas are being promoted as ecotourism destinations, with loose adherence to ecotourism principles. Some characteristics include "mainstream or casual" visitors to nature-based sites (Lindberg 1991), little or no interpretation programs, activities that are not necessarily nature-dependent, tour operators who market mass tours to natural sites, infrastructure which modify/degrade the natural ecosystem, revenues generated which do not necessarily go back into conservation and benefits enjoyed by only a minority of the local communities.

Some of the common negative impacts occurring as a result of high and frequent use of recreational and protected areas are: the mass clearing of forested areas for tourism-related infrastructure and access roads (including mass clearing of mangroves for coastal reclamation/development), littering and the indiscriminate disposal of solid waste along trails, at camp sites, and on river banks and into rivers, the burning of waste resulting in air pollution or in groundwater pollution when buried, soil erosion and compaction along popular trails, damage to surrounding vegetation at and retreat of wildlife from use areas, and the illegal collection of insects and seedlings. There is an important need to strengthen visitor management to mitigate some of these impacts, achieve conservation objectives while simultaneously ensuring satisfactory recreation experiences.

Socio-economic Benefits from Forests

A large number of local communities living on forest fringes and indigenous groups (some living within forests) depend on the forests for their livelihoods, subsistence and to some extent, their recreation. Several socio-economic studies on peat swamp forest utilization have indicated that many of these communities derive their incomes from other forest resources other than logging activities. Communities rely on the peat swamp for their fishing, hunting, fruit harvesting and medicinal needs. In addition, they rely on the hydrological services provided by the forests for their farming and agricultural activities. The estimated social benefits (covering hydrological, eco-tourism, fish and *assam kelubi* (a forest fruit)) was at RM 113.4 million, contributing about 10% of the total economic value of the North Selangor Peat Swamp Forest (Woon et al. 1999a). Similarly, the social benefits generated from the utilization of the Southeast Pahang Peat Swamp Forest (SEPPSF) amounted to approximately 13% of the total economic value (Woon et al 1999b). In a survey of 236 households living in the vicinity of the SEPPSF revealed that at least two thirds of the households had members engaging in fishing and the harvesting of rattan in the generation of income. More than a quarter depended on the forest for hunting for food and recreation and 17% of the households trapped forest birds for sale. The households also relied on the forest for fruit harvesting, medicinal plants and wood materials for handicraft making. These communities (74%) also preferred the utilization of the peat swamp for agriculture production as the conversion of the forest to oil palm plantations is seen as a good way of generating better incomes. Only 1% supported the use of the forest for ecotourism purposes. Tourism benefits only a minority of people and may in fact restrict the use of forest resources (Lim at al 1999).

Mangroves are equally productive ecosystems in terms of socio-economic benefits. The waters off mangrove forests are rich fishing grounds, providing income and food sources to dwellers near these forests. Today, aquaculture has become a lucrative economic activity located near mangrove forests. The mangroves in Matang and along the northern coast of Perak are pertinent to supporting a coastal fishing industry, which in 1990 generated RM 76.7 million while prawn farming was valued at RM7.6 million (Cheng 1994). Mangroves are also harvested for charcoal production.

Even on the periphery of protected areas there are indigenous communities who rely on forest resources within the park for their livelihood. The residents of Kampung Peta, located on the main access route to Endau-Rompin State Park, collect rattan from the park as their main source of income (for 85% of households surveyed).They also hunt and fish in the forest for their subsistence. Tourism activities only provide an additional source of income to the villagers and cannot be relied on as a steady source. In addition, opportunities to become boatmen, porters and guides are only available to a few villagers (Stecker 1996). The vast socio-economic benefits provided by the forests to communities and the nation have yet to be fully quantified and are often overlooked in the decisions on management and utilization of forests.

Issues and Challenges in the Management of Forest Services

With increasing pressure on forests to produce a multiple variety of goods and services and the need to reconcile differing values of stakeholders, there has been a transition in the traditional role of forest management. Forest management has also moved from ecological and technical concerns towards planning and managing for social and political expectations.

Management of the environment is the joint responsibility of the federal, state and local governments but problems in implementing environmental management often arise from conflicting jurisdictional issues and development objectives. While the federal government has the responsibility to meet conservation objectives, the States often view forests as sources of revenues rather than as a land use option. The economic contribution of non-timber forest benefits (most with poorly developed or no markets) has often been neglected in assessing land-use options. Land conversion for agriculture, urban and industrial development and logging have led to mass clearing of forests (encouraged by competing policies), all of which that yield higher economic rates of return for State finances. Furthermore, land use planning and policies often allocate upland and hilly areas with poor soil and steep terrain (>600m) as protection areas. However, most wildlife habitats are found at lower elevations, of which many are being threatened by deforestation and fragmentation of habitats.

In an Asian-Pacific study on forest conservation, Malaysia was considered to have only a modest protected areas network, scoring a Conservation Index of 0.3 (low). Although East Malaysia has seen a rise in number of protected areas, Peninsular Malaysia is considered to have an inadequate system of reserves (Paine et al 1997). There has been a proposal for a Protected Areas Policy, in which at least 10% of key ecosystems as well as already identified biodiversity hotspots will be placed under protected areas. Currently, there is under-representation of protection of wetlands (including mangroves and peat swamps), lowland habitats below 300m of altitude and lower and upper montane habitats, of which a majority of mammals are dependent (DWNP et al 1996). When a forest is set aside for protection, conservation benefits are not necessarily or immediately tangible (in terms of revenues) to the states. Distribution of revenues generated from nature tourism, in the form of taxes, often benefit Federal finances rather than state. Furthermore, not all protected areas are suited for or should include tourism as a management objective. Market and policy reforms are needed, in particular to better capture the economic values of amenity / ecotourism resources, the option benefits of wild genetic resources, and other non-timber resources such as bamboo, rattan and water.

There are an adequate number of forestry, environment and conservation related policies and legislation in place. Yet, the lack of efficient and effective implementation and enforcement is perceived as the biggest hindrance to natural resource management and protection (MOSTE 1997). Lack of funding and adequately trained staff are among the reasons for poor program implementation and enforcement efforts. In 1991, out of an aggregated national total budget (USD 7.42 million) for agencies in resource protection, a mere 0.2% was allocated for protected areas (Paine *et al.* 1997). The recent economic crisis, which saw operational budget slashed, has also affected the implementation of resource protection programs and enforcement. Capacity building, harmonization of policies, greater Federal-State collaboration and innovative funding mechanisms are needed to overcome some of these institutional weaknesses.

Despite several inadequacies in conservation efforts, the country recognizes the importance of *in-situ* conservation in national policies and planning. This commitment is expressed in the ratification of the Convention on Biological Diversity and in the formulation of a National Policy on Biological Diversity. In addition to conserving habitat, species and genetic diversity, protected areas are also recognized as cultural heritage and for their scientific, educational, recreational and eco-tourism values. One of the thrusts of the Seventh Malaysian Plan (1996 – 2000) is to enhance the level of environmental awareness and commitment among Malaysians. Key progress has been made in the integration of environmental considerations in policies, legislation, market reforms, planning and management of sectoral processes. One of the challenges in this new century is the effective and efficient deployment of the country's financial and skill bases to manage this extremely rich forest resource on a sustainable basis.

Common Trends and Issues

Japan and Malaysia differ in terms of an immense diversity of geography, climate, types of forests and biodiversity, social and economic conditions. Yet, most of the forests in these two countries are surrounded by urban populations or rural communities dependent on forest resources or services. Utilization (whether sustainable or destructive) is very much influenced by both national and international forces and trends. As such, forest management is shifting from conventional forestry concerns to the recognition of a spectrum of uses and integrating these multiple socio-economic uses with conservation and sustainability concerns.

Two trends are obvious, that is, the growing demand for forest recreation areas by urban populations and for nature / ecotourism opportunities in natural forest environments. Asian forests are not abundant enough to supply diverse opportunities to the different demands of users. At present, characteristics of use at easily accessible sites are influenced by over-developed facilities with little interpretation programs to promote awareness of the natural environment. Less developed areas offering wilderness experiences are often difficult to access. To cater for growing demands, urban-fringed forests should be recognized as key amenity resources since access is easy and fuel saving. However, the provision of recreation services should be based on sustainable principles especially in the planning of forest access as well as use. There is considerable growth in the use of private motor vehicles in Asia as it provides freedom and privacy. This tends to lead to further problems such as traffic congestion, accidents and air pollution at sites. For access to wilderness or national parks far from urban areas, public transportation should be encouraged. By introducing disincentives for the use of private vehicles to such areas, it is not only energy saving but also decreases the need to open up more forested areas for parking spaces.

Both countries discussed here have developed policies and legal instruments to ensure the sustainable provision of recreational and social services from forests. However, overlapping or adjacent forests and national parks are often managed by different agencies with different priorities for conservation and development. Conflicting jurisdictional and priority issues need to be resolved through better co-ordination and operational reforms to ensure effective implementation of policies and forest social programs. Nonetheless, the government's role in ensuring longer term conservation and wider social priorities will remain as crucial.

The governments of these countries have also made international commitments through the ratification of several international environment Conventions (Biological Diversity, Wetlands/ Ramsar, World Heritage Areas and Climate Change), taking on obligations to ensure the conservation of forests and provision of environmental and social services. It is foreseen that global environmental issues together with dynamic global economic conditions and social preferences increasingly influenced by global trends will have large impacts on the conservation of forests and the use of forests for recreation, tourism and other social services in both countries as well as Asia.

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Forest and Society Needs:

Evaluation of Technologies for Society Needs

Coordinators:

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Sustainable Development – Transferring the Concept to the Levels of Technology and Operations

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Abstract

Since the Rio Earth Summit of 1992, sustainability has been widely accepted as a concept for future development. However, rigorous applications of the underlying principles and goals at the level of production and distribution are notably rare. Two paths of developments have emerged. At the political-programmatical level, different sets of criteria and indicators have been developed that mainly address 'best policy' issues. At the technical-operational level, newly evolved environmental management concepts consider primarily the aspects of 'best practices'. These two approaches contain many gaps, and a general framework to guide future thinking and the development of tools is still missing. The goal of this paper is to describe the process for implementing sustainability goals at the operational level. A brief analysis of the sustainability concept has uncovered three major challenges at the levels of technology and operations: 1) environmental soundness of systems requires improved technologies and more efficient technical systems; 2) the careful deployment of technology relies on a more effective institutional framework; and 3) minimizing energy and matter flow per service unit is the main goal of future efficiency improvements. The proposed framework for implementation considered four main aspects: 1) Eco-efficiency is a general principle that makes environmental performance of products and processes measurable, and that is strongly related to the well-established principle of operational efficiency; 2) Environmental management systems provide a set of management, analysis, and assessment tools to achieve ecological goals within overall business processes; 3) New policy tools consider public involvement, independent private inspections, self-responsibility, and communication of environmental performance to consumers and the public; and 4) Life Cycle Assessment (LCA) and Risk Analysis (RA) provide the methods and tools needed to model the flow of matter and energy through a bounded production system, while assessing potential environmental damages and risks. To be able to adapt these options to the "real world" of forestry, planners must rethink the essence of engineering work, and management tools must be modified to meet the special requirements of forestry operations. Engineering is no longer an isolated technical task. It must now integrate technical processes with public involvement, environmental performance assessments, and public choice. A main challenge in future research and development activities will be to integrate Eco-efficiency philosophy with the well-established concept of operational efficiency. Engineering professions should also collaborate actively in the development and improvement of policy tools, as well as in the process of establishing scientifically based environmental standards for forest operations. Emerging tools, such as LCA or RA, must be tailored to foresters' specifications.

Keywords: Development needs, Eco-efficiency, Environmental analysis Environmental performance, Environmental management, Policy tools, Research, Sustainability

Introduction

In 1992, the international community accepted the concept of sustainability as a framework for future development. While many people agree with this general goal, useful ideas and tools are still lacking for implementing the projects and processes that are required for attaining environmental sustainability. Since the Rio World Summit of 1992, a dual-track policy has been adopted. At the political-programmatical level, discussion has been focused on different sets of criteria and indicators that mainly address issues of natural resource management ('best policies' aspect).

At the technical-operational level, environmental management concepts have been evolving. These provide different management, analysis, and assessment tools, and primarily consider issues of industrial metabolism ('best practices' aspect). The continuing problem is how to integrate 'best policies' and 'best practices' into the concept of sustainable development in the forest sector. Farrell (1995) has proposed several possibilities for combining these two aspects, while Galeano (1995) and Heinimann (1996, 1998a) have investigated these issues from a forest-engineering perspective.

The goal of this paper is to provide a framework that can guide future thinking about tools for implementing the general ideas of sustainability at the operational level. Because the primary emphasis here is on environmental management concepts, details of forest policy processes, such as the Montreal or Helsinki processes, will not be discussed. An analysis of the main challenges that derive from economic, social, and environmental sustainability dimensions will be presented first. Secondly, business activities will be linked to sustainability objectives, thus providing a framework of principles and tools for future development.

Sustainable Development – A Technology Perspective

Originally, environmental economists developed sustainability theory by considering the interaction of the economic system with the biosphere (Ayres 1978, Hall 1986). There is broad consensus that achieving sustainability relies on three components: economic, social, and environmental development. The United Nations Conference on Environment and Development (UNCED, held in 1992 in Rio) adopted the concept of sustainable development as a programmatic goal. The main principles and goals were documented in Agenda 21 (UNCED 1992), in which "combating deforestation" (Chapter 11), "sustainable mountain development" (Chapter 13), and "sustainable agriculture and rural development" (Chapter 14) were identified as the core activities of the forest sector. These concepts have intrinsic appeal, especially to people concerned with environmental issues. However, rigorous applications of specific principles and goals at the production and distribution levels are notably rare. To understand the problems that arise from this general model, a short review of the foundation of sustainability provides the key questions to be answered in the near future.

An economic system is intended to supply individuals and society with the necessities of life. Modern societies are based on a division of labor, which has made it possible to increase efficiency tremendously, but which has also resulted in inequalities of well-being and wealth. Environmental economics distinguishes between "natural capital", "manufactured capital", and "human capital" to differentiate the underlying concepts (Farrell 1995). Natural capital comprises the environmental assets that provide flows of ecological goods and services. Manufactured capital is generated by the means of production. Human capital refers to factors that provide knowledge, institutional arrangements, and basic values such as human rights, cultural heritage, etc. The central idea of sustainability theory is that natural and manufactured capital cannot substitute perfectly for one other (Farrell 1995). From an operational point of view, the theory of production is essential. It deals with optimizing the combination of natural, manufactured, and human capital to produce goods and services. Technology is the method by which these factors are combined, based on the state of scientific sophistication. Consequently, technological advancement is an improvement in the combination of those factors that results in greater efficiency. It is usually seen as one of the driving forces of economic and societal change. *Improving technology and controlling its deployment are, therefore, essential issues in the implementation of the concept of sustainability.* Exponents of the Club of Rome (von Weizsaecker *et al.* 1997) proposed an "efficiency revolution" as one approach to future development, because they were convinced that technological advancement offered about half the potential needed to achieve a sustainable state of development.

Sustainability theory relies on equity as a principle for social development. Its aim is to provide just distribution, i.e., a division of resource flows among different peoples, including future generations, that is fair or limited in its inequality (Farrell 1995). After the Rio World Summit in 1992, a subsequent conference focused on the dimension of social development. While planning this World Summit for Social Development of 1995, the United Research Institute for Social Development prepared briefing papers (UNRISD 1994) that identified three important problem areas: poverty, unemployment, and a lack of social integration. Important obstacles were also noted at the operational level, including the observation that the traditional institutional framework continues to lose its effectiveness in controlling human actions. Another problem is that tolerance has declined in day-to-day social relations. From the viewpoint of accomplishing projects and technical processes, human actions should minimize social impacts while maximizing public acceptance. A German expert group (Sachverständigenrat 1994) distinguished the two facets of social impacts: individual and social integrities. Individual integrity tries to guarantee minimal health and safety standards while social integrity consists of several dimensions. Burdge *et al.* (1995) have set up a framework to define these social impacts. Their concept is based on criteria such as use of natural resources, equity of risk exposure, socio-economic conditions, public health and safety, cultural heritage, and aesthetics. It is important to devise new methods for institutional guidance and control of the development and deployment of technology, and to find new procedures for improve public acceptance. The future is promising for the creation of alternative policy instruments and procedures of public involvement.

All human actions are enmeshed with the biosphere. World economies have grown in such a way that they may degrade the environment to the point where serious negative consequences emerge. Three important aspects of the biosphere limit human activities: 1) the capacity to absorb and recycle waste streams created by production and consumption; 2) the limit to which ecological services can be provided; and 3) the change of structures in the biosphere that results in system strain or damage. The publication by Meadows *et al.* (1972) was the first to quantify global environmental impacts and relate them to different scenarios of development. Nearly three decades have passed in which there have been attempts to minimize environmental impacts. At the beginning, a 'cleaning-up' philosophy, also called 'end-of-pipe solution', was used to purify different types of waste, such as sewage.

By the beginning of the 1980s, a more holistic approach was proposed for managing the flow of energy and materials from sources to sinks. This method was intended to operate on a scale that did not erode the carrying capacity of the biosphere. First proposed by ecologists, this philosophy is often called 'begin-of-pipe'. Odum (1989) states that input management requires a major change because the new focus is on waste reduction and recycling, rather than on waste disposal. *The main challenge to implementing this strategy is to integrate 'input management' with the technical and administrative processes of production, distribution, and consumption.* Since the World Summit of 1992, the newly developed environmental management concepts have included several tools and standard procedures to enable enterprises and firms to continuously improve their environmental performance.

Conceptual Framework to Operationalize the Principles of Sustainable Development

Eco-Efficiency

The Business Council for Sustainable Development participated in the preparations for the Rio World Summit in 1992. According to its president, the main outcome of the summit was the principle of 'eco-efficiency' (Schmidheiny 1992). Subsequently, the World Business Council for Sustainable Development (WBCSD). Defined eco-efficiency as creating economic values while reducing ecological impacts and resource use (de Simone and Popoff 1997). This definition covers two basic objectives that have been conceived, for example, by Galeano (1995) or Heinimann (1996). First, the world's consumers must minimize their use of environmental resources (biotic and abiotic raw materials, water, energy, and space). The second goal is to mitigate undesirable impacts on the natural environment, the social environment, and individual human beings. Linking it to economic efficiency has made this concept operational. In economic terms, efficiency is the relationship between input and output factors. Physical units, such as numbers of product or service units, measure output. Economic input factors, however, are measured differently, in units of person-hours (labor), machine-hours (equipment), or volume (fuels, materials). Efficiency measures are widely used as a particular benchmark of economic performance in firms and enterprises. Benchmarking is the study of the top competitor's product or business practices in order to improve the performance of one's own company.

Likewise, the same output measures are used to assess eco-efficiency. The first aspect, resource efficiency, relates the use of environmental resources to the amount of product or service units. Secondly, environmental waste also is related to the number of product or service units. This emerging concept is constantly being refined. The latest developments have been documented by Keffer *et al.* (1999), who provide the following definition of eco-efficiency:

> *Eco-efficiency is reached by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impact and resource intensity throughout the life cycle, to a level at least in line with the earth's estimated carrying capacity.*

They have introduced eco-efficiency metrics by proposing the following core indicators:

Product output: units -- numbers or mass of a specific product or service;

Environmental Input: Energy (GJ), Materials (kg), Water (m^3);

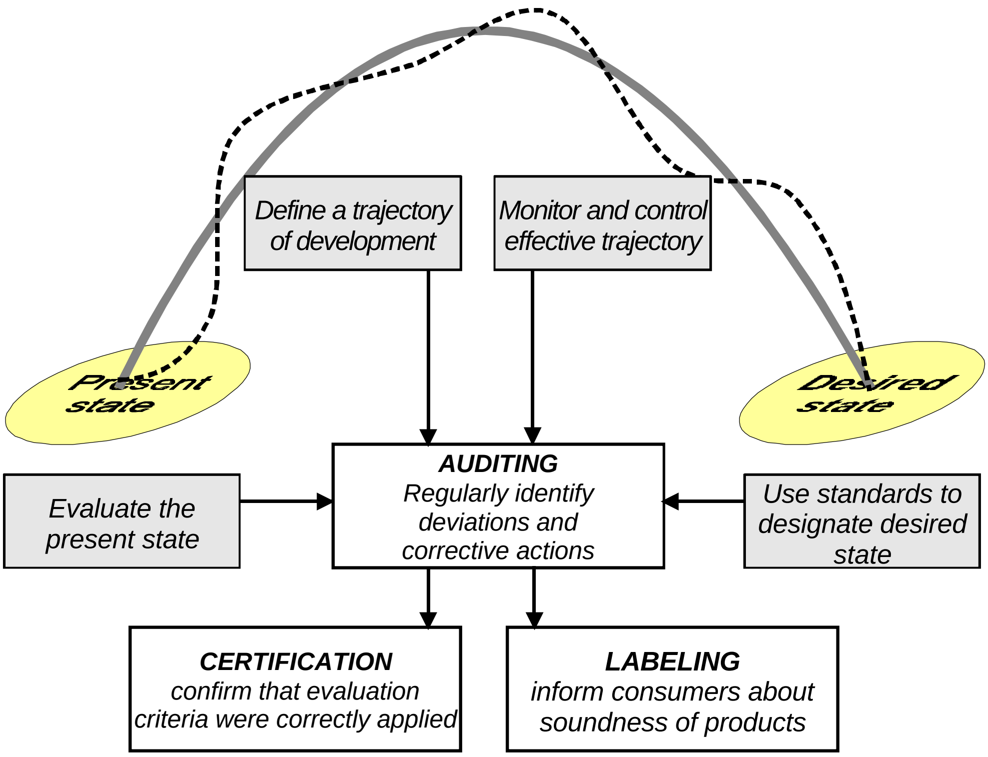
Environmental Outputs: Greenhouse Gas (GHG) Emissions (kg of CO_2 Equivalents), Ozone-Depleting Substance (ODS) Emissions (kg of CFC-11 Equivalents).

The purpose of these metrics is to enable companies to report and communicate the state and development of eco-efficiency in their businesses in a manner similar to how they communicate their financial core data. By following the benchmarking principle, comparisons of environmental performance also are possible.

Environmental Management Systems

The aim of management is to design, control, and develop administrative and technical processes that achieve specific goals while absorbing external disturbances (Fig. 1). Using an integrative management approach, environmental issues represent only one dimension of the overall system of objectives in a firm. A German study by Sachverständigenrat (1994), has followed well-accepted management principles in developing an approach to implementing environmental management. The first phase involves defining principles that will serve as general guidelines for action. Those principles may include: 1) reducing use of materials, 2) lowering energy use, 3) decreasing toxic dispersion, 4) enhancing the recyclability of materials, 5) maximizing sustainable use of renewable resources, 6) extending product durability, and 7) increasing the service intensity of products and services (Keffer *et al.* 1999). The second phase in developing an environmental management plan defines performance standards that can be measured via standard metrics.

Figure 1. Components of environmental management systems. A firm is responsible for designating its own desired state of environmental performance, evaluating its present performance, defining a trajectory of development, and implementing a controlling system. Independent bodies regularly inspect the activities to identify deviations and determine corrective actions (auditing). Communication to customers and to the public uses certificates and product labels.



The third phase deals with designing and implementing a control system that first can recognize deviations between actual environmental performance and environmental standards, and then initiate corrective actions. Making the control system functional seems to be the core problem of environmental management.

Environmental management systems integrate these three phases. They also provide additional instruments to assure quality control and to communicate environmental performance to the consumer and the public. Environmental management is a cybernetic process that continuously compares actual performance with a planned course of action, thus constantly improving production processes. The European Union enacted an Environmental Management and Audit Scheme, EMAS (EMAS 1993), to standardize this management approach. International efforts have led to a series of ISO standards (ISO 14000 series) that address different aspects of environmental management systems (ISO 14001, 1996). The Technical Committee TC 207 has been responsible for coordinating all standardization activities. Six main aspects are emphasized:

Environmental management systems -- ISO 14001 (1996) and ISO 14004 (1995);
Environmental auditing and related environmental investigations -- ISO 14010, 14011, and 14012;
Environmental labeling -- ISO 14020, 14021, and 14024;
Environmental performance evaluation -- ISO 14031;

Life cycle assessment -- ISO 14040 (1997), 14041 (1997), 14042 (1997), and 14043 (1997);
Terms and definitions -- ISO 14050.

The forestry sector has not yet followed the integrative approach of environmental management. Single components (e.g., certification and labeling) have dominated the debate, often overlooking the purpose of the whole system. The main challenge, therefore, will be to integrate principles, standards, controlling systems, and auditing procedures to align the forestry environmental management approach with the mainstream approach of other sectors. To promote this goal of integration, ISO has recently published a standard 14061 'Information to assist forestry organizations in the use of Environmental Management System standards ISO 14001 and ISO 14004'.

Policy Tools

Implementing a concept requires combining 'best policies' and 'best practices' to maximize the probability for success. From a technology standpoint, focusing too much on the 'best practices' aspect can be risky, thereby neglecting policy aspects and institutional feasibility. Therefore, it is important to understand the institutional framework and policy tools, i.e., the formalized rules and procedures for managing affairs among different groups of stakeholders. For a long time, legal compliance was the only requirement considered. The increasing maturity in a profession or scientific community leads to professional rules, such as technical standards and codes of practices, or ethics (Fig. 2). Because professional rules are voluntarily established, they cannot be enforced. Technical standards usually describe the rules for designing engineering structures whereas "state-of-the-art" rules outline the body of proven knowledge.

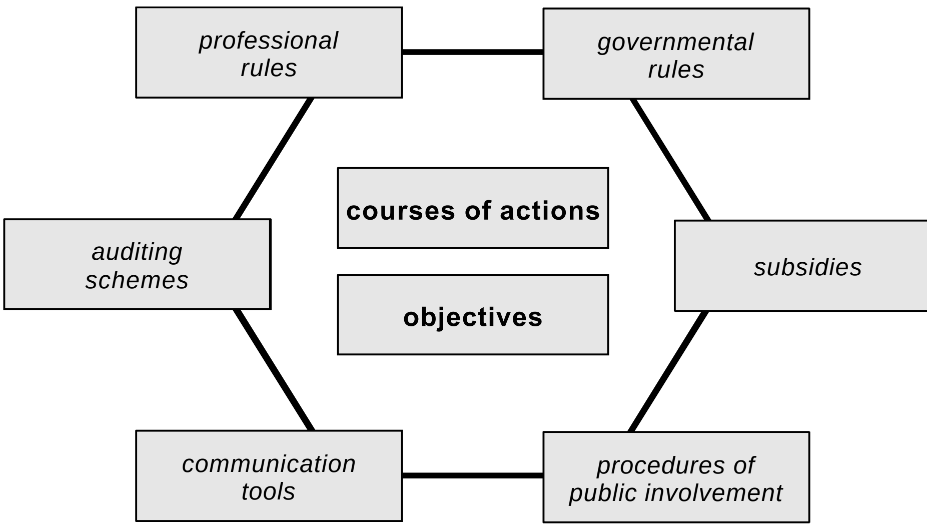


Figure 2. Policy tools building the institutional framework for action. Traditional tools (governmental rules, subsidies) continue to lose their effectiveness in controlling human actions. Novel policy instruments (public involvement, auditing, communication) aim to improve public acceptance.

During the last decade, professional groups have made great efforts to establish a set of international rules, even for the forestry sector.

The FAO model code of forest harvesting practices (Dykstra and Heinrich 1996), and the safety and health code (ILO 1998) are important contributions that should help improve the quality of forest operations and products, while minimizing adverse effects. Several countries and regions also have established their own codes of practices, particularly in Anglo-Saxon countries, and international technical standards are steadily evolving. The most advanced area seems to be in ergonomics, with about 100 technical standards already available or in preparation (Dul *et al.* 1996).

Following the 'carrot and stick' principle, the use of subsidies has been instrumental in promoting the desired courses of actions. However, guaranteeing legal compliance, proposing professional rules, and distributing subsidies do not necessarily result in their public acceptance. Because the traditional institutional framework continues to lose its effectiveness in controlling human actions, a search for new policy instruments has begun. This search considers principles such as self-responsibility, public involvement, continuous improvement, or intelligibility. Three classes of policy instruments have been emerging (Fig. 2):

Procedures of public involvement formalize the process of bargaining with different groups of stakeholders. In Forest Operations, public involvement has become a part of project-planning processes in some countries (e.g., road-network planning), where it is an essential component of environmental impact assessment (EIA) procedures (see Heinimann 1998a).

Auditing schemes are an independent review of a body's activities and operations to ensure that these are being performed or are functioning in accordance with objectives, rules, and standards. The audits identify, at regular intervals, deviations that might require corrective actions. These schemes are an important part of quality-control management that has recently been standardized (e.g., ISO 9000ff, ISO 14010, EMAS). Auditing procedures are an essential component of forestry certification schemes, as stipulated by the Forest Stewardship Council (FSC), the Canadian Sustainable Forest Certification Coalition (CSA SFM), and the Pan European Forest Certification Scheme (PEFC).

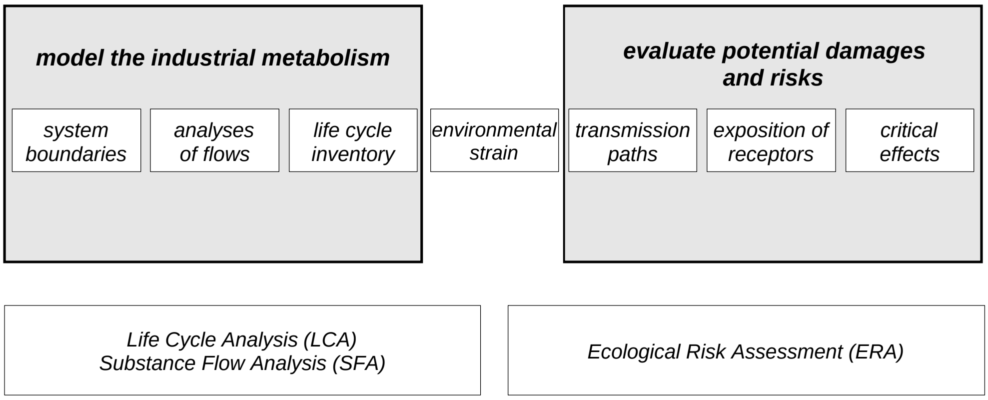
Communication tools allow consumers and the public to discern the environmental soundness of products, services, or processes. *Certifications* are formal statements of the results from a third-party evaluation, confirming that specific evaluation criteria have been correctly applied. Eco-certifications assure that a body is able to manage and continuously improve its environmental performance. *Eco-Labels*, granted by either governments or privately sponsored agencies, aim to typify products, thereby informing consumers that a labeled product has a certified environmental quality, though not necessarily better than that of a non-labeled product of the same category. Some forestry certification schemes provide specific labels (FSC, PEFC), while others do not (CSA SFM).

Traditional policy tools rely mainly on public institutions and on bans and precepts. The latest policy tools are based primarily on private institutions, self-responsibility, and continuous improvement. Adaptation of these novel policy instruments to the forestry sector is on-going; its potential will continue to develop.

Analysis Tools

To evaluate the 'best practices' aspect, analytical tools are needed for quantifying the environmental performance of processes and products. These environmental tools are formalized procedures, based on scientific principles that estimate the biophysical effects of different courses of action. They aim to make evaluations comprehensible and comparable.

Figure 3. Tools for environmental analysis. The tools to model the industrial metabolism have reached maturity while risk-assessment tools still need further improvement.



In this analysis, the industrial metabolism (Fig. 3) is described and modeled along a specific process network, using laws and principles from natural science. According to Bader and Baccini (1996), five types of system boundaries are common: 1) product, 2) process network, 3) region, 4) resource use, and 5) geogene ecosystems. Different methods describe the flow of matter and energy through a bounded system. The simplest approach is the quasi-static input-output analysis (see details in Heijungs *et al.* 1992, Heijungs 1997, Frischknecht 1998, and Hendrickson *et al.* 1998). The so-called Life Cycle Assessment (LCA) approach (ISO 14040, 1997) incorporates this methodology to derive life cycle inventories that quantify system inputs and outputs. Its acceptance has been increasing due to international standardization (ISO 14040, 1997). Bader and Baccini (1996) contend that quasi-static approaches have some major shortcomings in describing industrial metabolism under changing conditions. Therefore, they have developed a more general formalism, called Substance Flow Analysis (SFA), which uses physical laws to model the flows of matter and energy. Their approach can be used on a local to a global scale. Of special interest to forestry is work by Baccini and Bader (1996) in modelling environmental resource flow on a regional scale.

The most difficult part of environmental analysis is relating effects (systems inputs and outputs) to risks and potential damages. These effects must be linked to classes of environmental damage, such as resource depletion, global warming, acidification, etc. (Heijungs *et al.* 1992). Selecting risk categories is a normative process that is heavily influenced by the underlying value system and value preferences. Hofstetter (1998) has introduced a valuesphere model that considers three types of value systems.

Owens (1997) concluded that LCA has shortcomings that affect the appropriate evaluation of risks. He recommended using more detailed assessment approaches, such as risk analysis. Risk Analysis (RA) is a scientific framework to systematically investigate strain-stress relationships and to evaluate them using threshold values for the different dimensions of risk. Judging the tolerability of risks is a difficult process. Relying on public choice results in variable thresholds in space and time. RA was evolved in technical fields, but has recently become common in analyzing and evaluating environmental risk. Conceptual risk models (see Suter 1996) systematically identify 1) sources, 2) transmission paths, 3) exposition of receptors, and 4) critical effects (Fig. 3). Knowledge is still lacking in the understanding of critical effects; even the ISO 14042 standard (1997) was not able to present a conclusive framework. Human toxicology and ecotoxicology are emerging fields that investigate these risk issues (see, e.g., Hansson 1997).

The environmental performance of timber- and lumber-production processes has been extensively investigated (e.g., Sundberg and Svanquist 1987, Richter 1991, Karjalainen and Asikainen 1996, Winkler 1996, Zimmer and Wegener 1996, Heinimann 1998b). Analyses that consider the process network of 'timber production' are static, and rely on sweeping assumptions. Variability in site conditions, silvicultural regimes, and harvesting systems makes comparisons difficult, even impossible. Multinational efforts will help improve the quantification of environmental performance within the forest industry. A European initiative has begun a project „Life Cycle Analysis of Forestry and Forestry Products" (COST E9 program) to coordinate and harmonize LCA methodology. The program started in 1997 and should be finished by 2001. Expected results are documentation of the methodology as well as guidelines for gathering basic data on energy and matter flow.

Prospects for Future Developments

The previous phase of developments in forestry was dominated by environmental and institutional issues. Unfortunately, many people misjudged the significance of technology and engineering sciences, and their roles in sustainable development. Three major challenges arose for defining the necessary levels of technology and operations: 1) Environmental soundness of systems requires improved technologies and more efficient technical systems; 2) Careful deployment of technology relies on a more effective institutional framework; and 3) The main goal in improving future efficiency is to minimize energy and matter flow per service unit. These challenges provide a starting point for engineering disciplines to design and develop sustainable systems. Environmentally Sound Technologies (ESTs) are not just individual technologies, but total systems that include expertise, procedures, goods and services, and equipment as well as organizational and managerial procedures.

A framework is needed for guiding future thinking in transferring the sustainability concept. Eco-efficiency is an emerging principle that will allow environmental performance to be monitored in processes, firms, sectors, and national economies. First, however, the proposed metrics (Keffer *et al.* 1999) must be refined for the forestry sector. Land-use activities often imply adverse effects on watershed processes and site disturbances that should be integrated into eco-efficiency metrics. Environmental Management Systems provide the concept and tools to achieve ecological objectives within the overall business processes. To make such a system effective, a set of environmental standards is needed that goes beyond legal rules. Forest policy incorporates developed criteria and standards that are important for resource and ecosystem management. However, criteria and indicators are still incomplete at the operational level. The traditional institutional framework continues to lose its effectiveness in controlling human actions. New policy tools should help to increase acceptance of technology use via public involvement, independent inspections, and communication of environmental performance to consumers and to the public. The combined efforts of social and engineering sciences are needed to continuously improve and develop our institutional framework. Finally, to transform 'environmental feelings' into facts, we must improve and apply analysis tools. LCA essentially provides an approach to model the flow of energy and matter through a bounded system. However, relevant risks must still be evaluated. RA is a promising approach that could improve the understanding and management of environmental risks.

In bringing these options into the real world of forestry, several issues warrant consideration:

- The understanding of engineering must evolve from being perceived as a technical task to one that integrates technical processes with public involvement, EIAs, and public choice;
- The concept of operational efficiency must be expanded to consider the "eco-efficiency" approach proposed by the World Business Council for Sustainable Development (de Simone and Popoff 1997);

- A set of scientifically based environmental standards must be developed for forest operations, which relies on conceptual models for ecological risk assessment (as proposed by Suter 1996);
- Ecological aspects must be integrated into the design of forest products and processes;
- Emerging management tools must prove their usefulness. These include Enterprise Resource Planning systems (ERP) that currently are being developed by the largest management software providers (e.g., SAP, Oracle); and
- Active collaborations must be encouraged among engineering professions for improving and developing the institutional framework (e.g., adaptation of policy instruments, etc.).

In fact, sustainable development on the planet depends on resource cycling, rather than their extraction and eventual discard. "End-of-pipe" thinking must be substituted with forward-looking approaches to product- and process design. However, we are in the early days of sustainable development, and much more work is necessary in the forestry arena.

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Technological Advances - Autonomous Systems as the Basis for Future Wood-Harvesting Operations

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Abstract

Autonomous systems are broadly defined as functions and chains of functions carried out independently, without direct human control. This narrow definition excludes partly automated systems, e.g., remote-controlled machines, unless they are able to work independently. This presentation concentrates on current wood-harvesting operations that use the most advanced technology. The possibilities for implementing autonomous systems are greater in the silvicultural sector, but the approach and needs are very different. As a rule, an autonomous machine is easily connected with machine movements, and is designed to solve problems associated only with those movements. The dilemma, however, in wood harvesting is larger than that. Wood harvesting is a part of a forest-industry chain of processes. Replacing human supervision and decision-making will be a demanding task. The vision is probably very remote for a present-day forest harvester - forwarder combination chain to act autonomously, especially for silvicultural practices in natural forests. If management trends are toward controlled, cultivated forests, the possibilities for an autonomous system are much better. Progress will be incremental, with partial automation for subfunctions expected to be available soon.

Keywords: Automation, Harvesting operation

Introduction

Forest harvesting has become increasingly mechanized during the past 30 years, with no reason to presume that the overall technical development will not continue. The factors steering this development are costs, quality of the work and the material produced, development of the overall infrastructure, and concern for the environment. Much timber is still harvested with manual tools. In this situation, technologies designed to lighten the work can significantly improve quality and productivity. At the other extreme is the fully mechanized forest-harvesting chain.

Mechanized forest harvesting has been guided both by technical development, which has offered new possibilities for developing machinery, and by changes in the infrastructure and methods of working. The progress in equipment design has been unprecedented during the past 10 years, resulting in machines with properties that cannot be utilized in many markets yet.

An autonomous system is broadly defined as one consisting of functions and chains of functions that are carried out independently, without direct human control. If one closely adheres to this definition, partly automated systems must be excluded from the scope of our discussion. For example, remote-controlled machines would not be included in this autonomous category unless they were able to work independently. In this presentation, therefore, we will concentrate on examining the different technological steps required for developing an autonomous machine or system.

Remote Control – An Intermediate Phase?

Today, the task of the forest machine operator is to control the movements of the machine by making correct choices and optimizing the parameters related to quality. Many of the functions related to controlling the machine have already been automated, and will be further improved. This work has already changed the major role of the operator to one of monitoring the so-called process and related decision-making.

Removing the operator from the machine is, in a way, the first step toward introducing an autonomous machine - i.e., by remotely controlling the machine. In fact, the first remote-controlled machines already presented to the markets have not really increased the autonomy of the machine; a few wires were merely replaced with a radio connection. This modification could have great significance, however, both for machine construction and for the operator. These solutions are significant in a "philosophical sense".

Machine

After the operator is removed from the machine, it is then possible to remove the cab, which is the "problematic" component. Ordinarily, the cab must be positioned to provide the occupant with a good overall view in all directions, and a safe and pleasant working environment. Removal of the cab would create many new possibilities for designing and lowering the cost of the machine.

Operator

Currently, it is possible to move only the operator to the work site. If the operation were to be conducted with cab-less machinery, the operator would have to carry along the machine's control equipment. Significant factors in controlling the machine and making decisions are 1) the operator's ability to see the whole situation (operative decision-making) and 2) his conception of three-dimensional space. A person's ability to perceive these matters deteriorates as the distance from the equipment increases. To be able to control the machine as done currently, the operator would have to work beside the machine, but this would compromise the worker's safety. Therefore, the operator must be moved away from the near vicinity, which means that sensory knowledge and some of the decision-making has to be replaced by other means.

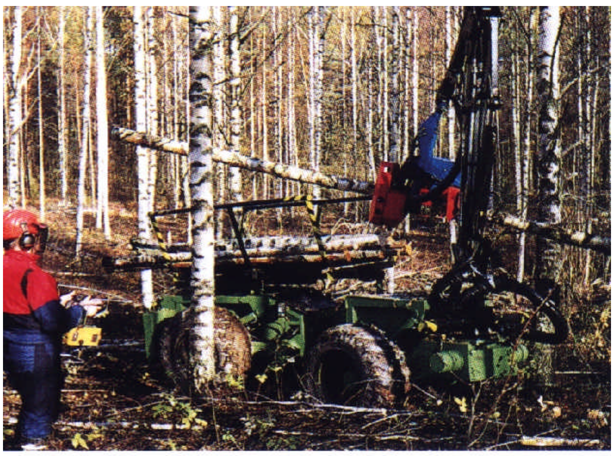
Opportunities and Problems of Autonomy

An essential factor in raising the degree of the machine's autonomy is the possibility for substituting technical solutions for sensory fact-gathering and the decision-making processes of the operator. The facets involved in automation and technological development of forest machines are:

Machine – tree interaction
Machine – terrain interaction
Machine – man interaction
Machine – surrounding information network

Advances in automation and technical development can be found for each facet, but the individual needs vary. Designing autonomous machines also requires more than identifying the interaction between man and machine. Significant innovations and their subsequent development into reliable and cost-effective products also require possible changes in the overall infrastructure and the ways in which organizations operate

Figure 1. Remote-controlled harvester-forwarder (RCM Harvester Ltd.).



Machine – Tree Interaction

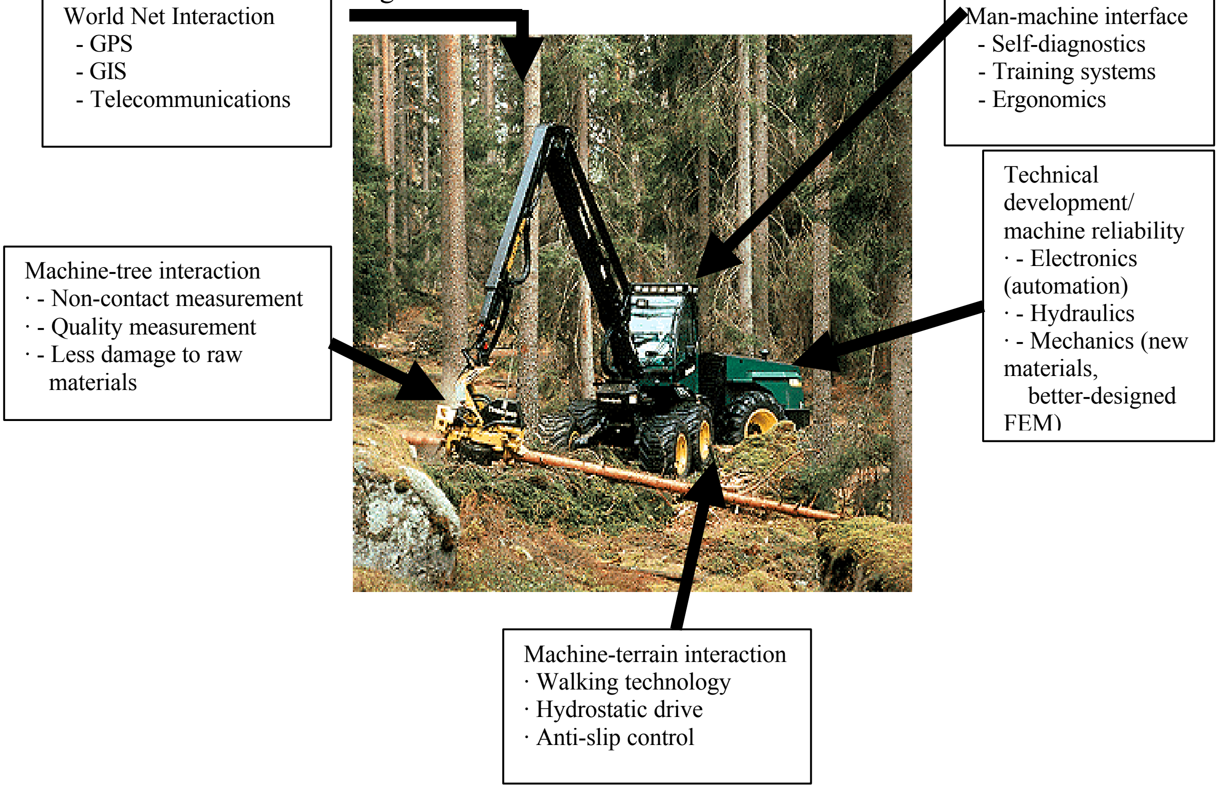
Interaction between the machine and the tree includes all work phases in which timber is moved or handled by the equipment. Increases in the degree of automation are possible, for example, in the automation of trunk feed in harvesters. Current programs can optimize and handle the trunk, based on tree dimensions and without the need for operator intervention. However, the operator is still the eyes of the machine and the decision-maker in matters relating to technical quality. Automation of the feed could be developed much further if trunk quality (straightness, knots, rot, etc.) could be measured, and this information used as a part of the optimization process. An exact method to measure quality is one of the greatest challenges when searching for new breakthroughs.

In crane control, the hydraulic six-lever control has been replaced by an electric two-lever control. Experiments have also been carried out with a single-lever control, but these prototypes have not reached the production stage. The next leap in the progress toward an autonomous machine could be automation of specific movement paths. These could possibly be realized in forwarders.

Machine – Terrain Interaction

The hydrostatic power transmission has improved control of the machine's maneuverability in the terrain, and has enabled development of new features (wheel-slip prevention, etc.). Movement of equipment is probably the technological area with the greatest challenges for developing autonomy. The introduction of GPS technology has lowered the price of applications to a reasonable level, and their accuracy is sufficient for many purposes. "Follow-the-track" or pointing out the drive route on the map is already possible, in principle. The accuracy of maps, which is naturally one of the key issues when developing new modes of operations, is improving very quickly.

Figure 2. Machine interaction with environment.



Machine – Man Interaction

The operator now is the most important component of the machine. Changes in the goals of forest-harvesting methods, as well as in objectives and logistics, have caused significant revisions in the operator's job description. The objective of simplifying the user's interface with the machine is very much in line with that of increasing the level of autonomy. Developing a clearly more sophisticated user interface is very challenging. The worst bottlenecks historically were caused by computer capacity, but current problems lie in designing expertise systems that are sufficiently comprehensive and versatile. At present, the operator has a very significant role in controlling the machine under changing environmental conditions and production requirements. An important intermediate goal is to develop the automation systems that serve this part of the machine, and to make them simpler and more straightforward.

Machine – Surrounding-Data Network Interaction

Today's forest machine is no longer simply equipment, but an integral part of a logistícal timber-supply chain. The future surrounding-data network will have even greater significance, as information relating to the job in question is sent and received through it. So far, the information has mainly been related to desired dimensions and optimization of tree trunks, and to production reporting. New issues include digital maps, geographical information (GIS), and GPS navigation systems. The amount and availability of information will improve, making these technologies much more versatile. The current forest machines mainly utilize ready-made and analyzed information, but one of the most significant future tasks could be the creation of information and correction of errors in that information.

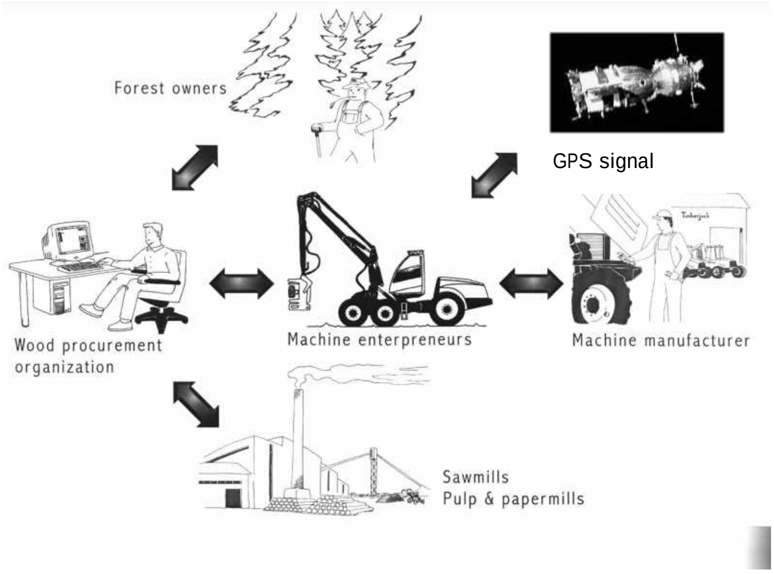
The biggest problem today is the great differences in standards and methods among countries and companies. Data are saved in different formats and with various standards of data communication. Efficient utilization of the already existing features requires harmonization of the concepts.

The increasing speed of data communication will bring entirely new opportunities. In a few years, the transfer of image and sound will probably be an everyday phenomenon. Internet trading will also rapidly become a common practice, bringing new possibilities and challenges. Today's goals and functions were based on the production-control requirements of the forest industry. Another approach, at least with more valuable wood, may be the buying and selling of timber from the seller's point of view. The material produced/yet to be produced would be offered to the market, with trading done in the same way as company shares. This, however, would require changing and developing logistics systems that could control individual logs rather than trade batches.

Maintenance

The machine operator still plays a very important role in its maintenance, being responsible for daily servicing and on-the-spot small repairs. Machine stoppages and waiting times are expensive for the contractor. Fault-finding diagnostic systems in the future may be used to improve preventive maintenance. Servicing, however, is an issue that will have to be significantly developed, in order to raise the degree of autonomy of the machine.

Figure 3. The current information network of a harvester system.



Conclusions

It is a long process to develop an autonomous machine or machine chain. Functions related to human senses and logical decision-making must be replaced by technical solutions. The challenge is great because regulations concerning the quality of timber will most likely be tightened concurrently. The conversion of a present-day forest harvester - forwarder combination chain into one that acts autonomously is probably very far away, especially if silviculture is practiced in natural forests. Moving management practices toward more controlled, cultivated forests will make an autonomous system much more possible.

Another vision often proposed is that of the contractor controlling operations from his home, and following the progress with his own monitor. Whether moving the operator/process controller away from the harvest site is a positive development is more of a question of values. Another possibility is to further improve working conditions so that several processes can be controlled on-the-spot. An intermediate solution would be of the Master - Slave type, where several machines are controlled by one operator. The machines could carry out simple, easily defined tasks but, in more demanding cases, the control and decision-making would continue to be the responsibility of the operator.

Strategies and Methods for Choosing Technology: Perspectives for Development Projects Based on Scandinavian Experiences

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Abstract

Sundberg's model, work studies, and cost calculations were compared to select the most appropriate technology for a wood-harvesting project. The main criterion was cost–effectiveness, to be met within the limits of environmental and ergonomic requirements, and within the historical role of Scandinavian logging technology in a forest cluster. Cost-effectiveness appears to be a good basis when choosing technology, but future perspectives also must be contemplated. In an open, global economic system, development is also dictated by new demands placed on the forest cluster. Cost-effectiveness has become an extensive indicator that must now consider the total costs and benefits of logging practices, industrial processing, and marketing. Continued progress in this direction will depend on environmental, societal, social, and cultural sustainability. In many countries with special forested areas, environmental aspects dominate forestry decision-making. There, the impacts of technology on the environment may be the main criteria when choosing a level of technology. The market economy, together with a functioning national innovation system, provides additional creative material for the selection process. Production is still viable at the local level (within suitable areas), but the most significant advances within the forest cluster seem to be made primarily within large global companies. This process is best supported by directing funds toward research and development activities, and by promoting the appropriate circumstances under which companies can compete.

Keywords: Choosing technology; Development project; Timber harvesting.

Introduction

In this paper, we will discuss the general utilization of basic, intermediate, or sophisticated forestry technologies. The level of technology suitable for a particular society usually is predicted through economical calculations. A more detailed analysis is then needed to choose the actual work methods and machinery. Work studies and cost calculations are often used for predicting the cost-effectiveness of different technologies. When sustainability or societal impacts are studied in more detail, however, one must also analyze such elements as enterprise environment, level of organization, infrastructure, social status, culture, and the society's particular traditions. For example, the application of technologies differs at the village-, industrial enterprise-, or government organization level. The same is true if we direct development toward either a 'centralized metropolis culture' or a 'decentralized local production culture' (Sarmela 1982).

To illustrate, the old industrial traditions and underlying ideological factors in Russia make it difficult for managers to accept, at a minimum, an intermediate level of technology, even if this level were certainly more cost-effective than sophisticated technology. This response persists, despite serious problems with unemployment and the promotion of intermediate technology, i.e., the use of chainsaws instead of harvesters.

Development specialists are divided in their opinions on the usefulness of 'grass-roots level' projects. Some say these projects have no influence on societal structure, while others believe that they are the most effective means for alleviating poverty. These two opinions do not seem to exclude one another. Reports by Pehu (1993) and the International Fund for Agricultural Development (IFAD) contend that grass-roots projects must address the very processes that lead to poverty, rather than merely distributing the aid. This influence need not change the structure of society, but only the processes within that structure. The result could be the creation of new economic activity related to production, rotation of money on the local level, and even the creation of a consciousness of their rights among the people. Grass-roots projects may be the only solution in a corrupt society from which capital flows out of the country. The target group, however, must be able to control the prerequisites for production. An innovative atmosphere at all employment levels may promote the successful application of technology and help with the transition to its next level.

Development may be approached in several ways, according to technological, economic, environmental, societal, social, sociological, and/or cultural traditions. The approach is mainly technological, economical, and societal. Case studies have described a society with poor infrastructure and old industrial traditions, where production had collapsed. The educational level was high and this society was trying to move from a centrally planned economy to a market economy. We therefore assumed that:

technological and economical developments are important factors for societal development,

production must be economically profitable and environmentally acceptable, and

social and environmental aspects are important to guarantees of societal peace and fulfill the perception of justice among the people.

The winning strategy must encourage profitable production, the formation of capital for industrial investments and societal needs, and long-term, overall improvements. This strategy must also be acceptable to local authorities and the local people. The objective of the study described here was to compare the conclusions drawn from Sundberg's optimization function (Sundberg and Silversides 1988), work studies, and cost calculations (in the context of historical progress in Finland and other Scandinavian countries), as well as to locate the strategies for development behind their progress.

Materials and Methods

The approach applied in this study was somewhat hermeneutic and historical. The historical progression of logging operations, especially in Scandinavian countries, was analyzed intuitively to identify the strategies behind their development. Recent projects in Russia were used as examples for testing ideas. Sundberg's theory is based on having logging costs at a common level, whereas work studies and cost calculations analyze alternative technologies more thoroughly. Historical analysis may also include global perspectives and environmental, societal, social, and cultural aspects. Some observations were also made on how to make a technological choice that is acceptable to decision-makers.

Results

Application of Sundberg's Model

Sundberg has derived optimization functions to predict the most appropriate level of technology for forestry operations (Sundberg and Silversides 1988). The functions solve for the labor and machine inputs that will generate the lowest unit costs for a logging operation:

$$L = \sqrt{\frac{bd}{e}}$$

$$M = a + \frac{b}{\sqrt{\frac{bd}{e}}}$$

where:
a, b = constants
d = cost per unit input of machines (M)
e = cost per unit input of labor (L).

The basis for deriving the optimization functions is a hyperbolic equation that indicates possible combinations of labor and machinery for implementing a specific logging operation. The following equation was formulated:

$$M = a + \frac{b}{L}$$

The constants *a* and *b* for some logging operations were predicted with a regression analysis that used time-study results. The constants were then placed into the optimization functions to calculate the optimum combinations of *L* and *M* at different labor-cost levels. Finally, the different levels of technologies represented by the various labor and machine combinations were examined, with results shown in Table 1.

This prediction only roughly estimates the most profitable level of technology. Some forest operations that are too heavy for people or animals must be mechanized (e.g., long-distance transport). In the Russian example, application of Sundberg's model resulted in a recommendation that intermediate technology, (e.g., chainsaws) would incur the lowest unit costs.

Application of Work Studies and Cost Calculations

In Finland and many other industrialized countries, the development of logging operations has largely been based on the results of work studies and cost calculations. Therefore, methods and machinery have been chosen according to their cost-effectiveness within the limits set by ergonomic and environmental requirements. Data from "real life" ave confirmed these study results. An evolution toward economically tenable solutions has been considered the only sustainable means of development in the market economy.

Work studies also provide comparisons among different work techniques, methods, equipment, and machines within a level of technology. As with Sundberg's model, comparative studies also suggested that intermediate technology, i.e., chainsaws (motor-manual work) rather than harvesters, was the most cost-effective choice for cutting in Russia (Sikanen *et al*. 1996). Motor-manual cutting can be applied through either CTL or tree-length harvesting; bucking can be done at either upper or lower landings (terminals); etc. Work studies and cost calculations allow comparisons in any of these situations. In one case study in Russia, calculations indicated that the traditional tree-length method was more cost-effective when used with bucking at an upper landing rather than at the traditional terminals. Ultimately, however, the CTL method seemed to be the most cost-effective alternative, especially for selective cuttings, but also for other logging methods (Harstela 1998). The greatest need identified for improvement was in loading for long-distance transport.

Today, the choice of appropriate technology cannot be based solely on logging costs. One must also pay attention to the costs and benefits along the entire production chain, from forest to market via the wood-processing industry. Timber quality and environmental and social factors also require consideration. Work studies and cost calculations are the basis for more comprehensive logistic studies.

Although these studies illustrate only the static situation, the results suggest a direction for development. The work studies in Finland and Sweden were supplemented with prognoses of current trends for labor and machine costs, and the most profitable mechanization level (e.g., Mikkonen *et al*. 1975). Although these prognoses could not precisely forecast the development of mechanization (Harstela 1993), they demonstrated that possibilities for new methods and machines should be investigated. Mechanization itself depends on economical progress and innovation that, for the most part, are still unpredictable. Therefore, one strategy for promoting development is to create an atmosphere for innovation. The question remains how this will be accomplished.

Table 1. The most profitable level of technology, according to daily wages for logging.

Most profitable level of technology	Daily wage of a worker, USD/day
Basic technology	… 20
Intermediate technology	10 … 40
Sophisticated technology	30 …

Development of Finnish Logging Technology as Part of the Forest Cluster

During the last few decades, CTL logging has been intensively developed in Sweden and Finland. These countries have taken a leading role in upgrading both the entire CTL technological environment and the machinery. What was the basis for these efforts that necessitated innovations and organized industrial structures? The societal environments were market economies, which still have some barriers to international trade but have become more receptive to the outside world. An open and extensive exchange of information has also occurred, especially among Scandinavian countries. The strategy of large forest industry corporations is to support institutional research, while maintaining their own research personnel. Governmental assistance is based on providing occupational education at all career levels, funding research institutions, and supporting new enterprises and innovators.

Innovations have come from all levels of occupational organizations. In the 1970s, training for forest workers was organized so that forest work became a respected occupation. In addition, a piece-rate payment system and the creation of an economically independent small-contractor system caused forest work to become relatively free of supervision. Various innovations relating to work techniques, methods, and forest machines originated from the workers, contractors, or other persons involved with the actual work. This has conformed well to innovation theories, which emphasize that identifying a need is a basis for innovation. Many professional foresters, researchers, and small and large manufacturers also assisted in identifying these needs. Consequently, this national innovation system produced material for work studies, which were necessary for selecting the most cost-effective technologies. Because they foresaw the need for continuous development and mechanization, large companies were willing to share in development costs while gaining experience from the running of prototype machines.

The development of a strong forest cluster and strong interactions between forest and wood-product industries, may also explain the development of logging technology in the Scandinavian countries. According to Porter's "diamond model" (Porter 1990) for industrial development (particularly for knowledge-intensive industries), favorable development occurs when "factor conditions" closely interact. These include the firm's strategy, demand conditions, and its supporting industries. The Scandinavian forest industry has developed from rather simple wood-working into a high-tech industry.

In Finland, the actual forest cluster includes traditional forestry; all branches of mechanical wood-working; the pulp and paper industry; as well as related machine-manufacturing, chemical, electronic, information technology, and energy-production industries. The question of why this cluster developed in Finland is not simple. However, Finland is rich in forests and, consequently, its forest industry has long had a strong impact on the national economy. After World War II, the resulting peace treaty imposed heavy war compensation on Finland. This influenced the development of machine manufacturing. The forest industry closely cooperated in this process. A unique form of collaboration among corporations involves sectors from timber procurement to marketing of products. Development has also been furthered by Finnish stockholders and industrial leaders willing to invest in Finnish industry (Kuisma 1993). The strong and growing corporations of the forest industry have opened markets for forest machinery and also enabled new logging technology to develop.

The open market-oriented society also has created wood-working enterprises and technology that are more suitable for small-scale logging operations, mainly by small landowners (e.g., farmers). Government policy now supports new enterprises, especially in under-developed regions. The many-faceted forest sector has included both large industrial companies and small enterprises that operate mainly within local markets. Today, that economic environment has changed. What will the future be like?

Perspectives for the Future

Liberalization, globalization, and technological advancement are the key words for mega trends in an international economy that lead to the "smile-phenomenon". There is only room for either increasingly larger, often global, corporations or for small local enterprises (Miller 1995). The companies in between these extremes will have difficulties. Although small companies are often innovative and make new openings, they lack the resources to support many-sided and high-tech expertise. This kind of development, toward a ‘two-bole system’, has been evident in both the forest industry and forest-machine manufacturing. Mega trends exist at a common level. Elsewhere, however, the future remains highly unpredictable and enterprises must foster an ability to respond quickly to new demands.

The ‘big-me’ scenario, based on material growth and rotation of materials, has faced some setbacks. This rotation of material demands a seemingly excessive amount of energy. The alternative ‘just-do-it’ scenario, sets out to do more with less. Information technology seems to follow this strategy. The forest industry must improve its materials technology. From an environmental point of view, the energy required for transport is a problem for all global production networks (Andersson 1993). This factor leads to a future in which both the large global corporation clusters and the small local production units will be involved in simple, heavy production. In addition, the small innovative enterprises may be able to control new technology in a specific narrow field of expertise as part of the production network.

For the forest cluster to maintain a leading role, it must develop its own high-tech methodology (Kettunen 1998). Research and development (R&D) and the maintenance of a high level of knowledge have now become the main strategies for cluster development. This has also been government policy in Finland. For instance, special funds have been allocated to the forest cluster’s R&D program. According to the diamond theory, a cluster develops only if all its parts are improving. This makes it difficult for some regions to compete against a particular region with a stronger and more complete cluster. In this case, one country may be too small a home base for a forest cluster as companies become globalized. It is then possible for a new region either to become part of a global corporation or production network, or else target its production for only local consumption.

Delphi analyses were used in a continental search for the most prominent areas of technology having the greatest potential. Three sectors were selected as most interesting: information technology, bio-technologies, and material technologies (van Zon 1992). Although ‘the forest cluster’ was not included, one must remember that the Delphi analysis is not a highly reliable forecasting method because it is based on an expert’s opinions and experience under current conditions. Because Finland’s forest cluster incorporates technology from all the areas that were selected, this may well provide synergy for the cluster’s own R&D. Forestry, therefore, has only to find and develop its own technology.

Environmental Aspects as a Basis for the Choice of Technology

In some countries, or in areas of special natural value or with sensitive ecosystems, the environmental impacts of timber harvesting dominate the choice of technology. Schmincke (1993) has argued that we must find balance between conservation, maintenance of biodiversity, and economic development so that the overall benefits are maximized. This may require developing more environmentally conscious logging technology for indigenous forests, although this often increases logging costs. The other alternative may be to stop commercial logging operations in those areas. In North American discussions of CTL versus tree-length logging methods, the main argument for increasing cut-to-length logging has been its favorable environmental impacts (Guimier 1999), although its application may also entail favorable logistic costs.

Environmental sustainability is an appealing concept as a basic requirement for all technologies; public pressure apparently is continuing in this direction. In open markets, however, production costs cannot exceed market prices; therefore, cost comparisons are valid even in situations where environmental aspects might dominate the debate on technological choice. Current environmental restrictions that are based on international agreements enable equal competition for companies in different countries, but this seems to be a slow and ineffective process for effecting competitive balance. Therefore, national and occupational responsibilities for environmental sustainability are required.

Discussion

If the future is to be as illustrated above, the strategy in a country such as Russia may be based on tailoring production to local markets, or embarking on joint ventures with global giants. Enterprises may also try to look for new, innovative openings that apply existing technology to local circumstances. To involve all occupational levels in the innovative development process and to create a good work ethic, occupational education and training should be an essential part of the project. Participatory leadership, open and lean organizations, and innovative teamwork are also ways to build up an innovation system within the enterprise.

Managers in Russia often want the most advanced technology possible for their logging operations. This may mean utilizing harvesters instead of chainsaws, even when cost calculations indicate the latter is more cost-effective. In developing Scandinavian logging technology, cost-effectiveness has been the favored basis for technology selection. The options when preparing for future changes, however, may include further mechanization. In the case of Russia, this would mean applying a more-intermediate level of technology, e.g., large-scale use of chainsaws, along with a few harvesters to gain experience for the future. This application fits a societal situation with serious unemployment. There, local authorities were presented with two alternatives to demonstrate the flow of capital during a timber sale to Japan: if harvesters were purchased, most of the capital would flow to a foreign country. Alternatively, if chainsaws were to be used, a larger portion of the capital would remain with local workers and enterprises as profit, which could then help renew local industries such as sawmilling.

In some autonomous republics in Russia, the strategy has been to contract private enterprises to manage both forestry and logging operations. Other regions have centralized their forestry and logging around government enterprises. There has been some discussion about which is the better way, from silvicultural, environmental, or economic points of view. This is not, however, a simple question in a society that is not free of corruption and which is in economic disorder. Although favorable development in logging technology has occurred within the Scandinavian market economy, forestry legislation also has established restrictions, which have also been enforced. This development was led by educated foresters within large companies and was supported by research. Perhaps one way to unite private entrepreneurship and Russian government responsibility would be through organizations of small logging contractors under the supervision of a government enterprise.

How will logging technology develop in the future as a part of the forest cluster in Finland? Today, three large, increasingly global companies exist along with several small companies. The large corporations are no longer willing to exchange information because they are large enough to maintain their own R&D activities. Knowledge and information have become the means for competition. Universities and research institutes must cooperate directly with companies to maintain their own competence while increasing their synergistic role. Although actual research results are confidential in cooperative projects with companies, the common, updated knowledge benefits the whole cluster. Most large companies no longer own their forest machines – these are both owned and operated by small contractor enterprises. Government policy still enables global enterprises to maintain their operations in Finland under favorable circumstances. Likewise, R&D activities enjoy government support.

New requirements for quality and grading of timber are part of the scenario of doing more with less. In fact, new assortments, even for pulpwood, may soon be a reality. Although this may entail increased costs for logging and transport, total costs may decrease, or the benefits to manufacturing might be sufficient to cover these extra costs. When cost-effectiveness is the criterion for choosing a technology, the analysis must cover all costs and benefits, from the forest to the end-user markets. Logistics will be an important aspect in timber procurement. New international commodities will be made from the hardware and software of information systems that plan and control operations, as well as from the knowledge to operate them.

What happens at the grass-roots level of machinery design? Who will pay the costs of testing prototypes? Large forest-machinery manufacturers currently have enough resources to cover these costs, but how will small, innovative manufacturers be able to succeed? One solution to this problem has been to introduce government funds for R&D programs that develop and study new machinery.

Conclusions

Cost-effectiveness, within certain environmental and ergonomic limits, appears to be a good basis for the choice of technology when future perspectives are being considered. Sundberg's functions provide a starting point in the search for the suitable level of technology that is appropriate for a particular country. However, the actual selection of technology must be based on detailed work studies and cost calculations. In an open, global economic system, new demands have been placed on the forest cluster. Therefore, cost-effectiveness is now an extensive indicator that must also incorporate the total costs and benefits of logging practices, industrial processing, and marketing.

A market economy, together with a well-functioning national innovation system, will drive development and provide innovative material for the selection process. Local production still exists within suitable areas, but the main areas of development for a forest cluster seem to arise from large global corporations. The key strategy in supporting development efforts within a country is to direct funds toward R&D activities, while also making circumstances favorable in which companies must compete. In the end, this is a selfish policy, because it holds market forces responsible for development, and does not guarantee fair distribution of the benefits from natural resources on a global scale.

With large-scale production apparently centered within global enterprises, regional development depends on its attractiveness to these big companies. Unfortunately, some specialists believe that economic liberalization and globalization will lead to extended polarization of countries and their citizens, rich and poor (Korten 1996). However, this mega trend is outside the control of an individual project whose goals are to adapt local development to global trends or else promote small-scale local production.

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An Analysis of the Economic Impacts of Information Technology Research on Forest Management in Southern Brazil

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Abstract

The objective of this research was to evaluate the economic benefits derived from public investments in research and development of a computer system. This system, SISPLAN, is designed to perform simulations on growth and productivity for afforestation and reforestation of *Pinus* in southern Brazil. Criteria can be generated for production planning and reforest management, thereby reducing the uncertainties associated mostly with forest activity planning. This is especially important in cases of technical-scientific knowledge that are not incorporated in production means, because it is generated during field-research activities involved with the ordering, handling, and management of the forest. The methodology consists of identifying the costs and economic benefits derived from the generation, utilization, and maintenance of the SISPLAN technology. The framework of this research is to provide the estimated economic impact, using the cost-benefit technique. Utilization of this system generates information that contributes to improving efficiency in the productive sector and effectiveness in public policies. Economic gains to Brazil were estimated at $77.2 million in 1997 (net present value), with a cost-benefit ratio of 55.7. This indicates that the research is an attractive economic investment.

Key words: Forest management; Information technology; *Pinus* spp.; Research evaluation.

Introduction

Technical change is widely accepted as an important determinant of growth and competitiveness. The pioneering work of Schultz (1954), Griliches (1958), and Mansfield (1968) documented the contribution of research to increased productivity, and provided the first measurement of economic returns from public and private research. Since then, economists have improved the methods for analyzing sources of aggregate productivity growth, as well as the factors responsible for the growth of the different sectors that make up national economies. Within the primary sector, most of these efforts have been toward crop and livestock production (Echeverría 1990). However, considerable interest and intellectual efforts also have been developed for measuring the benefits and returns to forestry research (Herruzo 1997). In general, the empirical results have indicated high economic returns for public and private investments in forestry research (Hyde *et al*. 1992).

The scientific literature deals principally with cases involving forestry research in physics, chemistry, and biology. However, a virtual methodological and empirical vacuum exists in areas of evaluation analysis for research in forest resource economics, forest management, and other disciplines that focus on improving the organization and planning of forest activities. (See Smith and Pardey's 1997) discussion of this in comparison with agricultural research.) This lack of evaluation studies has at least two negative outcomes. First, it is difficult to determine whether current expenditures in forestry economic research are adequate. Second, the lack of studies precludes comparing the social gains from forest economics research with the social gains derived from other research activities for which quantitative estimations may be available. The latter situation could place forestry economic research at a disadvantage when personnel are competing for scarce research funds.

One of the main problems in trying to compute the economic benefits of research activities is to determine the vehicle by which a particular type of research contributes to increasing social welfare. Results of forestry research activities performed in experimental sciences often materialize in the knowledge embodied in new processes and products, whose impact can be easily identified. On the other hand, forest economics and management research produces disembodied technical knowledge, in the form of new information, which may allow decision-makers to enhance productivity and economic welfare. In the latter case, however, the steps necessary for manifesting these benefits are less tangible and more difficult to measure directly. This could be one reason why empirical information on returns for this type of research activities is relatively scarce. Fortunately, the new information technologies, i.e., innovations oriented toward rapid and automated processing of information, are broadening the chances for transmitting "organizative" knowledge of the type generated by forest management research. We are presenting our results within this new context.

The objective of this analysis was to assess the economic benefits of a new silvicultural management tool, the production simulation system SISPLAN. This computerized projection system was developed in 1988 by the National Center for Forestry Research of the Brazilian Agricultural Research Corporation (*Embrapa Florestas*). It was designed to spawn new criteria for improving the planning and organization of *Pinus* plantations in southern Brazil.

The SISPLAN Technology

The origin of SISPLAN is better understood within the context of the recent Brazilian reforestation process. As part of its reforestation policy, the Brazilian Government implemented a broad program of fiscal incentives from 1966 to 1987 to induce reforestation with exotic species *Pinus* and *Eucalyptus*. The objectives of this fiscal-incentive scheme were two-fold: satisfying a growing internal demand for forest products while also slowing the increasing environmental costs of deforestation of native species. As a result of this program, the area reforested with the above-mentioned species increased from 600,000 ha in 1967 to more than 6.5 million ha in 1992. About 89% of this activity was realized through a fiscal-incentives program. The newly reforested area of *Pinus* was 1.06 million ha in southern Brazil alone (Bacha 1993, Antonangelo 1997). Program beneficiaries were required to follow a set of pre-established guidelines with respect to silvicultural practices, such as rotation age and the number and timing of thinnings. These management guidelines were based on limited information gathered from different sources available at the time. The use of forest management was justified by the increase in newly planted *Pinus* forests, together with diversification of potential uses for wood that resulted from changes in product prices.

Information technologies play an increasingly important role in the technical and economic administration of production processes, both at the management level and at the level of the decision-making centers. However, more-effective procedures are lacking to facilitate the knowledge diffusion on available silvicultural practices. Ultimately, this knowledge would facilitate the adoption of new technologies more adapted to increments in forest productivity, improvements in wood quality, and evaluations of the beneficial impacts to foresters and wood-based industries (Oliveira 1995, 1997).

The SISPLAN technology combines a production simulation model with financial economics methods (Oliveira 1995). This computerized system makes growth and yield projections based on the age of populations for specific location and management variables. Ultimately, it should facilitate organization of the newly available information about silvicultural practices and transmit it to foresters in a way that could be easily incorporated into their decision-making processes. Since 1989, the SISPLAN software has been used as a decision-making tool in managing more than 500,000 ha of *Pinus* plantations in southern Brazil (de Alencar 1999). To a lesser extent, SISPLAN is also being used in other areas of Brazil as well as in other Latin American countries. It has contributed to the adoption of more efficient management regimes, thereby increasing the profitability of forestry activities in those regions.

This technology consists of three modules: 1) SISPINUS software that simulates the thinning, annual growth, and distribution of wood for multiple uses as a function of log-diameter classes; 2) PLANIN software that calculates parameters of economic and financial evaluation, and analyzes sensibility of the profitability at different discount rates; and 3) REPLAN software that generates a database of the profitability for different systems of management in forest populations, as a function of, among other variables, clear-cut, site index, and discount rates. Integrating the three modules allows us to obtain a combined vision of the biological and economic factors. It also allows for the simulation of different scenarios in production planning as a function of different destinations for the wood, changes in the prices, costs, and discount rates (see Oliveira 1995, 1997).

Methodology

The evaluation approach used in this paper for estimating benefits and returns to research from SISPLAN is based on Marshallian welfare theory. It follows the evaluation approaches to forestry research assessment adopted by Huang and Teeter (1990) and McKenney *et al.* (1991, 1993, 1996), among others.

Private benefits of research are determined by the extra production due to new silvicultural methods induced by the new technology (the production projection system SISPLAN). Total net benefits (economic benefits) of research are obtained by subtracting the cost of research from the total private benefits. A new technology derived from research is considered profitable if it generates positive net benefits. Given the long time span of forestry investments, a large part of the research benefits have not been realized yet, even though the SISPLAN has been available since 1989. For this reason, the analysis has a double nature *ex ante* and *ex post*.

The changes in Marshallian economic surpluses that are induced by research depend on market conditions (demand and supply-price elasticity), and on the nature of the supply and demand shifts. In many research assessment projects, particularly in agriculture, demand and supply conditions are explicitly modeled. In forestry, however, obtaining information about these conditions is difficult, and a long span exists between the time of research and when production is changed. Therefore, evaluation approaches less sensitive to market conditions usually are employed (McKenney *et al.* 1996). We have adopted this strategy in order to assess the economic gains of research and development of SISPLAN technology for this paper**.** The extra production attributed to research is valued at a single market price (current price). It assumes that the supply curve is vertical and shifts against a horizontal demand curve. Total private-research benefits are then measured by the change in the expected value of the extra productivity. (Thus, although economic surplus changes may not be explicitly measured, economic surplus calculations are still implicitly being made when net present values are calculated to place a value on the extra output attributed to research; see Alston *et al.* 1995.)

The model developed below assumes that the availability of the SISPLAN technology provides foresters with information conducive to adopting more-profitable silvicultural methods. This increase in profitability may be caused by one or more of the following circumstances: 1) selection of the optimum rotation age; 2) selection of optimal thinning regimes; and 3) increased timber value when production is better targeted to industrial uses.

Private benefits (on a per-hectare basis) derived from adoption of the technology are obtained by subtracting the net present value (NPV) of the traditional management regime from the NPV of the most profitable management regime (simulated with the SISPLAN). The optimal forest rotation age for commercial harvest is given by Faustmann-Pressler-Ohlin's well-known formula (hereafter referred to as FPO), which maximizes the NPV of timber harvest by considering infinite plantation cycles (see Samuelson 1976, Hyde 1980, and Johansson and Löfgren 1985). The simplest expression of the FPO formula is:

$$NPV = [I(t)\ \ e^{it}\ \ \ K]\,(1\ \ \ e^{it})^{1} \qquad [1]$$

where NPV = net present value of timber harvested at time t ($/ha); I(t) = timber revenues; t = rotation period; i = discount rate; K = cost of production.

Following Romero *et al.* (1998), Formula [1] can be extended to a more general forestry context as follows:

$$NPV = \ I(t)\ \ e^{it} + \ \ {}_{h} R_{h}\ e^{ih}\ \ \ K\ \ \ G\ {}_{0}^{t} e^{it}dt\ \ \ T\ {}_{0}^{t} e^{it}dt\ \ \ \ {}_{s} M_{s}\ e^{is}\ \ \ E\ \ e^{it}$$

$$(1\ \ \ e^{it})^{1} \qquad [2]$$

$$h = h_1, h_2, \ldots$$

$$s = s_1, s_2, \ldots$$

The symbols and variables from [2] are defined as: I (t) = sales revenue derived from final felling; t = rotation period; i = discount rate; R = cash flow associated with the thinning operations; these operations take place in subperiods h_1 , h_2 ,...... ; K = planting costs; G = general annual management payments; T = annual technology payments; M = payments associated with cultural operations; these operations take place in subperiods s = s_1 , s_2 ,..... ; E = harvest costs. It is assumed that annual expenditures are distributed evenly throughout the year.

By performing simple algebraic operations on [2], the following general expression for NPV is obtained:

$$NPV = \ I\ \ e^{it} + \ \ {}_{h} R_{h}\ e^{ih}\ \ \ K\ \ \ G\ \ i^{1}\ (1\ \ \ e^{it})\ \ T\ \ i^{1}\ (1\ \ \ e^{it})\ \ \ \ {}_{s} M_{s}\ e^{is}\ \ \ E\ \ e^{it}$$

$$(1\ \ \ e^{it})^{1} \qquad (3)$$

Sales revenues derived from final felling and thinning operations are obtained by multiplying timber volumes (according to final use, i.e., fuelwood, pulpwood, sawnwood, and veneer) by their corresponding prices.

Annual Private Benefits

Assuming the forester uses this technology to manage a new plantation in year 'r', the increase in benefits due to the technology is obtained by subtracting the NPV of the traditional management regime from the NPV (on a per-hectare basis) of the adopted management regime. The difference in both NPV for each year 'r', multiplied by the forested area over which the technology is adopted in each year 'r', determines the potential regional NPV of the technology. Therefore, from expressions [1] and [3], the NPV due to the additional revenues that are generated by adopting the technology is obtained as follows:

$$PB_r = A_r \ \{ [\ I \ e^{it} + \underset{h}{\ } R_h \ e^{ih} \quad K \quad G \ i^{1} \ (1 \quad e^{it}) \ \ T \ i^{1} \ (1 \quad e^{it}) \quad \underset{s}{\ } M_s \ e^{is}$$
$$E \ e^{it} \ ]_2 \quad [\ I \ e^{it} + \underset{h}{\ } R_h \ e^{ih} \quad K \quad G \ i^{1} \ (1 \quad e^{it}) \ \ T \ i^{1} \ (1 \quad e^{it}) \quad \underset{s}{\ } M_s \ e^{is}$$
$$E \ e^{it} \ ]_1 \ \} \ (1 \quad e^{it})^{1} \qquad (4)$$

where PB_r = private benefits of the area planted in year r and harvested in year t; A_r = area in which the technology is adopted in year r (ha); r = year in which plantation was initiated.

The area of land over which the technology is adopted is obtained by multiplying the area planted each year with *Pinus* by a coefficient Ta_r, which represents the adoption rate in that same year. That is:

$$A_r = AT_r Ta_r$$

where AT_r = total area with new plantations in year 'r'.

Total Private Benefits

Total private benefits of the technology referred to in the base year are expressed as:

$$TPB_a = PB_r \int_m^n e^{i(a \ r)} dt \qquad [5]$$

where TPB_a = Total private benefits; PB_r = Annual private benefits; a= base year (1997); *m*, *n* = first and last year of the study period. Expression [5] assumes that data corresponding to year 'r' are used. If only base-year data are available, the total private benefits will be obtained by adding annual private benefits.

Total Net Benefits

Total net benefits of the technology are obtained by subtracting the total costs of research from the private total benefits obtained in [5]. These research costs may include the resources assigned to research as well as any additional expenses required for developing and maintaining the technology.

$$TNB_a = TPB_a \quad C_r \int_x^z e^{i(a \ r)} dt \qquad [6]$$

where TNB_a = Total net benefits of the research; C_r = Annual costs of research; *x, z* = first and last year of the research program, respectively.

Benefit-Cost Ratio

Any forestry research program with a positive total net benefit is profitable. However, computing the total net benefit, per se (NPV of investment), does not provide a convenient ranking of alternatives for public investments. A substitute is to express the total net benefit per unit of research investment (benefit-cost ratio), then rank the programs accordingly. In the context of the model, the benefit-cost ratio can be express as:

$$B / C = TNB / CI \qquad [7]$$

where TNB = Total net benefits; CI = Total costs of research

Analysis of Sensibility

The Analysis of Sensibility is used to determine how the results of the pattern may be influenced by possible variations in the values for different economic and technological parameters that define the investment (e.g., price of the wood, discount appraisals, or site index).

Parameters and Data

Data required for the analysis include: 1) forested area involved in adopting the technology; 2) commercial volume retrieved from alternative management regimes; 3) roundwood prices; 4) production costs; 5) costs of research and development; and 6) discount rates.

In this analysis, the time interval is 1981 to 2005. Year 1981 was selected as the starting point because only trees planted in that year and after could be fully managed with SISPLAN. This is because the first thinning is usually performed eight years after planting; SISPLAN was not available until 1989. Likewise, the year 2005 was chosen because estimates are lacking for *Pinus* plantations in southern Brazil beyond that year. Based on the amount of land managed by the foresters and firms who acquired the SISPLAN, the area adopting the technology during this time interval was estimated at 546,000 ha. This amounts to an adoption rate of 84.5% (de Alencar 1999). Roundwood timber values were determined according to their final destination (i.e., fuelwood, pulpwood, sawnwood, or veneer). Table 1 indicates the roundwood prices for *Pinus*, expressed in 1997 US\$ m^{-3}. To evaluate the potential benefits of SISPLAN, 25 management regimes (MR) were simulated (Appendix 1). The selection of each management regime was based on available studies of silvicultural practices in southern Brazil (Ahrens 1992, Oliveira 1995). *Pinus taeda* was chosen because it accounts for more than 50% of the area planted to *Pinus* in southern Brazil. This species is highly productive, and provides good-quality long-fiber wood that is well-suited for lumber and white pulp and paper products. MR14 corresponded to the silvicultural guidelines established by the program for fiscal incentives to reforest, implemented by the Brazilian government in 1966. For our analysis, this management regime is considered representative of the old technology. MR14 has a rotation age of 20 years, with thinnings at Years 8, 12, and 16. The other 24 management regimes are considered new technologies, i.e., new management alternatives derived from research.

Appendix 2 summarizes commercial volumes according to various industrial uses in each simulated management regime. Commercial volumes were estimated by assuming that conditions were similar for genetic content, original stand density, and site quality. The largest total volume was harvested under MR25 (776.5 m^3 ha^{-1}). The rotation age here was 30 years. The maximum clear-cut volumes for each industrial use were obtained by MR19 for veneer (289.0 m^3 ha^{-1}); MR6 for sawnwood (425.1 m^3 ha^{-1}); and MR1 for both pulpwood (132.5 m^3 ha^{-1}) and fuelwood (21.1 m^3 ha^{-1}).

Besides the information on commercial volumes and roundwood prices, computing the cash flows for the 25 management regimes requires additional information on production costs. Table 2 contains the estimated average costs (referred to 1997) for silvicultural operations on a *Pinus* plantation in southern Brazil. These estimates include costs for planting, operating, thinning and felling, and management. The yearly research and development costs of SISPLAN (in the form of personnel costs and supporting operational expenses) are shown in Table 3. Research expenditures for SISPLAN began in 1988. A first version of the system was obtained in 1989, and extensions and modifications to the system were later performed. Maintenance research costs are assumed to last until 2005. Throughout the study interval, the estimated total cost for investing in the technology is 1997 US\$1.39 million (de Alencar 1999).

The discount rate also has a significant effect on profitability because investments in forestry plantations take a long time to realize benefits. In this study, a real discount rate (6%) was needed because all monetary calculations were performed in constant 1997 US\$. In the sensitivity analysis, discounts of 4% and 8% were used. (For an example of the magnitude of the discount rate, see Kula 1994).

Table 1. Average roundwood prices for *Pinus*, by industrial use.

Industrial uses	Diameter (cm)	Average price* (US\$ m^{-3})
Fuelwood	<8	9.38
Pulpwood	8 – 15	12.49
Sawnwood	15 – 25	19.2
Veneer	> 25	27.86

* (1997 US$)

Source: Based on information provided by STCP (1998) and personal communications with forestry research experts.

Table 2. Average costs for managing a *Pinus* plantation.

Cost categories	US$ (1997)
1 – Planting costs	600 ha^{-1}
2 – Operating costs	
1º year	150 ha^{-1}
4º year	50 ha^{-1}
9º year	40 ha^{-1}
3 – Thinning and felling	6 m^{-3}
4 – Management payments	20 $year^{-1}$

Source: Personal communications with foresters and research experts

Table 3. Yearly research and development costs of SISPLAN (in millions of US$).

YEAR	PERSONNEL (A)	OPERATIONAL (B)	R&D (C=A+B)	TOTAL R&D*
1988	44.24	12.74	56.98	97.78
1989	44.50	6.51	51.06	82.52
1990	34.87	11.62	46.48	70.74
1991	35.18	9.97	45.15	64.71
1992	35.49	6.45	41.95	56.63
1993	35.81	8.26	44.07	56.02
1994	36.12	24.87	60.00	73.03
1995	67.06	15.76	82.83	93.39
1996	80.65	20.11	100.76	106.99
1997	81,34	14,40	95,74	95,74
2005	81.34	14.40	95.74	59.25[1]
TOTAL	1,146.03	245.92	1,391.94	1,387.78

Base-line year values (1997)[1-](2005).

* 6% annual discount rate, 1997.

Source**:** Based on information obtained from Embrapa Forest.

Results

The economic model used in this analysis generated the following economic results: private benefits per ha, total private benefits, total net benefits, and a benefit-cost ratio. Appendix 3 presents the present net values of the 25 simulated management regimes, with net private benefits per ha expressed in 1997 US$. The net present values (NPV) ranged from $1.708 (MR19) to $2.160 (MR1) per ha. To compute the potential benefits of SISPLAN, three situations were considered (Table 4). *Case 1* compared MR14, established by the Brazilian government program of fiscal incentives for reforestation (old technology), with MR1, the most profitable management regime. *Case 2* compared MR14 with MR9. Rotation age was the same for both, but their thinning plans differed. The objective with this comparison was to see how profitability was affected by thinning regimes different from the one established by the fiscal incentive program. Finally, *Case 3* compared the most profitable management regime, MR1, with the least profitable, MR19. This comparison was intended to show the maximum potential benefit that could be derived from the SISPLAN technology. Column 2 in Table 4 indicates the private benefit per ha based on the NPV obtained for each management regime (Appendix 3). The total net benefits were derived after subtracting public expenditures involved with the development of SISPLAN (Table 4).

he comparison of MR1 and MR14 (*Case 1*) in Table 4 indicates that the total net benefit of investments for research and development, using SISPLAN, was US $77.2 million, with a benefit-cost ratio of 55.7. MR1 had a rotation age of 16 years, with no thinning operations (Appendix 1). This regime was especially suited for the production of pulpwood and fuelwood. The longer rotation age for MR14 (20 years) provided for greater output, and was better suited for producing veneer logs. MR14´s lower profitability was due, in part, to the cost involved in the three thinning operations not used in MR1. The comparison of MR9 and MR14 (*Case 2*) showed total net benefits of $37.9 million and a benefit-cost ratio of 27.3. Finally, when MR1 (most profitable) and MR19 (least profitable) were compared, the total net benefits were $245.5 million, with a benefit-cost ratio of 176. These three cases demonstrate high public returns to investments in research and development, based on SISPLAN. Similar results were found in analyses of forestry research by Huang and Teeter (1990, and McKenney *et al.* (1993).

Some additional comments are required. First, MR1, shown to be most profitable, is used by the Brazilian pulp and paper industry, which demands *Pinus* roundwood with small diameters. In general, these industries both produce and process wood. In contrast, the regime showing the lowest profitability (MR19; 30-year rotation), is preferred by mechanical-processing firms (i.e., sawnwood and veneer) in Brazil. These firms require roundwood with better technological properties and larger diameters for use in construction, furniture making, and plywood. Therefore, in the current context of southern Brazil, it is more profitable to produce roundwood for pulp and paper-making than for other industrial uses, if one considers only the profitability of wood production (the first part of the production chain). This latter conclusion is also made in a recent report of the ”Banco Nacional de Desenvolvimento Econômico e Social” of Brazil (BNDES 1995). This report signals the economic disadvantage of long rotations in Brazil, although they may be short when compared with the rotations of more than 80 years that characterize temperate forests.

Second, management regimes that are less profitable, but which have longer time spans (e.g., MR19), could provide a substitute for the use of native woods and, in turn, ameliorate the increasing exploitation of these valuable ecological resources. Thus, there appears to be a trade-off between financial and environmental gains. To reduce this trade-off, public policies should be implemented that provide the necessary technical and institutional means for increasing the profitability of management regimes with longer rotation ages, such as RM19, thus providing optimal or at least near-optimal solutions.

Potential benefits of SISPLAN (as shown in Table 4) are affected by the assumptions used in the initial simulation of the model. Sensibility analyses were performed on wood prices, discount rate, and site index. First, when roundwood prices were increased, the profitability of shorter rotation regimes also increased. Alternatively, when roundwood prices were reduced, longer rotation regimes were more beneficial. The change in timber prices also affected the profitability of public investment in the research and development of SISPLAN. In this sense, higher wood prices were also identified with a higher benefit-cost ratio of research. Second, model results were also sensible to the choice of a particular discount rate. As was also demonstrated by Samuelson (1976), the empirical results indicated a tendency toward reduced rotations as the discount rate increased, because returns to forestry investments diminish more rapidly with time. Although the choice of alternative discount rates affected the estimations of SISPLAN research benefits, the relative advantage of the new technology over the old was unaltered. Finally, our results were not significantly affected when the site index was altered.

Conclusions

Information technologies present great possibilities for transmitting technical knowledge and, ultimately, analyzing the impact of research activities. This is true mainly for scientific technical knowledge, which is not incorporated as much into the productive process as that generated by forest-planning research.

The economic evaluation of the computerized projection system SISPLAN showed that the potential benefits were derived from research investments on management technologies that contribute to improved planning and organization activities in forestry. Estimates for our base case (the government-recommended policy at that time) suggested economic gains to Brazil of $77.2 million (net present value referred to 1997), with a cost-benefit ratio of 55.7. The research, therefore, was an attractive economic investment.

Our results also show how countries like Brazil, with intermediate forestry research systems, can reap important gains from more-developed systems through the transfer of technical knowledge. The analysis of the development of SISPLAN illustrates how, with limited personnel and financial resources, a country can capture a large volume of technical knowledge and channel it to improve its silviculture. Of course, for this type of technological ”spill-in” effects to materialize, some previous local scientific and technological research is required, as has been the case analyzed in Brazil.

Finally, the SISPLAN projection system has also generated ”spill-out” technological effects. This technology is now used in other Brazilian regions and in other countries that were not contemplated in this analysis. However, a complete evaluation of the SISPLAN technology should consider, in addition to these spillover effects, the potential environmental externalities derived from the adoption of this technology.

Table 4. Benefits of SISPLAN.

Management regimes	Private benefits/ha (US$)*	Total private benefits (US$$10^6$)*	Total net benefits (US$$10^6$)*	Benefit/Cost Ratio
CASE 1 (MR1-MR14)	144	78. 6	77. 2	55. 7
CASE 2 (MR9-MR14)	72	39. 3	37. 9	27. 3
CASE 3 (MR1-MR19)	452	246. 8	245. 5	176. 9

* Year 1997

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Appendix 1. Management regimes*.

Management regimes	Year of thinning and clear-cut 0 8 10 12 14 16 18 20 22 24 26 28 30
MR1	0--------------------------------- 16
MR2	0--- Th1 ------------------------ 16
MR3	0--- Th1-------------------------------- 18
MR4	0--- Th1 --------------------------------------- 20
MR5	0--- Th1 -- 22
MR6	0--- Th1 -- 24
MR7	0--- Th1 --------- Th2 ---------- 16
MR8	0--- Th1 --------- Th2 ----------------- 18
MR9	0--- Th1 --------- Th2 ------------------------- 20
MR10	0--- Th1 --------- Th2 --------------------------------- 22
MR11	0--- Th1 --------- Th2 -- 24
MR12	0--- Th1 --------- Th2 --- 26
MR13	0--- Th1 --------- Th2 -----------Th3 --- 18
MR14	**0--- Th1 --------- Th2 ----------Th3 ---------- 20**
MR15	0--- Th1 --------- Th2 -----------Th3 ------------------ 22
MR16	0--- Th1 --------- Th2--------- --Th3 ------------------------- 24
MR17	0--- Th1---------- Th2 -----------Th3 --------------------------------- 26
MR18	0--- Th1 --------- Th2 -----------Th3-- 28
MR19	0--- Th1 --------- Th2 -----------Th3 --- 30
MR20	0---------- Th1---------- Th2 ---------- Th3 ---- 20
MR21	0---------- Th1---------- Th2 ---------- Th3 ------------ 22
MR22	0---------- Th1---------- Th2 ---------- Th3 ------------------ 24
MR23	0---------- Th1---------- Th2 ---------- Th3 -------------------------- 26
MR24	0---------- Th1---------- Th2 ---------- Th3 ----------------------------------- 28
MR25	0 --------- Th1---------- Th2 ---------- Th3 -- 30

Source: Based on Ahrens (1992, p. 75) and Oliveira (1995, p. 112).

***All the management regimes were simulated, and considered the same genetic content and the same number of trees per**
ha, at the same index site. However, the thinning and final harvest periods varied, as did the inclusion of selective cutting.

Appendix 2. **Commercial volume.**

Management Regimes	Final felling volume by industrial use					Total volume (m^3 ha^{-1})
	Veneer	Sawnwood	Pulpwood	Fuelwood	Total	
MR1	**9.2**	**370.7**	**132.5**	**21.1**	**533.5**	**533.5**
MR2	15.4	316.6	95.3	14.2	441.5	488.6
MR3	40.6	355.7	96.6	14.6	507.6	554.7
MR4	66.5	396.5	92.9	13.3	569.2	616.3
MR5	115.9	390.8	98.8	13.6	619.1	666.2
MR6	140.2	425.1	86.5	13.1	664.8	711.9
MR7	21.2	255.9	54.6	8.7	340.4	455.3
MR8	44.3	298.7	50.5	7.7	401.2	516.1
MR9	106.0	291.3	52.9	8.3	458.5	573.4
MR10	139.6	317.9	47.1	8.3	512.9	627.8
MR11	174.3	328.0	53.8	7.3	563.5	678.4
MR12	222.2	333.1	49.8	7.9	613.0	727.9
MR13	37.3	209.1	30.3	4.3	281.0	492.9
MR14	**95.4**	**201.6**	**28.1**	**4.8**	**329.9**	**541.8**
MR15	133.1	212.7	27.2	4.9	377.9	589.8
MR16	170.2	222.6	26.8	4.7	424.3	636.2
MR17	215.7	221.6	27.0	4.7	469.0	680.9
MR18	256.3	219.7	29.5	4.7	510.3	722.2
MR19	**289.0**	**227.7**	**27.3**	**4.6**	**548.6**	**760.5**
MR20	70.7	203.8	29.8	5.4	309.7	570.0
MR21	105.0	218.5	29.8	4.3	357.7	618.0
MR22	140.5	228.2	28.4	4.6	401.7	662.0
MR23	185.1	226.5	28.7	4.7	445.0	705.3
MR24	220.6	226.9	30.6	4.7	482.7	743.0
MR25	248.6	234.4	28.3	5.0	516.2	776.5

Appendix 3. Net present value (NPV) of alternative management regimes (US$-1997).

Management regime	NPV	Management regime	NPV
MR1	**2160**	*MR14*	**2016**
MR2	2007	MR15	2011
MR3	2066	MR16	1973
MR4	2053	MR17	1921
MR5	1974	MR18	1825
MR6	1829	**MR19**	**1708**
MR7	1848	MR20	2022
MR8	1964	MR21	2047
MR9	***2088***	***MR22***	***2015***
MR10	2051	MR23	1973
MR11	1943	MR24	1873
MR12	1863	MR25	1751
MR13	1833		

Methods for Environmental Assessment of Forestry Operations – An Overview

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Abstract

This overview presents some assessment methods for communicating environmental performance in forestry. Perspectives are also offered for the development of Life Cycle Assessment, LCA, in forestry. Several methods, such as Substance Flow Analysis, Risk Analysis, and LCA use static models and predominantly quantitative elements to assess environmental performance. Certification and an Environmental Impact Assessment, EIA, also include qualitative elements and public involvement. Examples of LCA-related studies in forest operations and two possible developments for LCA will be presented here. Although LCA comprises more qualitative elements, difficulties arise when it is linked to dynamic models for biological processes. An important issue is whether to include land use in this method of forestry modeling. Other methods might be preferable, e.g., when handling topics with qualitative values or political priorities. The alternative is to restrict the use of LCA in forestry to principally a technosphere, and use other means, e.g., EIA or certification, for analysing issues that affect qualitative values. Regardless of the direction chosen, the basic concerns when developing LCA are the quality of the data, the building of models, and the development of tools that are sufficiently simple, relevant, and robust to provide support in the decision-making process.

Keywords: Environmental management; Energy use; Forest management; Forest operations; LCA.

Environmental Issues Go Global

After World War 2, the world experienced strong economic development, but the negative aspects of industrialism became clear. Many people feared that the impact on nature, regarded earlier as an acceptable sacrifice for economic progress, would put the very existence of human life at risk. A well-known alarm clock was Rachel Carson's *Silent Spring* (1962). Environmental issues thus gained more importance in the industrial world during the 1970s. They reached global recognition in connection with the 1987 United Nations conference on environment and development, UNCED (WCED 1987, Humphreys 1996). UNCED established the term Sustainable Performance, a political goal to serve the present generation without putting future generations at risk. Sustainability includes three general principles (Upton and Bass 1995):

> Environmental sustainability requires that the ecosystem be able to support healthy organisms, while simultaneously maintaining its productivity, adaptability, and capability for renewal.
>
> Social sustainability reflects the relationship between development and social norms. An activity is considered socially sustainable if it conforms with social norms or does not stretch them beyond a community's tolerance for change.
>
> Economic sustainability requires that the benefits for the parties involved exceed the costs incurred and that the capital is handed down from one generation to the next.

UNCED was followed-up by the Earth Summit 1992 in Rio. This meeting reflected the controversies between industrialized nations and the less developed world. In spite of these differences, Earth Summit resulted in Agenda 21, concerning global cooperation in social, economic and environmental development, as well as the Convention on Biological Diversity (Upton and Bass 1995, Humphreys 1996). The latter represents an agreement about the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising from the use of genetic resources. The Commission on Sustainable Development (CSD) was created in December 1992 (Humphreys 1996) to ensure effective follow-up of UNCED, and to report on implementation of the Earth

Summit. In Rio, forests were among the most controversial issues being considered. The North-South polarization concerning forests did not permit agreements beyond the text of a non-legally binding authoritative statement of “Forest Principles”. After the Earth Summit, the CSD established the Intergovernmental Panel on Forests (United Nations 1999), to continue the forest policy dialogue. IFF, the Intergovernmental Forum on Forests, later followed up the IPF; it will cease its activities in 2000.

Goal and Scope

This paper presents an overview of some methods for assessing the impacts of forest operations on the environment. The scope comprises the chain of operations in forest management, from the creation of the stand until timber is delivered to the gate of the timber yard or at the mill. This presentation will concentrate on LCA (Life Cycle Assessment) and will investigate 1) whether methodology must be adapted to forestry, 2) and what the requirements are for improvement. This paper is written against a background of the author’s experience in European forest operations.

Standards Replace Legislation

Today, environmental issues concern so many that they represent hard facts in eco-sensitive markets. The process behind UNCED encouraged the International Organization for Standardization (ISO; Upton and Bass 1995, STG 1996) to establish environmental standards. Following the success of the ISO 9000 standards for quality management, ISO introduced the 14000 series for use in environmental management by an organization. Five areas are addressed in this family of standards:

- Environmental Management Systems
- Environmental Performance Evaluations
- Environmental Auditing
- Life Cycle Assessment
- Environmental Labelling

Through standardization, complicated international legislation can be avoided in the area of environmental management. The ISO 14000 series of standards for Environmental Management Systems (EMS) are standards of procedures, whose level of attainment is set by the organization itself. A third independent party, with no vested interest in the organization, must perform the audit for the certification process.

Forest legislation in many countries that export forest industry products have not satisfied consumers in some export markets. Hence, the exporting countries and Environmental Non-Governmental Organizations took the initiative to create standards for forest management. Groups that endorse forest management standards, e.g., Forest Stewardship Council (FSC), International Tropical Timber Organization (ITTO), and Pan European Forest Certification Scheme (PEFC), prescribe a certain performance or level of management that the company must reach. In Canada, parties involved in sustainable forestry have developed the CSA Sustainable Forest Management System Standard together with Canadian Standards Association (CSA). This is compatible with the ISO 14001Standard for Environmental Management Systems.

Means of Environmental Management

Because of prevailing pressures from markets and governments, several decision-support methods for studying environmental mechanisms were developed prior to the ISO process (Hofstetter 1998). These were drawn up differently, depending on whether they focused on product/organization/site or on society/environment/economy. Environmental performance can be followed in several ways (Figure 1). Substance Flow Analysis (SFA), Risk Analysis and LCA are analytical, and aim to quantify consequences for the environment with the aid of principles of natural sciences. LCA, Environmental Impact Assessment (EIA), and Certification all contain qualitative elements that tackle economic or social issues.

SFA (CIT Ekologik 1996), or Material Flow Accounting (MFA; CML 1998), is a method for tracing the flow of a substance in a defined area or organization. This involves identifying the substance, its flow, and the organizational or geographical entity. The flows are quantified and their effects then evaluated.

Risk Analysis, Assessment or Management (McCallum and Fredericks 1996, Anon. 1997) is a technique to analyze, evaluate, and control risks; its dimension also includes society. The entity for Risk Management is an organization, site, area, or project. The ISO 14001 requires that environmental risk management must be undertaken (STG 1996).

The EIA is an instrument for evaluation and decision-making, with public involvement. In many situations, legislation requires EIA when land development is impending or when new methods of agriculture or forestry, for example, are to be introduced (Westling 1995,Environmental Protection Authority 1999). EIA is a means of comparing the effects of change on natural resources in a natural environment. As such, an EIA describes and evaluates environmental effects, identifies any lack of knowledge, and prescribes actions. It is a part of a transparent democratic process and can deal with quantitative or qualitative estimates at the level of area or site.

Certification is a market-based instrument for raising awareness or providing incentives for producers, retailers, and consumers toward a certain quality of product. This quality may be derived from aspects of the manufacturing process, patterns of trade, social consequences, or environmental impacts. The goal of certification is to follow a standard of procedures, e.g., ISO 14001, or to reach a certain level, such as with the FSC. Certification is always voluntary. The achievements of the organization are assessed by an audit; the highest level of credibility is gained when the assessment is done by an accredited third party.

LCA is a method for assessing the environmental impacts of a product or service during its lifetime (Nordic Council of Ministers 1992, STG 1998, Heinimann 1999). This method is related to SFA or MFA (Klöpffer 1998), but has a product perspective rather than a site perspective (Hofstetter, 1998). LCA is intended as a comparative assessment that can be used in:

assisting in decision-making for improving products or processes,

marketing purposes (for an environmental profile), and

advising the public or politicians in the process of public decision-making.

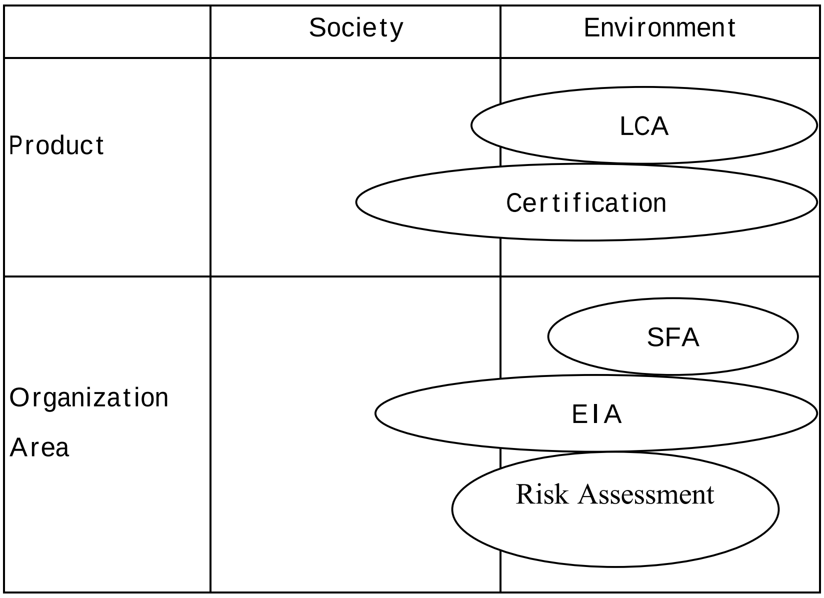
ISO14040 characterizes the four steps in a complete LCA 1) defining the Goal and Scope; 2) Inventorying data as a Life Cycle Inventory (LCI); 3) Impact Assessment, and 4) Interpretation. The Impact Assessment has three stages. Data from the inventory are assigned to impact categories (classification), and the influence of each compound is valued according to a quantitative weighting system (characterization). These characterized values are normalized to a common reference impact (Wenzel et al. 1997). Impact categories are determined according to an agreed value on safeguard subjects, e.g., Global Warming Potential (GWP) or Acidification Potential (Nordic Council of Ministers 1992). The interpretation is the weighting of end-effects across impact categories.

LCA under Development

Life Cycle Assessment is one of many tools for studying the environmental dimension in sustainability. This fairly new approach has possibilities for improvement (Ecomed 2000). LCA should be regarded as support for a decision-making process, rather than as a single indicator for good and bad. It comprises comparisons between alternatives and the results are compared from a product perspective. In that sense, LCA provides a global assessment as it follows the product from beginning to end, regardless of where it is used. Input data reflect average processes and average ecological conditions. Presently, LCA models are static, with no consideration given to time and space. Their results are only descriptive.

LCA is dominated by the inventory analysis of a product system (Hofstetter 1998). Its interpretation is influenced by the environmental implication of single compounds. This is called a bottom-up approach. With enhanced knowledge of a system, this approach leads to extensive protocols of inventory data. It is difficult to determine the important criteria for evaluating the environmental impact of the whole system.

Figure 1. Position of some decision-support tools according to the level of analysis (product-organization-area) and concerned party (society-environment).



Another approach is top-down modelling, in which modelling is influenced by relevant, identifiable impacts on the environment. This approach must be supported by values, which means that the modeller has to consider which safeguard subjects (e.g., human or ecological health) are relevant in the context. Data collection is adjusted to satisfy the evaluation of those subjects.

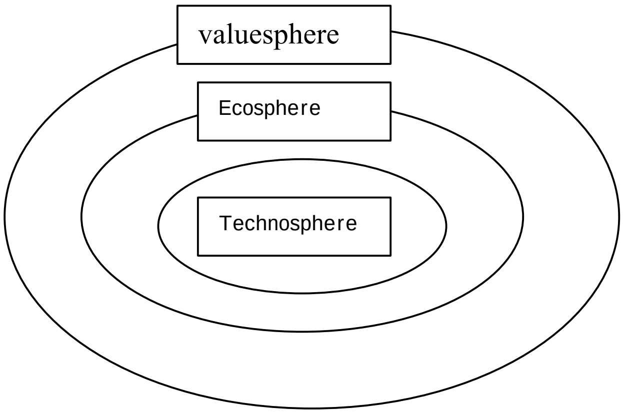
Hofstetter (1998) describes an extended look at LCA as modeling in three spheres (Fig. 2), i.e., a fundamental "Technosphere", an "Ecosphere", and a "Valuesphere". He anticipates the LCA tool should address all three spheres, with e.g., sociological and psychological models for Valuesphere, and models based on natural sciences to describe the Technosphere and Ecosphere.

LCA Approaches in Forestry

LCA-related techniques can address environmental issues in forestry operations, as shown in several recent studies. These followed a bottom-up approach and were basic Life Cycle Inventories of the use of fossil fuels. To avoid the obvious variation that results from using different conversion factors from input sources to emissions, results were compared in terms of the input energy of fossil fuel.

Schweinle (1996) provided a thoroughly technical and biological analysis of forest production in Germany, from an LCA perspective. The forest production system was considered a theoretical high forest. All measures, from reforestation to timber transport, were accounted for in a number of forest types classified by the dominant species. The results were characterized according to some impact categories. GWP was analyzed as a net effect by the forests. The total energy inputs in the chain of actions from stand establishment of Norway spruce to its harvesting, in terms of fossil fuels, were around 801 and 315 MJ per t atro m. R. (ton completely dried wood over bark) for pulpwood and sawn timber, respectively. The energy expenditure for transporting timber 50 km to the wood yard or mill constituted an additional 303 and 215 MJ per t atro m. R., respectively. These results were compared with work by Wegener *et al*. (1994), who had calculated a smaller total for energy used in production and transport.

Figure 2. Three spheres linked by LCA, according to Hofstetter (1998).



In the Nordic countries, Berg (1998) inventoried energy use for forest operations ranging from stand establishment to timber transport to industry. Rates of energy use in northern and central Sweden were 193 and 183 MJ/m^3 of wood, respectively. Within this total, timber transport accounted for 104 and 93 MJ, respectively. In a study from Central Europe, Knechtle (1997) examined the system from the view point of machine history during its lifetime, rather than from an operations perspective. This meant that energy input in machine manufacturing and end-of-life were also incorporated. Resources (for harvesting and timber transport) that were allocated to the processed-timber volume consumed 114 and 91 MJ/m^3 of wood for motor-manual and mechanized logging, respectively. Of this amount, the energy used for attaining raw materials and manufacturing varied between the systems. In the motor-manual operation, 2.2% of the energy used for power saws could be accounted for by raw materials and manufacturing; for forwarders and skidders, the corresponding amount was 16 to 18%, and for harvesters, 12 to 20%. Results from these and other studies are presented in Table 1. Although these cited papers present fair descriptions of the methods, the results are hardly directly comparable because of different or unclear systems boundaries.

The variation among results might be explained by shifting conditions such as terrain, infrastructure, type of machinery, forest management regime, type of cutting (felling-thinning), and tree size. This presentation illustrates the problems associated with data origin and its quality when forestry inventory data are collected for an LCA. The consequences of these dynamic effects, not explicitly shown in the table, include situations where:

data originate from thinning (small trees) or final felling (big trees), or

harvesting and necessary regeneration work results in a new forest with production goals that differ from those of the stand just harvested.

Carriers, i.e., fossil fuels as diesel oil or petrol, provide the energy for these operations. Their inputs can be re-categorized as emissions to the air, water, or ground via emission factors. These factors are compiled or deducted according to the present state of available information, true or not. Operations with similar levels of energy use may produce varying emissions depending on fuel quality.

Table 1. Studies on energy use: MJ/m^3 of solid wood over bark.

	Forest operations	Transport to industry	Sum
Schweinle (1996) sawn timber[1]	135	92	227
Schweinle (1996) pulpwood[1]	343	130	473
Knechtle (1997, 1999) [3] mechanized	91		
Knechtle (1997, 1999)[3] motor-manual	111		
Wegener et al. (1994)[2] [3]	62	125	187
Berg (1998) North[3]	89	104	193
Berg (1998) Central[3]	90	93	183

[1]Spruce transport distance 50 km. 1t atro m. R =2.33 m^3,

[2] Transport distance 50 km.

[3] All assortments

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These would be expressed in terms of emission factors, e.g., the amount of carbon dioxide per MJ. A study of engine emissions from agricultural tractors and forestry machines (Hansson *et al.* 1998) demonstrated that using one single emission factor (for one fuel) for all types of driving operations could result in very high levels of error. In fact, they conclude that the emission factors hitherto used in LCI - LCA studies were not applicable to agricultural tractors. A further evaluation of impact categories could be misleading unless the emission factors and boundaries are relevant to the comparison.

Nevertheless, despite these difficulties, several LCA of forest products are made with data that use forest production as a base. Because paper products are refined products, made from worked-up timber, analyses show that forestry processes represent only a small part of the total environmental load that can be quantified (Anon. 1998a). The importance of forestry is palpable when less-processed goods, such as sawmill products, are analyzed. EMPA (Künninger and Richter 1998) conducted an LCA of railway sleepers, comparing those made of wood (beech), steel, and concrete. The aim was to investigate the impact on the environment due to all the steps connected with the manufacturing, use, and disposal of the sleepers. These analyses revealed that most environmental impacts are caused by the rail-construction work, the use of the rails, and the maintenance. Procuring the raw material had smaller significance. Concrete sleepers were environmentally less disturbing than those made of other materials. The problem with the beech sleepers was not caused by the heavy load during forest production, but because impregnation and more maintenance work were required during the shorter lifetime of those sleepers. This analysis helped identify the hot spots or the environmental problem area associated with each sleeper type, thus enabling improvements in reducing environmental impacts.

Different stages in the process of timber transport from forest to industry have been identified as major sources of energy use and as contributors to GWP (Wegener 1994, Karjalainen and Asikainen 1996, Schweinle 1996, Winkler 1997, Heinimann 1998, Berg 1999). In addition, Karjalainen and Asikainen (1996) have studied forestry operations throughout Finland, from the perspective of carbon storage and GWP. The amount of carbon stored in timber (in Finland) exceeded emissions from fossil fuels.

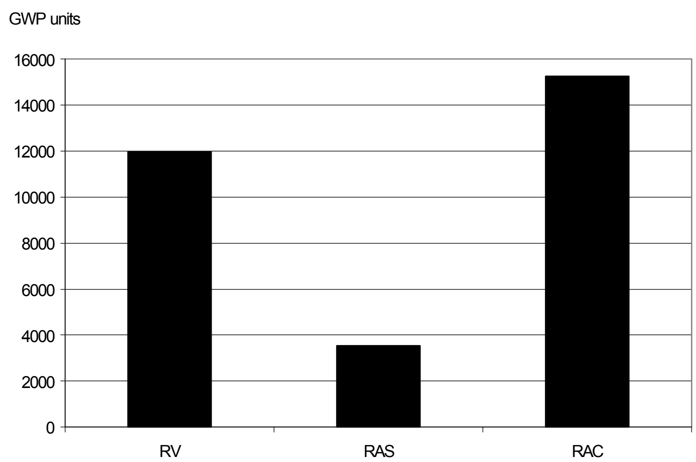
The effects of timber transport to a mill in northern Sweden were compared according to the impact caused by using rail versus road vehicles (Berg 1999). The infrastructure is such that timber can be transported by road vehicles only, or with road vehicles and electrified railway. Both solutions carry the same cost, but the railway is considered better because, although its transport distance is longer, rail has, inter alia, a lower environmental load. The main providers of electricity in Sweden are nuclear power plants and hydropower dams. In these studies, the emissions from the railway system were compared with the use of a hypothetical source of electricity, namely, a coal-condensing plant. The survey of the environmental impact on GWP (Fig. 3) showed that the railway solution contributed far less per m^3 to GWP than did timber transport by road vehicles alone, despite the longer distance. However, if electricity were to be supplied from a coal-condensing plant, the order would be reversed. This case shows that the energy carrier is vitally important when choosing among transport solutions. A supposedly environment-friendly investment in railway transportation can become less desirable if the conditions for energy supply are changed.

LCA is mainly a method for quantitative estimates. An evaluation of land-use aspects would also be desirable (Blonk *et al.* 1997). This concern is also expressed in an on-going Cost E9 project "LCA of Forestry and Forest Products". The report from an environmental project by Axel Springer Verlag AG, Stora, and Canfor (Anon. 1998b) includes a proposal for a new forestry assessment method in LCA. Their report contains examples of land use on government holdings in British Columbia, government and private holdings in Germany, and company and private holdings in Sweden. It can be difficult to incorporate such a qualitative aspect as land use in a quantitative assessment method, and interpreting biological indicators can differ among sites. As far as I am aware the report was the first attempt to address the practicalities of the problem. This approach reached no solution, but illustrated the difficulties of reflecting the complicated interaction between different land qualities and on-going or historical land use.

Future Perspectives

Environmental concern has developed from green dreams over survival issues on the political agenda to a money-making business. The public fears a limit of resources. It is always good to economize the consumption of raw materials and energy use, but in some markets, greater sales can result from suggestions that a company practices good environmental management.

Figure 3. Global warming potential expressed as GWP units per m^3 solid i. b. By road vehicles only (RV), by road vehicles and railway with electricity of Swedish average (RAS), and by road vehicles and railway with electricity from a coal-condensing plant (RAC).



A number of tools have been developed by concerned parties to support their own functions. The perspective clearly changes, depending on whether the observer is a consumer, producer, or a state. The design of the tool also depends on whether the entity for evaluation is a forest product, forest area, or organization.

LCA methodology can be used for assessing operations to provide inventory data for the forest industry. Complex analyses can also be performed when the technical and biological aspects of technical management and ecosystem reaction are considered. In this paper, a number of reports were analyzed, but few were comparable because of shifting scope, data quality, and boundaries. LCA is powerful when used with quantitative input data, but qualitative inputs can also be handled. LCA's strength lies in maintaining a life-cycle perspective through a complicated chain of events. Problem areas, "hot spots", can then be identified.

From my perspective, two basic developments are possible for LCA in forestry. This method might be developed to comprise a Technosphere, Ecosphere, and Valuesphere, according to the paradigm described by Hofstetter (1998). However, difficulties arise with this. Forest operations in the "Technosphere" are described by inventories of data according to static models. These static models must be linked with models of dynamic processes for forest growth and sequestration of compounds that have environmental impacts. There is also room for a dynamic approach in forest operations -- "the Technosphere", which is well motivated because forest operations also are dynamic. Variability in results is caused by the type of forest management system, stand conditions, and tree properties. Complexity increases if a "Valuesphere" is added. A central issue is whether to include land use in the LCA of forestry. This is a challenge to model builders because of the lack of both models and apparent data. The issue here is whether other methods are preferable, e.g., when handling topics with qualitative values or political priorities. Many problems concerning ecosystem state and stability fall into this category, and our knowledge is often limited.

Another direction is to restrict the use of LCA in forestry to predominantly the "Technosphere". Other means, such as the Environment Impact Assessment or Certification, would be used for addressing issues that affect environment or society. In such a process, LCA would have a strong role in providing basic data for the evaluation.

Environmental management is one very vital aspect of forestry today. Efficient tools are needed. Regardless of the direction chosen, the basic need in developing LCA concerns data and its quality, the building of models, and the development of tools that are sufficiently simple, relevant and robust to provide support in the decision-making process.

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Role of Wood Procurement-Related Environmental and Quality Management Systems in Meeting Stakeholder Interests

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Abstract

Finland has been active in promoting sustainable forest management (SFM) at both the international and national levels. National criteria and indicators for SFM have been developed and reported on to describe and monitor society needs. The nature conservation and forestry legislation has been completely rewritten during the past few years in order to safeguard the key biotopes in Finnish forests, which are mainly owned by families and other non-industrial small-scale woodlot owners. Forest management guidelines have been improved to comprehensively include management of valuable biotopes, and protection of biodiversity trees, soil and water, as well as issues related to recreation, game management, and other socio-cultural values. A National Forestry Program (NFP) was developed as a transparent and open-ended process, and has recently been approved by the Government. The NFP incorporates economical, ecological, social and cultural aspects, and related actions as well as establishing the mechanisms to continue the process. In addition, Forest Certification issues have been investigated in an open manner. To support these activities at a company level, the forest industry has been active in developing environmental and quality management systems (EMS and QMS, respectively). These have been not only for the manufacturing side but also for wood procurement. The three main companies, Stora Enso Metsä, UPM-Kymmene Forest, and Metsäliitto, which together procure 80% of the domestic timber in Finland, all have certified QMS and EMS for wood procurement. Furthermore, based on the long-term work carried out by the Trade Association of Finnish Forestry and Earth Constructing Contractors, forest machine contractors are increasingly establishing their own QMS and EMS. Because of the small scale of the contracting companies, certification of these systems may not be economically viable. However, auditing mechanisms by either the forest industry or an independent party are being developed and, to some extent, are already in use. Both QMS and EMS, as addressed in the international standards ISO 9000 and ISO 14000 series, respectively, concentrate on management issues such as procedures, organization, responsibilities, competence, information flow, records, etc. The principle of continual improvement is clearly stated in ISO 14000, and will probably be included in the upcoming, revised version of ISO 9000. The main purpose of QMS and EMS is to help companies improve their own practices. The existence of such systems, however, especially the certified ones, also generally improves the public image of the company and is definitively an asset in business relations. Practically all nationally important issues related to ecological, social, and cultural aspects have been included or referred to in the QMS and EMS of forest industry. Environmental issues must be considered at all levels of the organizations. Thus, the systems have an important role in bringing theory and ideas into practice at the local level.

Keywords: Contractors, Environmental management systems, Forest industry, Quality management systems; Sustainable forest management, Wood procurement

Introduction

Forestry and Forest Industry in Finland

In Finland, forested land accounts for 23 million ha, or 70% of total land area. Finland is a family-forestry country; small non-industrial private woodlot owners hold 59% of the forested area. Another 28% of the forests are state-owned (40% of which is in nature conservation areas), while 8% are owned by forest industry companies. The remaining 5% is owned by municipalities, parishes, and other collective parties (Sevola 1999). The annual growth of the forests is about 75 million m^3, with a total drain (removals and mortality) of approximately 64 million m^3. In 1998, the industry used about 57 million m^3 of domestic roundwood. Some 80% of that roundwood came from family forests. Roundwood imports were 10 million m^3 (Sevola 1999).

Three major forest industry companies - Stora Enso Metsä, UPM-Kymmene Forest, and Metsäliitto Group - dominate the markets, buying 80% of the domestic roundwood. Their main products are sawn timber, pulp, paper, and paperboard. The majority of the sawn timber, paper, and paperboard are exported (Table 1), and account for 29% of the total value of Finnish exports.

Sustainable Forest Management

Since the 1992 UN Convention on Environment and Development (UNCED) in Rio de Janeiro, sustainable forest management (SFM) has become a hot topic. In Finland, wood production-related sustainability has been carefully monitored for some 80 years, since the pioneering work in national forest inventories of the 1920s. The ecological and socio-cultural aspects of SFM have also been appreciated for decades; the first national parks were established in the 1930s, and the unique everyman's right now grants everyone free access to the forest for recreation as well as for gathering berries and edible mushrooms.

Based on UNCED, the work related to Criteria and Indicators (C&I) of SFM has been carried out nationally and in international forums. The national report on C&I (Ministry of Agriculture and Forestry 1997) is currently being updated. Finland, like many other countries, has recently redesigned forestry-related legislation and forest management guidelines to better reflect the ideas of SFM.

Ecological sustainability is secured via protection measures. In Finland, 1.7 million ha of forests are strictly protected. An additional 0.7 million ha are limited in their wood production. Furthermore, under the Nature Conservation and Forestry Acts, certain valuable biotopes are strictly protected. The Nature Conservation Act also requires all forest species needing strict protection to be carefully considered.

To protect biodiversity in production forests, the Forestry Act lists certain valuable biotopes, e.g., the immediate surroundings of springs, brooks, and small lakes; specific herb-rich forests and swamps; as well as forests around gorges and gullies. These biotopes are to be managed so that their special values are not threatened. In many cases, these areas are fully excluded from harvesting and other forest management operations. In addition, certain key tree species (e.g., aspen, goat willow, alder, and rowan), snags and other decaying wood, as well as groups of old trees are retained in harvesting operations. Special measures are also taken to increase the amount of burnt wood in the forests for dependent flora and fauna.

Table 1. 1998 wood consumption, production, and the proportion of exports in the Finnish forest industry (Sevola 1999).

Type of product	Wood consumption (mill. m^3)	Production (mill. m^3)	Exports (%)
Sawn goods	27	11.3	73
Other wood products	5	1.6	58
Mechanical pulp	13*	4.6**	0
Chemical pulp	35*	6.7**	25
Paper and paperboard	-	12.7**	89

* including sawmill chips (2.8 mill. m^3 for mechanical pulp, 9.5 for chemical)
** mill. metric tonnes

Finnish Forest Certification Scheme

Voluntary Certification, as defined for this paper, is a documented procedure in which an accredited, independent body establishes the extent to which an organization or product meets the requirements of an applicable standard or set of regulations. Conformance with these requirements is assessed through document review and auditing. Certificates typically are valid for a limited period, e.g., three to five years, and require annual or semi-annual surveillance.

In this paper, forest certification refers to endorsement of the management and use of forests. The Finnish Forest Certification Scheme has been in development since 1996 (Finnish Forest Association 2000), as a response to increasing interest in SMF when marketing forest products. The elements of the Finnish scheme are specified in eight draft standards:

1) vocabulary of forest certification,
2) application of group certification,
3) forest certification criteria,
4) Audit guidelines for certification at the regional Forest Centre level,
5) Audit guidelines for certification at the Forest Management Association (FMA) level,
6) verification of chain-of-custody – material flows accounting method,
7) verification of chain-of-custody – physical segregation method, and
8) requirements for auditors and certification bodies.

A Forest Certification Council has been established to implement the scheme and further develop the standards. The Council is assisted by a secretariat and a working group for development work, as well as by an independent appeals panel (Forest Certification Council 1999, Finnish Forest Association 2000).

Based on the scheme, certification can take place at three different levels:

group certification at the Forestry Centre level (37 criteria)

group certification at the Forest Management Association level (13 Forestry Centre level and 24 FMA level criteria)

forest owner level (23 required and 12 compensatory criteria)

The criteria were formulated openly, and were completed in 1997. Twenty-nine organizations participated in the work, representing economic, social, and ecological interests. Nine organizations with economic interests were the forest industry companies, forest owners' organizations, and the Finnish Forest and Park Service. The 11 social organizations included trade unions, organizations for hunting, skiing, and other recreational activities, the Sámi Parliament (organization for indigenous people in North Finland), and the Finnish 4H Federation.

In practice, forest certification has been carried out at the regional (Forestry Centre) level. The system is voluntary for forest owners and requires an audit by a third party. This includes both forest certification and wood chain-of-custody certification, but excludes its own product labelling. Links will be made to the Pan-European Forest Certification Scheme (PEFC) and, possibly, to other international certification and labelling schemes for product labelling (Forest Certification Council 1999, Finnish Forest Association 2000).

By 1999, 7 of the 13 Forestry Centre areas in Finland had been certified, thereby covering the management and use of over 13 million ha of forests. More than 180,000 forest owners have chosen to participate in the certification. By the end of 2000, all 13 Forestry Centre areas will be certified (Finnish Forest Association 2000).

Members of the Trade Association of Finnish Forestry and Earth Constructing Contractors have already committed themselves to the national certification criteria. The complete list of the criteria, with explanations, can be found at the FFCS website (http://www.smy.fi/certification/eng/). For example, nine of the group certification criteria are directly related to forest harvesting:

- increase biological control of spruce root rot and spongy sap rot of pine in high-risk areas during summer harvesting;
- retain all typical features during forest operations in key biotypes;
- maintain existing monitoring systems for harvest damage, stores of unpeeled soft-wood, and root rot control;
- provide at least 20% of the clerical staff, forest workers, and harvester/forwarder operators with annual, supplemental training, including topics on biodiversity and occupational safety;
- in forest organizations, engage only entrepreneurs who have paid their legal dues and taxes, and who adhere to the employment legislation and collective agreements in force;
- leave intact the existing snags, hollow and other decaying trees, single windfalls, trees of previous generation, natural oaks, maples, ashes, elms, lindens, goat willows, and large aspens;
- in regeneration areas, leave at least five storm-resistant trees per ha;
- during harvesting, ditch cleaning and supplemental ditching, forest fertilization, site preparation, and prescribed burning, leave a buffer zone along waterways and minor water bodies;
- during forest harvesting, avoid damage to residual crop trees and the terrain.

Basic Features of Quality and Environmental Management Systems

A Certified Quality Management System (QMS) provides a framework for managing the quality of products and services in an organization. Customers are reassured that the goods and services supplied will meet their quality expectations. In certain cases, a certified QMS is a prerequisite for inclusion in tender lists. A QMS not only improves the product or service, but also increases staff effectiveness and enhances customer satisfaction. It may also improve in-house communication, decrease the number of employee accidents, and reduce material and energy waste. A certified QMS based on an internationally recognized standard makes it easier to do business around the world.

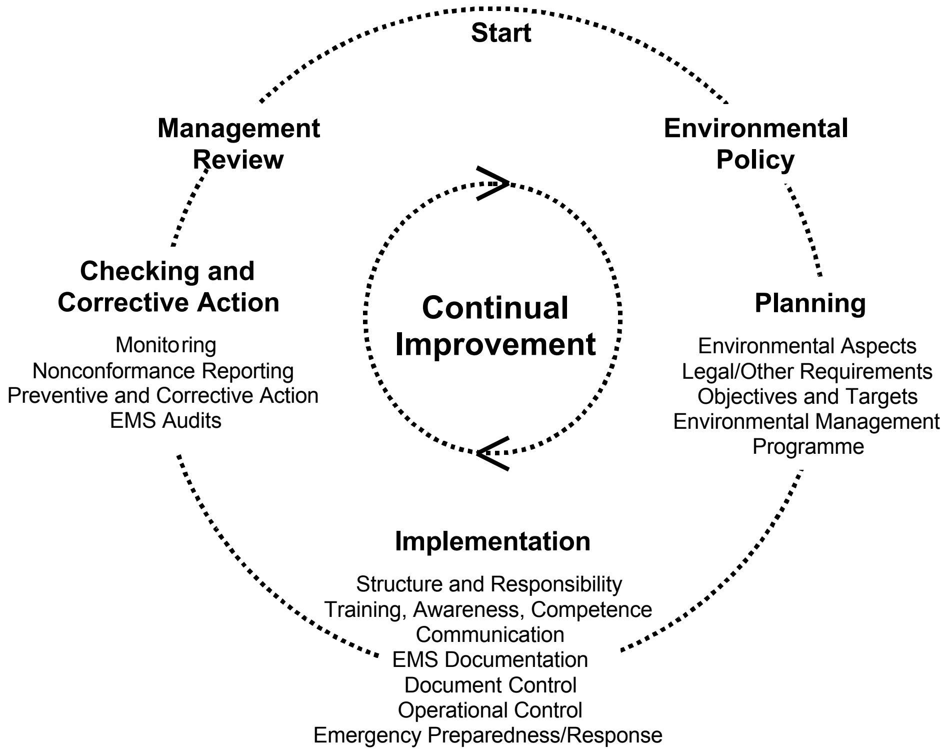
The ISO 9000 series contains international standards for QMS. The standards describe the elements to be included in QMS. Although the series does not contain any technical specifications regarding the actual manufacturing process or the final product, these can be included on a voluntary basis.

QMS elements in the ISO 9000 series standards include:

- management responsibility
- quality manual and system procedures
- contract review
- design control
- purchasing
- process control
- handling, storage, packaging, preservation, and delivery
- product identification and traceability
- inspection and testing
- control of inspection, measuring, and testing equipment
- corrective and preventive action
- control of documents, data, and quality records
- internal quality audits
- training
- servicing
- statistical techniques

An Environmental Management System (EMS) is a continual cycle of planning, implementing, reviewing, and improving the actions that an organization takes to set and meet its environmental policy and objectives (Fig. 1). It provides a proactive systematic approach to meet both business and environmental goals, and to satisfy environment-related stakeholder expectations in an increasingly transparent society.

Figure 1. Environmental Management System.



The numerous potential benefits from a certified EMS standard certification include:

Operating-Cost Savings

- improved efficiency of resource and energy utilization
- reduction of waste disposal costs through minimization of waste
- savings in emission fees or equivalent
- reduction in employee accidents

Environmental Compliance

- compliance with both internal and external environmental requirements
- minimal environmental impacts
- environmental statistics made available

Public Relations and Promotion of a Responsible Corporate Image

- improved external relations and corporate image among customers, suppliers, sub-contractors, regulatory bodies, investors, stockholders, insurance companies, environmental groups, and the public
- useful basis for identifying improved regulatory approaches
- increased shareholder value through EMS excellence

Creation of Marketing Opportunities

- good environmental performance gives a competitive advantage and is likely to attract potential customers and open wider markets
- "Better sooner than later"

The ISO 14000 series describes structures, procedures, and documentation related to EMS. It is applicable to manufacturers of all size, as well as service and public-sector organizations. The key element of the EMS is the organization's written *environmental policy* of commitment to continual improvement of its environmental performance. Environmental objectives and targets are derived from the environmental policy and implemented through clearly defined structures and responsibilities. Important elements of the EMS include:

- training, awareness, and competence
- communication
- operational and document control
- emergency preparedness and response
- monitoring and measurement
- non-conformance reporting as well as corrective and preventive action
- internal environmental auditing
- management review

As a standard, ISO 14000 does not establish any absolute requirements for environmental performance beyond the commitment in the policy, except for existing laws. The standard recognizes that an organization may have occasional regulatory non-compliances and still meet the requirements of the standard. Two organizations with similar functions may have different levels of environmental performance, yet both would be in conformance with the standard. The key ISO 9000 standards are currently being completely revised. For instance, new requirements will likely include a commitment to continual improvement (currently in ISO 14000 but not in ISO 9000) and arrangements for communication with customers. The revised ISO 9000 should be available by the end of 2000.

In many cases, QMS and EMS are incorporated into a single system. Companies with certified QMS/EMS may use the respective label in marketing (advertisement, letterheads, etc.). However, these are not eco-labels and cannot be attached to the final product. Certification of QMS/EMS ensures that the system is working and continues to conform to the standard. Deficiencies can be identified, thereby ensuring that the necessary corrective and preventive measures are taken. These systems provide independent verification and recognition, and reinforce the environmental commitment of an organization in the eyes of customers, employees, and the public. The initial cost of setting up QMS and EMS can be relatively high because the process requires much time and effort. Procedures must be written down and personnel trained. Certification with external initial and surveillance auditing may prove relatively expensive, especially for small companies. Depending on the market situation, this can often be an unavoidable investment for the future, however.

The European Eco-Management and Audit Scheme (EMAS) was introduced by the Council of the European Union (EU), and has been implemented on a voluntary basis in EU-member states since 1995. Because it is an EU Regulation, it has the status of law for countries within the EU. In addition to ISO 14000 requirements, the participating organizations are required to prepare an annual *environmental statement* and have it validated by accredited, independent environmental verifiers. The environmental statement must be registered nationally and made available to the public. Furthermore, the EMAS contains requirements for identifying ”environmental impacts”, which can be more complicated than the ”environmental aspects” found in the ISO 14000.

When compiling the environmental statement, the organization should consider the information needs of the public and other interested parties. The report should include a description of the organization, its environmental policy, the significant environmental impacts, related environmental objectives and targets, and a summary of its environmental performance. The verifier checks the compliance of the organization’s EMS with the respective EU Regulation, and the reliability of the information in the environmental statement and other related documents.

EMAS is currently available for industrial enterprises only. An amendment to the regulation is under preparation, and will enable all organizations to participate, with the aim of improving the efficiency of their environmental operations.

QMS and EMS in Wood Procurement

Because most of the major forest industry companies already have certified QMS and EMS for their industrial operations, the pressure is increasing for the certification of wood procurement as well as forest management.

In Finland, the major wood-procurement companies — Stora Enso Metsä, UPM-Kymmene Forest, and Metsäliitto — have developed QMS and EMS (ISO 9000/14000) for their operations. Metsäliitto was certified in June 1997, Stora Enso Metsä in June 1998, and UPM-Kymmene Forest in September 1998. The Finnish Forest and Park Service received their ISO 14000 certificate in April 1998. FFPS also has a QMS, but has not yet applied for certification. Stora Enso Metsä and UPM-Kymmene Forest have also participated in EMAS since 1999, and have prepared environmental statements (e.g., Stora Enso Metsä 1999).

All organizations emphasize that the task of developing the systems has been more difficult than was foreseen. The processes have included extensive training components, for both the systems themselves and the upgraded environmental and forestry legislation of the late 1990s. Training for staff, as well as for harvesting contractors and machine operators, has been done accordingly. The latter has been necessary because nearly all forest harvesting is carried out by private contractors who, typically, own one to three pieces of harvesting machinery each.

QMS and EMS have been developed mostly because of their high potential as marketing and management tools, as well as being tools for improving operations. Other important benefits include:

- staff motivation
- increased profitability
- external recognition
- increased competitiveness
- building up company spirit after mergers
- staff development

QMS and EMS typically are available in electronic formats (Lotus Notes or equivalent), which improves their availability and makes upgrading more efficient. Future developments may include an upgrade of the revised ISO 9000, and improved user-friendliness in the systems. Occupational Health and Safety Management Systems, as outlined in the British standard BS 8800, also are likely to be incorporated.

The new environmental and forestry legislation, management guidelines, and the criteria applied in the national certification scheme for forest management are incorporated in the QMS/EMS. The key areas to be monitored and documented include:

- log dimensions and quality
- thinning quality (spacing, damage)
- worker safety
- biodiversity in production forests (key biotopes, key tree species, decaying and burnt wood, trees left standing)
- protection of soil and water (protective zones, erosion control, avoidance of rutting and soil compaction, guidelines for operations in groundwater areas)
- landscape architecture
- forest health (level of pollutants, defoliation, damage, nutrient balance)
- protection of pre-historical and other cultural sites
- recreational infrastructure
- integrated management plans
- other environmental aspects (energy efficiency, emissions into the air, noise, amount and treatment of waste)

Much attention is paid to securing communication channels between purchasing agents, harvesters, contractors, and operators. Contractors and operators require detailed instructions with site maps and all machines must be equipped with cellular phones. In addition, because of full-scale training, the level of environmental and quality consciousness as well as emergency preparedness among supervisors and contractors has increased.

Communication with public authorities and other stakeholders is an essential part of the current ISO 14000 and the upcoming revised version of ISO 9000. The companies have implemented procedures for receiving and documenting information provided by stakeholders and for responding to their requests. This facilitates a dialogue with the stakeholders and helps the organizations improve their policies.

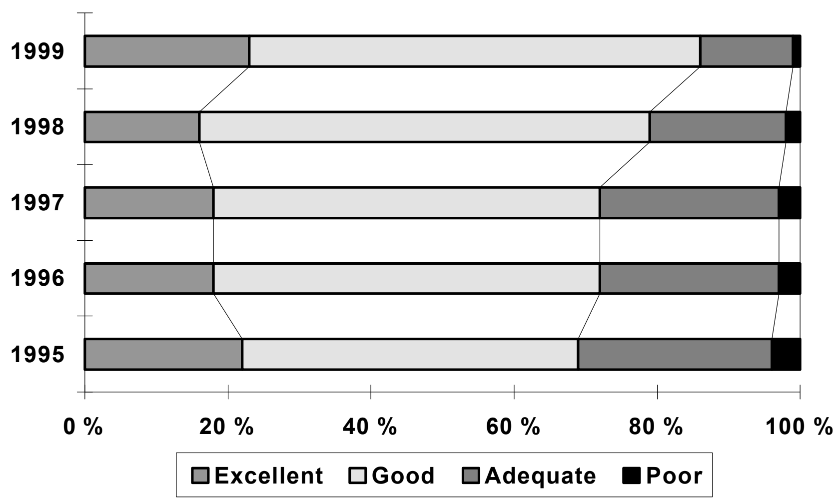
The Forestry Development Centre, Tapio, has been monitoring nature-care aspects in forest harvesting operations since 1995. The areas of interest are management of key biotopes, ”biodiverse” trees that are not cut during regeneration felling, and protection of water during harvesting and site preparation. In 1999, the Centre investigated 1729 harvested stands, which represented 2% of the regeneration felling and 0.4% of the thinned stands. The overall results show a clear improvement in nature-care aspects (Fig, 2). In 1999, 91% of the valuable biotopes were entirely or almost entirely preserved, compared with 73% in 1995. The share of stands with an excellent or good rating for biodiversity trees left standing also increased during that period, from 66 to 81%. Protection of water bodies was excellent or good in 92% of the cases in 1999 vs. 83% in 1995.

These improvements are the net effect of updated forestry-related legislation and guidelines, on-going inventory of valuable biotopes, the forest certification process, and the development of QMS/EMS for wood procurement. However, no matter how well staff and contractors are trained, non-conformances do occur occasionally. Nevertheless, the EMS/QMS contain procedures for managing these non-conformances and learning from them.

QMS and EMS in Forest-Harvesting Contracts

QMS and EMS are also gaining popularity among harvesting contractors. The Trade Association of Finnish Forestry and Earth Constructing Contractors has been very active in assisting contractors in its QMS/EMS development work. This activity began in earth construction during 1993 and spread into forest harvesting one year later. Currently, over 300 of the 1200 forest-harvesting members of the association have or are developing an integrated QMS/EMS for their companies. A 20-page model system has been developed by the association. In addition, six-day training courses are provided and individual consultations are arranged. These training programs have received some funding from the European Union.

Figure 2. Overall rating for nature care in forest harvesting operations.



The model EMS and QMS consist of the following components:

- quality policy
- flow of internal and external information
- responsibilities of the contractor and the operators
- staff training and competence
- equipment maintenance and repair
- work quality-assessment procedures
- working instructions for harvester and forwarder
- environmental aspects and waste disposal
- occupational safety
- list of supplemental guidelines
- contract review
- data collection
  - scaling certificates
  - calibration sheets
  - stand-specific instructions from client (notes and verification by operator, significant changes verified by client representative)
  - worker time card
  - feedback from operators, clients, and forest owners
  - training records
- special communication requirements when working in dangerous conditions (on-site repairs, operation close to power lines, etc.)
- feedback to clients

Among the Finnish forest industry companies, Stora Enso Metsä has been the most active in promoting QMS/EMS for forest-harvesting contractors. More than half of their Finnish contractors already have or are building QMS/EMS for their companies. Because the systems are a prerequisite for contract renewal, all contractors should have their systems ready within a few years. The Finnish Forest and Park Service also requires its contractors to build respective systems. The other two major players in wood procurement, UPM-Kymmene Forest and Metsäliitto, also strongly support QMS/EMS for contractors, but do not currently require their contractors to have such systems. By 2010, 80% of the forest-harvesting contractors will have established QMS/EMS for their companies.

Of the 1000 log truck contractors in Finland, 700 are members of the Association of Forest Industry Road Carriers, one of the branch organizations of the Finnish Trucking Association. These contractors handle nearly all roundwood transport by road. Some 200 log truck contractors have QMS for their companies. As with their forest harvesting systems, Stora Enso Metsä requires all truck contractors to have QMS within a certain time frame, while the other companies are recommending and supporting that such systems be built.

In the terminology of the Finnish Trucking Association, the EMS Level 2 is equivalent to the ISO 14000. Few such systems now exist in the roundwood transport sector. Level 1 requires a half-day course on economical driving and another half-day course on general environmental issues. In addition, the companies must complete and submit annual contractor's Environmental Workbooks, individually summarizing the major environmental issues in trucking. So far, a couple dozen companies in the roundwood transport sector have received the Level 1 certificate from the Association, after having completed the requirements. The Association is also developing a model system that incorporates quality, environmental, and safety issues for trucking contractors.

Because the contracting companies for both forest harvesting and trucking are usually small, the independent certification of their systems may not be economically feasible for them. Instead, second-party auditing by representatives of forest industry companies is applied. The contractors are assessed for their conformance with requirements; those who pass receive quality certificates.

Conclusions

The Finnish economy is highly dependent on forestry and forest industries. Finland has been active in promoting sustainable forest management both nationally and internationally.

A growing interest in the market, especially in Europe, has been a driving force in establishing a national certification scheme for the management and use of forests. The scheme, FFCS, will be linked to the Pan-European Forest Certification Scheme (PEFC) and, possibly, to other international certification and labelling schemes for product labelling.

Finnish forest industries have been active in developing QMS/EMS, not only for themselves, but also for wood procurement. Despite the high workload, the companies consider QMS and EMS valuable tools in improving management practices. Furthermore, QMS/EMS improves stakeholder relations through dialogue and increased availability of relevant environmental and quality-related information. For certified systems, an independent third party verifies this information along with the functioning of the entire system. This may also include systematic analysis of stakeholder expectations.

Some forest industry companies also require their contractors to develop QMS and EMS. Even where this is not the case, interest in developing management systems is increasing among forest-harvesting contractors.

The main purpose of QMS/EMS is to help companies improve their own practices. However, the existence of such systems, especially certified ones, also generally improves the public image of the company and is definitively regarded as an asset in marketing and other business relations. Practically all nationally important issues related to ecological, social, and cultural aspects have been included or referred to in the QMS/EMS of the forest industry. Dialogue with stakeholders continues to introduce new issues for consideration in the continual improvement of company policy. Environmental and other issues must be considered at all levels of the organizations; these usually involve a major training component. Thus, the QMS and EMS play major roles in bringing theory and ideas of sustainable forest management into practice at the local level.

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Forestry Work and Its Impact on Human Factors: The Perspective from Developing Countries

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Abstract

Throughout the world, approximately 1 to 2% of the tropical forests (about 1.700 million ha) are cleared each year for wood and non-wood products, and to give way to agricultural activities, infrastructure, and settlements. The increasing number of forest users and pressure groups on this environment has forced timber-harvesting companies in several countries to adopt harvesting systems that attempt to guarantee sustainability. Forests and forest product industries provide employment to the local population and habitats for various animal and plant species, but only a small proportion of the forests are under proper management. Many factors contribute to the lack of economically, environmentally, and socially acceptable harvesting systems, including the unavailability of trained manpower, an absence of laws and regulations governing forest operations, and a lack of capital for undertaking proper forest operations. Mechanization has reduced the use of manual labour in developed countries, but most of the forest operations in developing countries depend on human power. Because much of that labour is untrained, the result is usually low productivity, rapid turnover rates for employees, and high accident rates among forest workers. Likewise, the inherent differences in body size and physical working environment means that some tools and machines designed for forest workers in developed countries do not properly fit workers in developing countries. This may cause both physical and mental stress, accidents, and injuries. Therefore, data must be gathered on anthropometric parameters, as well as on workplace conditions and workers' physical capacity in these developing countries. Appropriate employee training also should precede the transfer of technology, and must accommodate the existing infrastructure and socio-economic conditions of a particular area. As the forest industry becomes globalized, developing countries are faced with challenges in training forest workers in how best to operate and maintain equipment, and in providing them with protective gear to reduce accident risks and injuries. Rural living and working conditions also must be improved in order to attract and retain a young and educated labor force. This paper presents an analysis of forest working conditions and harvesting problems in developing countries, and the ergonomic and technological interventions required for improving productivity. These measures may also ensure that forests meet the needs of the present without compromising the ability of future generations to continue fulfilling these objectives.

Keywords: Appropriate logging technology, Ergonomic intervention; Manual versus mechanized logging methods, Logging in tropics, Tropical forest workers

Introduction

Tropical forests cover about 1.7 billion ha, mostly in developing countries. Despite global efforts to conserve these forests, approximately 1.5 to 2 million ha (about 1 to 2%) of the total forests are cleared annually to provide for agricultural land, infrastructure, and urbanization (Heinrich 1994, EU 1997). About 3.4 billion m^3 of roundwood are removed from these forests each year for industrial uses as well as for fuel wood (Heinrich 1997). Because of this alarming shrinkage in forestland and increasing pressures from society or the community in general, many logging companies lately have found it necessary to change their practices so that harvesting is carried out in a manner that guarantees sustainability of the forest resource base.

In the past, forests were mainly associated with timber harvesting but, today, a multitude of non-wood products also beneficial to the local population are harvested. These other products include plants for ornamental and medicinal use, honey, resins, tannin, fruits, mushrooms, and wildlife (Dykstra and Heinrich 1994). Currently, a number of countries from the developing world earn a significant amount of foreign currency from the export of non-timber products. For example, of the US $5.4 million derived from the export of forest products by Tanzania in 1998/99, timber and timber products accounted for only 50% of that total. The balance came from the export of honey and beeswax (23%), or tree seeds and carvings (27%; GoT 1999). In other countries, e.g., Indonesia, non-wood products account for 10% of the total exports from their forests (Dykstra and Heinrich 1994). Forest harvesting clearly is no longer synonymous with logging. These additional activities result in a variety of forest outputs beneficial to the local population in terms of service, employment, and income generated.

Because of their complexity and diversity, tropical forests require well-planned and controlled forest operations to make full use of the potential timber and non-timber products. To achieve this, trained manpower must be in place to take responsibility for pre-harvest planning, execution of operations, and monitoring and evaluating of post-harvest operations (Heinrich 1994). With such trained manpower, productivity may be increased without compromising the regeneration capacity of the forest. Unfortunately, many developing countries lack or have inadequate, trained manpower for adopting new logging technologies and optimizing both timber and non-timber production.

This paper analyzes the current forest working conditions and harvesting problems in developing countries. Here we determine the ergonomic and technological interventions required for improving productivity and ensuring that forests meet the needs of the present as well as future generations.

Forest Operations in Developing Countries

Forests and Forest Workers

Forests and forest products in many developing countries contribute about 2 to 4% of the national GDP, in addition to providing jobs for a good portion of the population (ILO 1981, Fenner 1996, Abeli and Nsolomo 1998, Fue *et al*. 1999). In some countries, such as Malaysia, forest products account for 15% of the total exports, while that sector employs up to 12.5% of the total labour force (Dykstra and Heinrich 1994). Despite their contributions to the socio-economic development in these countries, the majority of these forests are ill-equipped in terms of personnel, equipment, and funds (FAO 1993). Only a small fraction of these forests could be considered properly managed; many of them are managed only to facilitate the collection of revenues from timber products, wildlife- or game-viewing, and non-wood products.

Studies of tropical forests show that only a few tree species are logged intensively because of restrictive market demands and a poor knowledge of the physical and mechanical wood properties of the many other available tree species (EU 1997). Intensive exploitation of these few, valuable tree species has led to reduced seed production and regeneration capacity of the productive forests. Because only a small volume of timber per unit area is harvested, logging in such forests is also relatively more expensive.

Population increases have created more demand for agricultural land, housing, and domestic fuel wood (EU 1997). With population growth of about 2.8 to 3%, more people are finding refuge in the forests in order to earn a living or look for basic necessities, legally or illegally. This has been the main cause of deforestation or forest degradation, especially near settlements or towns (Abeli and Nsolomo 1998).

Although improper logging, especially in steep areas, may cause land degradation, logging *per se* does not cause deforestation (Dykstra and Heinrich 1994). By using appropriate logging and forest-management practices, only a few, selected tree species are harvested or thinned while the majority of the trees remain for future use. To encourage sustainable forest management, more efforts are being directed toward training of forest workers and users, stronger legal and institutional frameworks, and the involvement of the nearby population (EU 1997).

Although every forest manager aims to adopt economically, environmentally, and socially acceptable harvesting operations, attaining this goal can be limited by such factors as forest type, physical workplace conditions, accessibility, requirements of industry or market, availability of trained manpower, proper tools and equipment, laws and regulations governing forest operations, and available financial resources. In most developing countries, financial resources to invest in forest operations are limited while a trained and skilled work force also is scarce. Worse still, laws and regulations to promote sustainable use of forests are not in place or, if formulated, are not adequately enforced.

Forestry Work

Compared with other occupations, forestry work is strenuous, dangerous, and energy-demanding, especially where performed manually (Abeli 1979, Ayaz 1986). Unlike other occupations, this work is normally performed under conditions where mankind has little influence or control over the terrain and ground- or weather conditions. Therefore, productivity is low, the physical workload or stress high, and the rate of labour turnover relatively high (Lipo-glavsek 1998, Fue *et al.* 1999). Creating a safe and good working environment is a way to improve workers' morale and reduce labor turnover.

Most of the forest operations in developing countries utilize manual and semi-mechanized methods, which demand high expenditures of energy (Ole Meiludie *et al*. 1988). The crew usually works under hot and humid weather conditions, and travels long distances to their workplaces. This long-distance travel causes stress, reduces the effective working time, and may cause accidents. At some sites, forest laborers work in isolation, with no appropriate safety gear and inadequate contingency plans. These factors, combined with poor supervision, contribute to low productivity and high accident rates in the forests (Abeli 1979, Fenner 1996).

Studies of forest operations in developing countries have revealed that some forest hand tools, equipment, and machines are not designed appropriately to fit the workers and the working environment. Ergonomic studies, including anthropometric surveys, have not been done so that manufacturers can produce optimally designed tools and equipment. For example, differences in body dimensions, weight, and weather conditions have presumably resulted in some forestry tools and equipment causing stress, injuries, and accidents in Chile, India, Sudan, and Brazil (ILO 1982, Apud 1989). It is possible, however, that employee training, work organization, and tool maintenance could also have contributed to stress and accidents in these cases.

Technology Transfer

Physical, social, and mental differences are fundamental between the populations of the developed and the developing countries (Shahnavaz 1992). Technology designed for the former is not necessarily ideal for the latter population. Where this technology has been transferred without adjustments or modifications to fit the local conditions, stress, injuries, and poor quality of work have sometimes been the result. When technology is to be transferred from the developed world to developing countries, Shahnavaz (1992) proposes that the following ergonomic principles be observed or considered:

> Anthropometry: Because body sizes and dimensions differ, some of the imported logging tools and equipment designed for the developed world might not fit the users in developing countries, without modifications.
>
> Physical working capacity: The capacity of the human body to perform prolonged physical work is related to individual health, age, weight, sex, level of nutrition, as well as the working environment. These factors must be considered when designing tools and equipment for use in developing countries.
>
> Workplace conditions: High temperatures and humidity, and poor ventilation make tractor cabins (meant for winter logging) uncomfortable for tropical work. Likewise, discomfort can prompt workers to hardly wear or put on protective gear. Because human comfort depends on relative humidity, temperature, and wind velocity,

these factors must be considered when planning and designing optimal workplaces and organization in the tropics.

Mechanization in forestry is meant to render the work less labourious, minimize energy requirements, increase worker output, and reduce drudgery. However, inappropriately used mechanization has increased mental workload and has caused accidents and injuries to workers (ILO 1982). Accidents have been caused mostly because of a lack of experienced and skilled workers for using these machines and a disregard for the basic principles of work physiology. Again, accidents also occur because logging machines and hand tools are not being appropriately designed to fit the local conditions or population. Despite these few negative instances, however, overall mechanization has eliminated much of the physical effort and minimized wood waste. It is now possible to undertake tasks that once were difficult, uneconomical, and almost unthinkable.

The science of ergonomics has been used in the design and introduction of appropriate new technologies to workplaces, thereby ensuring efficient use of the labour force. This science has also been used in designing jobs that fit and give satisfaction to workers, besides being a tool for evaluating the choice of technology to be adopted in new areas (Shahnavaz 1992). In transferring this technology, ergonomic factors such as working techniques, physical workload, energy requirements, occupational safety, health, and working conditions must be taken into account at the planning and design stages (Apud 1989, Shahnavaz 1992, Dykstra and Heinrich 1994).

Technology transfer is the utilization of a technique in a place or situation where it was not previously found. After its introduction, the technology is either accepted and used as it is, or modified to suit local conditions. The new technology may again be transferred to a different physical environment, to be used by workers who vary either in their physical dimensions and capacities or in their attitudes toward their jobs because of their socio-economic background. Thus, appropriate studies and training must precede the transfer of technology and should, as far as possible, fit into the infrastructure, physical working environment, and social economic conditions of the recipient country. The aim of technology should always be to improve the standard of living of the recipient population and provide good working conditions, while offering possibilities for future improvement.

Accidents and Their Impact in Forestry

The number of accidents in developing countries is higher than in developed countries, although the degree of severity is much less (Mbowe 1995). Fortunately, where technology transfer has been adopted correctly, productivity has improved and occupational accidents, injuries, and diseases have been greatly reduced. In contrast, where workers have not been trained on the proper use and adoption of new technologies, the result has been high rates of absenteeism and sick leave among forest workers due to accidents and injuries. For example, a study of logging in Brazil showed that the number of accidents per month was 49, while the risk of incidence for forest workers was 42% (Fenner 1996). This study also revealed that the average number of days lost per accident was 18.

In a study of a logging crew of 160 in Tanzania, about 33% of the workers had experienced accidents varying from minor (65%) to severe (35%; Mbowe 1995). Accidents were classified as severe if a worker was kept out of work for at least one day; here, the number of days lost per accident averaged 3.7.

In Nigeria, where 802 ha of plantation forest were established between 1990 and 1994, accidents and ailments caused a financial loss of $17,400, in 435 cases reported over the five-year period. Losses incurred from accidents accounted for about 7 to 9% of the total budget, while the average number of days lost per accident was four.

Despite there being some published reports of accidents in forest operations, accident records are not very reliable. For example, a study in Tanzania showed that between 1980 and 1990, only 34 accidents were reported at SUA Training Forest (Fue *et al.* 1996). These accidents were estimated to have cost only $240, while the number of lost days due to accidents for the entire 10-year period was apparently only 173. The recommendations in this study were to 1) educate forest workers on the importance of reporting accidents whenever they occur, and 2) train the managers to keep proper records of accidents and the actual cost of treating and compensating accident victims.

Challenges for the Future

In many developing countries, a number of challenges face the logging industry and the forest sector in general. While there seems to be very little internal pressure in these countries to adopt sustainable forest-management systems, globally the pressure is mounting and intensifying. For instance, the introduction of Timber Certification will force developing countries to follow or adopt internationally accepted forest-harvesting practices if they are to sell their forest products on the world market. On the other hand, in order for these countries to adopt environmentally sound and sustainable harvest practices, they must learn from and share experiences with managers in other countries.

Improvement of Working/Living Conditions

Where forests have been or are being converted to other uses, a significant portion of the nearby population that once depended on these lands loses a source of employment. As a result, some inhabitants resort to subsistence agriculture while the young people migrate to urban areas to look for other and better opportunities. In developing countries, the labour force engaged in forest operations is old and unskilled because the younger and better-educated ones tend to move to big towns and cities. To stop this migration, deliberate efforts are needed for improving the living conditions in the rural areas. For example, forest workers must be offered good incentives and attractive wages. Currently, even though forestry work is difficult and hazardous, it is a lowly paid job.

In addition to improving the working and living conditions of forest workers in rural areas, logging companies must ensure that forest workers are provided with the right tools, protective gear, shelter, and training on safe working methods. Companies must also provide social services like schools, health services, a good water supply, and reliable communications within or near working areas (Strehlke 1987). When these are lacking, logging companies must work closely with the local communities to make these services available because productivity depends on the workers' health and living conditions.

When forest workers live at their job sites or in nearby villages, the workers and their family members should be encouraged to cultivate small farms or gardens to supplement incomes from forestry activities. Cultivation of food crops will not only subsidize incomes but will also improve the nutritional status of the workers, thereby increasing their physical working capacity and leading to a higher work output (Strehlke 1987). However, where cultivation is not possible, employers need to provide food and other items to workers at subsidized cost.

Because heat stress hinders higher productivity in the tropics, a sufficient supply of drinking water, with adequate replacement of electrolytes, is essential. Heat stress can also be reduced by wearing loose-fitting clothes and broad hats, and by implementing adequate rest periods and job rotation at workplaces to avoid working continuously at one point or directly under the sun (Chandra 1987, Strehlke 1987).

Training

Both supervisors and forest workers must undergo in-service training to increase job satisfaction and self-confidence. Employers have to realize that a trained and stable work force is more efficient and more productive than untrained and temporary laborers. Although the use of untrained workers appears to be economical, these employees are expensive in the long run when they cause accidents, equipment damage, and unnecessary wood waste (Ayaz 1986, Fue et al. 1999). Trained supervisors will also assign tasks that are fair and reasonable, and will serve as a good link between workers and management.

Training programs for forest workers should be very thorough and well-planned to convey the knowledge that is essential to the tasks being assigned. Specifically, training must be concentrated on safe operation and maintenance of logging equipment, improvement of workplace conditions, development and promotion of local tools and auxiliaries, as well as on safety and hygiene matters. Such topics could be offered as part of 'on-the-job training' or organized into short courses at vocational training centers.

Technology Intervention

Lack of technological know-how in many developing countries has hindered the process of innovation. This has resulted in these countries being perpetual importers of technologies from the developed countries. Because of a lack of trained personnel, these "acquiring" countries also have had little opportunity to develop technologies that best fit their workers and the working environment. Importation of working tools to these countries will continue, so it is important that, when introducing new technologies, the following should be observed or considered:

- Investigations of occupational safety, health, and working conditions of the forest workers
- Consultations with recipient countries during the planning and design stages for tools
- Proper selection of equipment to match the required level of technology in the recipient countries.

Shahnavaz (1992) defined an appropriate technology as a technology in line with the prevailing conditions of a particular population and the environment in which it is used. Because countries differ in culture, race, political systems, and socio-economic well-being, it is difficult to have a technology that is appropriate for all. The lack of a uniform prescription or single system that is relevant or appropriate for all countries simultaneously means that each country must define and develop a technology appropriate to the needs and in line with the resources available. For instance, work, equipment, and tools have to be designed and adapted to the anthropometrics of workers to provide comfort and protection against stress and accidents.

Although the main objective of technology transfer is to improve the economic situation and the general standard of living for the working population, this technology has to be transferred appropriately. Historically, technology has sometimes been inappropriately transferred in one of three ways: 1) Incomplete transfer - not all aspects of technology transferred, with some omitted or neglected; 2) Imperfect transfer - end-users not considered (e.g., operating manuals not in local language); or 3) Inadequate transfer - environmental working conditions not considered.

No matter how efficient the new technology was at its origin, before it can be transferred, the existing technology in the recipient country must be thoroughly studied. Where possible, the new technology must be modified to fit existing conditions or the existing technology will have to be improved to match the new technology (Heinrich 1994). It is also important to identify the right technology to fit the local population or working environment, as well as seeking the best method or approach for transfer to the end users. For example, in the case of new machines, basic principles and instructions on how to operate and maintain them should be available in local languages to achieve optimal output.

Labour- Versus Capital-Intensive Methods

Although the notion exists that developing countries have an abundance of labour, in the real-field situation, a skilled, reliable, and permanent labour force that is wholly devoted to forestry is in short supply. Most of those engaged in forestry operations are farmers or villagers living near the forests. Forestry jobs are usually taken as a supplemental activity during the agricultural off-season. Therefore, it is difficult for forest enterprises to invest (in terms of training) in such seasonal, part-time workers. When logging takes place far from the villages, problems arise in recruiting enough forest workers and transporting them to the work sites. To solve the problem of daily transport, these workers are sometimes forced to stay in logging camps with deplorable living conditions. If resources were sufficient, the use of capital-intensive methods would definitely reduce the number of workers to be transported to and from the forest every day.

Most of the research studies done in the developed world have aimed at making logging and forestry technology more labour-saving or with less demand for labour because of the high cost. However, in developing countries where labour is still cheap, the objective in research studies is to improve the existing labor-intensive methods by introducing efficient tools and energy-saving techniques. Because labour-intensive methods also create employment for the rural population, this method has always received government support. When deciding which logging method to adopt or recommend in a given area, a number of factors are considered, including the availability of labour and capital, and the terrain conditions. Both the capital-intensive (mechanized) and the labour-intensive logging methods have advantages and disadvantages (Table 1).

While labour-intensive logging methods seem to be more accepted in developing countries, some logging companies still prefer to work with a small labour force to avoid the overhead costs associated with accident compensation, subsidies on transport, housing, annual leave, and legal conflicts. In some areas, labour-intensive methods have occasionally met with some resistance from forest workers, especially those already used to capital-intensive methods. Such workers normally view manual methods as outdated technology with low status in the society. To avoid employee conflicts if labour-intensive methods are to be introduced in such areas, it is better to recruit new working crews rather than forcing already trained and experienced machine operators to change to manual methods (ILO 1981).

Personal-Protection Equipment

Human beings at work are liable to make mistakes that sometimes lead to accidents or injury to themselves and others workers, or damage to tools or equipment (Zander 1979, Pettersson 1983). These human errors can be reduced if the tools and machines are matched to the working conditions and, above all, to the capabilities and limitations of individual workers

Unlike other branches of industry, the nature of the logging industry makes it impossible to create a working environment that is completely free from accidents or hazards. Therefore, besides matching tools to environment, other additional measures have to be taken or introduced at workplaces to minimize or reduce accident risks. These include:

- Provision of personal protective clothing and equipment
- Use of properly designed and maintained equipment or tools
- Training of forest workers on proper operation and handling of logging tools and machines
- Improving workplace and living conditions of forest workers
- Increasing awareness of the importance of safety measures to both workers and supervisors

Experience has shown that most logging companies will not improve the working environment for its workers if the workers are willing to work in such an environment. To protect these employees, labour laws, regulations, and safety rules must be formulated and enacted for all forest operations to ensure that forest workers are protected and compensated by employers in case of accidents. These regulations should require that employers provide protective gear to their crews, that crews wear the protective gear during work, and that accidents be reported and analyzed by the relevant bodies.

Table 1. Advantages and disadvantages of mechanized and labour intensive methods in developing countries.

Method	Advantages	Disadvantages
Mechanized method	Demands less human energy	Requires skilled and trained manpower
	Productivity per unit time is high	Although few, when accidents occur they are severe and sometimes cause or lead to death
	Low number of accidents per working session	Causes more environmental damage
	Inaccessible and difficult areas made accessible	Requires heavy investment and foreign currency to purchase equipment.
	Able to harvest big and heavy logs from difficult terrain	Creates unemployment, especially in rural areas
Labour-intensive method	Employs large number of people, especially in rural areas	Not economical in large-scale operations
	Uses locally available resources such as manpower	Results in high physical work loads or high energy consumption
	Doesn't require foreign currency to purchase and run logging equipment	Improperly designed tools cause stress and sometimes accidents or injuries
	Causes minimum soil and tree damage	Doesn't attract young and trained labor force
	Requires no heavy investments on capital or training of workers	Cannot handle or harvest big and heavy logs from the forests

Conclusions

Most logging in developing countries is done manually by an untrained and unskilled labour force. Productivity is low, while the number of accidents and labour turnover is relatively high. Inadequate techniques, use of poorly maintained tools, high physical workloads, and overall poor working and living conditions are the main factors contributing to low productivity.

Body sizes and dimensions differ between workers in the developed world and those in the developing world. Therefore, tools and equipment should be studied to identify specific areas needing improvements or modifications. Modified tools would reduce not only stress or workloads, but also the number of accidents and injuries in these developing countries.

Collecting anthropometrical data is essential for facilitating the design of appropriate tools and machines. This should precede other initiatives aimed at improving working conditions. Other measures should include training of forest workers on correct working techniques, proper operation and maintenance of tools, implementation of safety measures on the job, and the importance of improving the working environment.

To improve productivity and reduce workloads for forest workers, research studies must also be conducted to 1) improve working methods as well as the health and nutritional status of forest workers, 2) plan optimal work organizations, and 3) encourage the use of appropriate protective gear.

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Sub-Plenary Session: B4 - Posters

Forest and Society Needs:

Evaluation of Technologies for Society Needs

Coordinators:

Hans Heinimann
Loren Kellogg

Fulfilling Societal Needs through Participatory Silviculture - An Evaluation

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Abstract

A revolutionary development in forest management took place in India in the late 1980s, when participation of local, forest-dependent communities was sought for the management and protection of State forests under the umbrella of the Joint Forest Management (JFM) program. This new approach has now been adopted by 21 of the 25 Indian States. Approximately 3.5 million ha of forestland have been regenerated by more than 35,000 forest protection groups in different parts of the country. This has been accomplished through indigenous and innovative methods and approaches. The Latest Report on the State of Indian Forests (in 1997) shows that, although the amount of new forest cover is small in regions where JFM has been implemented, there have been marked increases in biodiversity, biomass productivity, tree basal area, and other ecological parameters in these areas.

As the phenomenon of JFM has strongly taken root, managers have realized that classical silvicultural systems and operations are not adequately equipped to address the newly emerging needs and demands of the society. The JFM program considers the dependence of local, forest-dwelling communities as well as those living on the forest fringes. Thus, intermittent yields of locally valuable, multiple forest products become critical to the sustainability of this co-management concept. This also conforms to the emerging global consensus regarding the vital role of forests in facilitating the anti-poverty crusade, which is high on national agendas around the world.

Forest management is now recognized as being more than just protection. The local community should be involved in the manipulation of trees and other forest vegetation if total and effective co-management is to be achieved. Thus has evolved the practice of <u>Participatory Silviculture</u>, which is the new thrust area in the JFM-practicing States of India. The techniques and operations implemented under Participatory Silviculture incorporate local knowledge and use perceptions, temporal and spatial dimensions of local needs, and institutional setup. Additional factors include aspects of a wider socio-economic environment apart from forest types, the history of forest management, and other vegetation-related characters. Beginning with species selection and through to silvicultural operations, local needs and aspirations are considered supreme. These silvicultural methods, though simpler, are evolved jointly and continuously by the technically skilled foresters and the forest-dependent community. Local communities now conduct their own operations, such as lopping for fodder and fuelwood, rotational blocking for NTFP collection, multiple shoot (MS) cutting, stump dressing, pruning, etc.

This poster attempts to answer the following questions regarding the potential role of Participatory Silviculture in the sustainable management of community forests:

1) Are community forests being managed effectively to respond to the needs of the user groups?
2) What kind of silvicultural manipulations are being carried out by the forest user groups, and how do both scientific and local knowledge come into play in determining such practices?
3) Is there any need and/or scope for further strengthening and improvement of these silvicultural interventions to address both social and environmental needs?

The poster highlights and analyzes the results obtained from field studies in Central India (Harda Forest Division), Bihar (Singhbhum Forest Division), West Bengal (Bankura Forest Division), and Nepal (Kavre Forest District). Ecological factors have been re-examined that limit natural forest recovery on degraded areas under co-management. The studies also

evaluated various management options and the socio-economic and policy issues that influence silvicultural decisions for restoring and rehabilitating degraded natural forests.

Keywords : India, Societal needs, Participatory silviculture.

Transfer of Timber Harvesting Technology to Societies in Economic Transition – The Taiga Model Forest Project in Northwestern Russia

by

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Abstract

A dramatic economic transition in Russia has caused difficulties for Russian forest industries. Annual cuts have been drastically decreased, and numerous sawmills and pulp mills are experiencing hardships because of a shortage of raw material. At the same time, exports of roundwood make up the core of forestry income. Reliance on earlier timber-harvesting systems has been very difficult, because Russia's own machine production is also struggling in the transition. Therefore, redesigning the harvesting systems is proposed as a solution. Western machine manufacturers consider Russia a potentially strong market, but the lack of capital hinders transactions. In addition, unemployment is a serious problem among forest workers.

A Taiga Model Forest (TMF) project was launched to establish a model forest area for demonstration and experimental purposes. One objective of this project was to find profitable and cost-effective technological applications for forest operations in northwestern Russia. Technology transfer within the project itself was mainly an exchange of scientific knowledge among scientists. Nevertheless, one purpose of the project was to demonstrate Scandinavian timber harvesting and to compare it with local Russian methods in a large thinning experiment. Shortcomings of this approach included the Russian counterparts' lack of knowledge in the actual planning of forest operations, as well as the unstable situation in Russian society. Both of these situations have caused serious problems with the realization of the TMF project's goals. In this paper, the TMF project was analyzed in a Samli's framework of technology transfer. One aim was to examine international transfer of forest technology by observing an on-going case. The Samli's model used in this study was improved upon by attaching outside motives to the framework. These outside motives (from non-governmental environmental organizations) had been one of the driving forces when the TMF project was established.

Comparative studies based on unit-cost calculations indicate that, economically, an intermediate technology would be the most profitable method in this case. This is because of a low level of salary in relation to the price of advanced technology. An intermediate timber-harvesting technology would also be more profitable for the economics of northwestern Russia because of its positive influence on employment and its smaller demand for foreign currency when procuring harvesting equipment.

The best results from the TMF were obtained in the training and advising of forest workers, who quickly adopted the principles of the new methods. In the TMF, Scandinavian forest road-construction methods also were demonstrated in cooperation with Russian road-construction companies. The local machinery labor was suitable for forest-road construction when the Scandinavian methods were used.

Intermediate technology practices in timber harvesting seem to be the most promising way to help northwestern Russian forestry in this difficult situation. However, because the current need for forest worker education is so great, the transition to more cost-effective Scandinavian systems may be slow.

Keywords : Timber harvesting, Taiga model forest project, Northwestern Rusia.

Using the Delphi Method to Forecast Priorities in Forest – Engineering Technology

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Abstract

Forest engineering technology must be promoted as a pivotal component in sound management of Japan's forests. Using the Delphi method, we conducted a technology-forecast survey to gain a long-term perspective on the future of forest engineering. Survey results were consolidated through two questionnaires. We selected respondents who were experts with extensive knowledge of forest engineering: 20% from the forestry sector, 19% in machine manufacturing, 26% university-related, 29% in public research institutes, and 6% in other areas. For the first part of the survey, we sent questionnaires to 79 respondents, of whom 50 were then sent the second questionnaire. We excluded those who withdrew from the survey after the first questionnaire. The rate of response was 63% for the first part and 90% for the second.

The preliminary questionnaire was used to determine the forecast topics. We divided forest-engineering technology into four categories: machinery, operations, ergonomics, and roads. Within each category, the respondents were asked to state topics of concern that could be addressed, or ”realized”, in Japan by 2030. Predictions for the technological stage of fulfillment for each topic were made with one of three phrases: ‘in development’, ‘in practical use’, or ‘in widespread use’. The respondents proposed more than 100 topics. After all topics were prioritized according to importance and generality, 37 were selected for special consideration (14 in machinery, 13 in operations, 5 in ergonomics, and 5 in roads).

The respondents forecast the time for realization of half the topics by 2010, 90% by 2015. The earliest two topics forecasted (in 2007) were ”Widespread use of the instruction manual of forest operations for voluntary workers” and ”Widespread use of non-clear cutting operations using mobile tower yarders”. The topic ”Development of unmanned harvesting machines” was forecasted for realization after 2020.

Based on results from the second survey, an importance index was calculated for each topic; the overall average was 59.7. The topics with the three highest indexes (all >80) were related to environmentally aware technology: ”Widespread use of the evaluation and management methods of environmental conservation in forestry”, ”Widespread use of near-natural road construction methods”, and ”Widespread use of the accurate predicting methods of environmental impact through forest operations”. We also asked for ‘Effective measures the government should adopt for realization’ of each topic. Among the choices, ”Increase in government funding for research” was most frequent (average 50.5%). ”Personal exchange between the industrial, academic and government sectors” was chosen in 39.9% of the replies.

The forecasted realization time for each topic will be referred to during development of technology strategies in the forestry sector. Environmental concerns should be emphasized more in the future as R&D is promoted in the field of forest engineering technology. In particular, financial support for R&D and collaboration between industry, university, and government are expected to be considered when forest technology policies are proposed.

Keywords: Effective measures for realization; Forest-engineering technology forecast; Forecasted realization time; Importance index; The Delphi method.

A Practical Approach to Prioritizing Forestry Research Projects

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Abstract

Various approaches have been proposed for prioritizing forestry research programs. Evaluating the merits and demerits of each approach may provide a means for ranking individual programs. Unfortunately, all of the current methods are rooted in agricultural environments, with the primary focus only on prioritizing particular species in annual crops. In contrast, the man-made models that are designed for studying natural systems in forestry consider species to be but one of many components in the system. Therefore, a practical approach is needed, which is applicable to the unique requirements of forestry. Our proposed method comprises two phases: Phase I -- prioritization of forestry projects; and Phase II --prioritization of research programs. This approach reduces subjectivity by introducing objective questions whenever judgments must be made.

The process of Phase I begins by identifying the relevant issues in forest management, viz., Geographical Cover of forests; Conservation of Bio-diversity; Protection of forest resources from all kinds of destabilizing factors; Restoration of the degraded forests; Production of material goods; and Extension of forestry for practice by the public. These are the primary objectives in tropical forest management. Forests are categorized, based on both biotic and abiotic characteristics, by the amount of ground they cover. At this stage, judgments are made according to the relevance or importance of each objective in various forest categories. Grades are assigned as Absent, Poor, Low, High, and Highest.
The subjectivity inherent with making judgments can be reduced by using objective questions. The graded judgments carry scalar values of 0, 1, 3, 6, or 10. Direct or inverse weights are introduced that account for the extent to which a forest is impacted by each objective. The total scores earned by the various combinations of forests and objectives are ranked in descending order. Rankings are improved by introducing the level of impact that each objective has on Economic, Environmental, Political, and Sociological aspects. The final ranking, which includes the improved, combined scores, provides the priority for forestry projects.

Phase II commences with identifying the chief components involved in technological activities. These components are ranked according to their contributions toward fulfilling forestry objectives. The technological activities are assigned to one of five levels: 0, 1, 2, 3, or 4, with 'Level 0' referring to rudimentary or absent, meaningful technology; and 'Level 4' indicating the highest level of technology that is feasible for a particular component. Technological Levels are scored as 0, 10, 30, 60, or 100%, respectively.

The goal of all research programs is to progress from some lower level to higher technological levels. Each upgrade is a gain toward fulfillment of the objectives. The gains from technological upgrade are estimated for all the components of Prioritized Forestry Programs. This is followed by an estimate of the final score, which is the product of both the expected gains from the technological upgrade and the score of the Prioritized Forestry Programs that was estimated under Phase I. Using this method results in the identification of Prioritized Forestry Research Programs, with final scores listed in descending order.

Keywords: Forestry; Prioritizing; Research programs; Step-by-step procedures.

Impacts of Forest Harvesting Operations on Soil Properties

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Abstract

Forest operations in northeastern China include planning for harvest systems, logging, transport, road-network design and construction, slash disposal, and planting after harvesting. These activities are significantly correlated with soil disturbance, which can be measured in terms of the degree of break and compaction as well as the loss of soil nutrients. Four sub-projects were conducted to study the effects of forest operations on physical and chemical soil properties at the operation sites. The study variables included such factors as cutting system, skidding traffic, layout and construction of forest-road networks, and slash disposal. In general, the degree to which soil physical properties were affected was closely related to the level of energy input, i.e., how much timber was removed from the forest, during operations at the harvest site.

Three cutting systems were employed: selective cutting, thinning, and small-area clear-cutting. Of these, selective cutting has been the most commonly used system over the past 10 years, and will probably be the best harvesting method in the near future. However, soil physical properties were affected most significantly by this method, as measured by the degree of disturbance associated with the volume of timber removed per ha. This is because more movements and greater energy inputs were required for executing the operations on each tree. Clear-cutting and thinning were ranked second and third, respectively. In terms of disturbance per unit area, however, the clear-cutting system had the most significant impact on both physical and chemical properties of soil, accounting for approximately 15% of the variation. This was because of the more-concentrated operations involved with this system.

Timber was moved from the site by tracked crawler, wheeled skidder, cable-yarding, or animal skidding. During the winter, ground-skidding traffic did not significantly influence soil physical properties, even after six to eight passes by the machinery. However, the opposite was true when the ground was not frozen. The wheeled skidder then had a greater impact than did any other means of log transport. Field investigations showed good natural regeneration in the areas disturbed by crawlers, but not at the landings or in the main skidding-track ruts. Animal skidding was an environmentally sound technique, with moderate operating costs. Because no soil damage is inflicted during winter operations and only slight amounts during the other seasons, the use of animals has increased to about 90% of all the skidding done in the last 5 years.

Three slash-disposal methods -- burning, piling, and spreading -- have been employed during the last 10 years of harvesting. Although the burning method has impacted the soil more because of nutrient losses, it has been beneficial in improving soil acidification. The other two slash methods have had moderate influences.

A well-planned forest-road network can reduce soil erosion. To lessen the impact of forest-road construction on soil properties, we are presenting a new mathematical model for optimal layout of forest roads. Both economical and ecological benefits are considered in this plan.

Keywords: Forest operations; Impacts on soil properties; Regeneration quality.

The Historical Development of Forest Operations in China and a Look Ahead 10 Years

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Abstract

The history of forest operations in China since ancient times (more than 2000 years ago) has included developments in operation technology, equipment, organization, and professional education. We used the Entropy Growing Analysis method for studying the dynamics of these developments, particularly with regard to the interaction between human society and forest ecosystems in a given region. In China, the deforestation rate is highly correlated with an increasing population rate i.e., each era of great population explosion has resulted in large-scale deforestation.

Forestry activities have changed greatly in the last century because of the fast development of science and new technology, unbelievable population growth, and rapidly changing social structures and market systems. In the first half of the 20th century, large forests were destroyed during continuous wars, mad land-grabbing by invaders, and unanticipated establishment of farms by immigrants. The main goal of forest operations during that period was to extract as much timber and farmland from the forest as possible. Machinery, such as a forest railway transportation system powered by steam engines, significantly improved operational efficiency. Unfortunately, this new trend toward mechanization increased the capacity for human interference in the forest. However, the rest of the work was done manually, and contracted teams were a popular means for organizing forest operations.

Since 1949, and particularly in the past 20 years, forest operations in China have been greatly modified. Not only have the science and technology of forest operations been developed significantly; the environmental aspects, profitability, and economic efficiency have also been emphasized. Forests are now recognized as important suppliers of non-wood forest products such as water and soil protection, climate adjustment, and an assortment of flora and wildlife. These factors are considered when decisions are made about harvesting, timber extraction, and civil engineering in forests. In integrated forestry, planning is done from the viewpoint of sustainability for both timber and non-timber forest products. All activities, e.g., forest resource surveying and harvesting planning, road planning and construction, harvesting, post-harvest site disposal, and planting and protection must now serve these key purposes. As well, forest-operations technology and techniques have been converted from manual- to machine-driven, and are now part of an environmentally sound complex. Planning and organization has been changed from that of small, manual working groups to large-machinery operations. The working system now involves many contracted groups at different levels.

"The Natural Forest Conservation Project", begun in 1998, identified the challenges and opportunities in Chinese forest operations. The market for small- and mid-sized machines, with multi-functions, will be the most dominant in the near future, depending on the forest resources available in China. Environmentally sound, low-cost, and highly efficient forestry technology and techniques will be in the spotlight of both research and practice in the next 10 years. Forest operations will also play quite an important role in the management of sustainable forestry.

Keywords: Forest operations in China; Historical development; 21st century; 10-year look ahead.

Sub-Plenary Session: C1

Changes in Environment and Society:

Environment Change and Forests

Coordinators:

Bryce Stokes
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Carbon Sequestration In The Global Forest Sector

by

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Abstract

In this paper we describe why carbon is an issue in forestry: forests and forestry have an important role in the global *and regional* carbon cycle and therefore provides connection to the global climate and climate change. The role of forests in carbon cycle has been emphasised in the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and more recently in conferences of the parties to the UNFCCC in Kyoto and Buenos Aires.

The first part of this paper deals with commercial forestry: what are the specifics of intensive versus extensive forestry in relation to carbon sequestration. This includes comparisons between natural forests and plantations, previous land-use, forest management (available mechanisms for optimising production and C storage), and to what extent management for maximum C competes with / complements other management objectives (for example timber supply, biodiversity, aesthetic). The contribution of forest products as a temporary reservoir, but with human control, in the carbon cycle is also included. Finally, the role of wood in products that avoid energy emission in their manufacture and as a source of energy to replace fossil fuels is addressed.

The second part deals with these issues at the regional/biome level - in boreal, temperate and tropical forests – examining differences in carbon stocks and fluxes, as well as differences in timescales. This section consider the unique properties in each biome, i.e. forest fires in boreal regions, intensive forest management in temperate forests, land use change in tropical regions. Several case examples are described, including a discussion of the relative role of wood products/bioenergy and the future role for forest sector carbon offsets.

As a conclusion, potential environmental and economic changes with environment and new values associated with carbon are discussed. Past changes, present fluxes and future possibilities (risk and opportunities), scientific challenges, gaps in data and understanding, as well as recommendations for research and development are highlighted.

Keywords: Global forest , Carbon sequestration

The Combined Challenge of Forestry and Terrestrial Carbon Management

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Abstract

Forests are a critical element in the global carbon cycle. While forests are currently a small net carbon sink worldwide, there is the risk that this trend will change, significantly increasing the accumulation of greenhouse gases in the atmosphere. The forest sector must become engaged in the process of using forests as a key instrument in addressing climate change. There is a need for large scale reforestation and the protection of remaining primary forests as part of the global efforts to achieve a safe level of atmospheric carbon dioxide. The design of large scale reforestation programs should consider social and economic factors and should incorporate other environmental benefits related to watershed management and biodiversity enhancement. A system of environmental credits could be used to stimulate such a new approach to forest management.

Keywords: Carbon sequestration, Kyoto protocol, Watershed management, Environmental credits

Introduction

Climate Change is now recognized by the global scientific community as the greatest environmental threat facing the world today (UNEP 1999). The negotiation of the Kyoto Protocol to the Framework Convention on Climate Change in December of 1997 (UNEP 1998, UN 1992) has included a recognition of the role of forests as a significant terrestrial storehouse of carbon and a potential tool in removing carbon dioxide from the atmosphere. In fact the loss or degradation of forest cover worldwide has been a significant contributing factor to past increases in carbon dioxide in the atmosphere. The emphasis on forests as a key element in global efforts to address climate change may provide the forestry community with a new impetus to expand forest cover and strengthen the commercial foundation for forest conservation and management. However, the size of this challenge means that care must be taken to ensure that climate change related actions are integrated with forest management, and not overwhelming it.

Forests serve three principal roles in global efforts to address climate change (IPCC 1996). The first is as a major storehouse of carbon in terrestrial vegetation and forest soils and, where the area of forests is extended or biomass increased, as a sink of carbon dioxide from the atmosphere. Secondly, wood products can serve as a low embodied energy building material, replacing those materials with higher embodied energy or emissions associated with their production. Finally, forests can contribute many forms of renewable energy for society, including biomass energy, charcoal and liquid fuels such as ethanol (Lugar and Woolsey 1999). Together, these three roles may generate both an increased emphasis on the establishment or re-establishment of forests and on their use in substitution for fossil fuel based energy and production systems (Brand 1998).

The Kyoto Protocol left the details of many issues related to accounting for forest-based carbon sequestration and storage for ongoing negotiation. At the fifth Conference of the Parties to the Framework Convention on Climate Change (COP5), held in Bonn, Germany in November 1999, it was decided that negotiations related to forest sinks should be intensified, with the aim of concluding agreement on key outstanding issues by COP 6, in November 2000. These negotiations encompass issues that are technical, commercial and political in nature. The rules that emerge will have an effect on the patterns of investment in forest management, the objectives of forest management and the size and nature of markets for forest products. It is important therefore, that the forestry community be actively engaged in supporting and providing input to these negotiations.

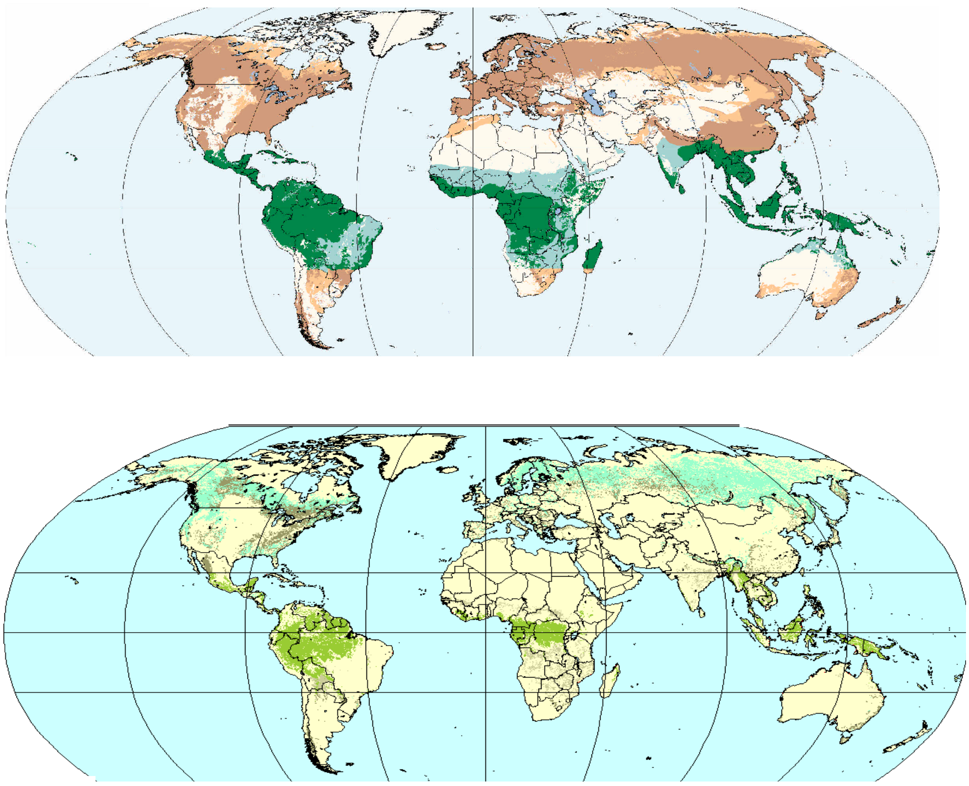
This paper will review technical issues related to carbon sequestration and storage in forests and the potential ramifications to forestry of the Kyoto Protocol being ratified and entering into force. It will be important that the forestry community takes a pro-active stance on the role that may be played by forests in addressing the global threat of climate change.

The Role of Forests in the Global Carbon Cycle

At a macro-scale, forests are currently considered globally to be a carbon dioxide sink from the atmosphere (IPCC 2000). Over the past two centuries, it is estimated that approximately 265 Gt C has been emitted as carbon dioxide from fossil fuels and cement product, while a further 140 Gt has been emitted from land based change, primarily related to forest clearing. Of this total, it is further estimated that about 225 Gt have been re-sequestered in oceans and in the biosphere. At present the terrestrial ecosystems are estimated to be a small net sink, of about 0.2 Gt per year, meaning that vegetation growth across the globe slightly exceeds emissions from forest clearing or harvesting. It has been suggested, however, that this sequestration cannot continue indefinitely and, if it stops or reverses, will lead to substantial increases in the rate of annual atmospheric greenhouse gas accumulation (Anon. 1999).

Protection of remaining primary forests and the re-establishment of forests, therefore, is a key challenge for the international community (Figure 1). A sole focus on the reduction of emissions from fossil fuels will not address the fundamental objective of the Climate Change Convention to achieve a safe level of greenhouse gas concentration in the atmosphere (FCCC 1992). It is for this reason that both the Framework Convention and the Kyoto Protocol made arrangements for accounting for land use, land use change and forestry as part of the national level management of greenhouse gas emissions.

Figure 1. Extent of primary forests 8,000 years ago and today. Protection and regeneration of forest cover is a significant element in addressing the global greenhouse gas accounts (Source: World Commission on Forests and Sustainable Development).



Forests are managed at a regional or management unit scale, rather than at a national scale. For this reason, the forest-related aspects of the Kyoto Protocol must be translated down to a project scale for meaningful actions to be taken. If the Protocol comes into force with agreed modalities for the flexibility mechanisms (Emissions Trading, Joint Implementation and the Clean Development Mechanism) and for the use of carbon sinks, there is the potential for a direct reward system for increases in terrestrial carbon sequestration.

Carbon Accounting at a Project Scale

The growth of a forest established on previously cleared land follows a logistic growth curve—initially slow as the forest occupies the site, then rapid as canopy cover occurs, then declining as the forest matures and respiration rates approach photosynthesis rates. Forest management has long relied on the ability to measure and forecast the volume of timber in tree stems. In many jurisdictions there has also been significant effort in measuring total above-ground biomass of the tree. Carbon accounting, however, requires a complete measurement and forecasting of the carbon content in the forest, including the stem, crown, root systems and soils. For this reason, the development of improved tools for forest carbon measurement and accounting has been an active area of research in recent years (eg Woomer and Palm 1998, Hruska et al 1999).

Forests can be managed for both conservation and production purposes. Where conservation is the primary objective and the forests are intended to be maintained without harvest in perpetuity, the initial growth period, up to maturity will represent carbon sequestration. In forests being managed through a harvesting cycle, the carbon accounts will include periods of sequestration and periods of emissions related to harvesting. Current guidelines issued by the Inter-governmental Panel on Climate Change require that any harvesting of forest products be treated as an immediate emission back to the atmosphere (IPCC 1996). Combining a series of forest stands into a carbon pool can smooth the overall carbon stocks over time. For example, a forest management unit established over a rotation period with balanced age classes will sequester carbon throughout the first rotation and then stabilize (Figure 2)

From a commercial point of view, a market for carbon sequestration credits would potentially stimulate the establishment of new forests. Conservation forests would be able to earn revenue from 'carbon credits' if the Kyoto Protocol mechanisms are finalized and endorsed. Production forests would benefit from a cash flow during the early stages of forest growth, where long time periods without revenue have often acted as an impediment to forestry investment. Creating a forestry system that manages the dual incomes from carbon sequestration and timber or energy production will be a new challenge for foresters. In particular, the carbon sequestration must occur on a long term basis, or else any credits sold would need to be re-purchased if the forest is cleared and reverts to pasture or other non-forest land use.

New South Wales, Australia, has pioneered the development of some of these businesses. The government introduced legal carbon rights that can be registered on land ownership titles. State Forests of NSW has used that legislation to design investment packages that blend together the management of forests for carbon sequestration and timber production. In February of 2000, the Tokyo Electric Power Company, which is the world's largest privately owned electricity company, signed a contract with State Forests to provide up to 40,000 ha of new forests in the next decade. This contract may be a harbinger of a new class of investor in the forest sector and a new partnership between the forestry and energy sectors.

Landscape or Management Unit Scale Issues in Management of Carbon Sequestration

At the landscape or management unit scale foresters must contend with the intersection of socio-economic and environmental or ecological systems. Building up the carbon sequestration capacity on a regional basis will involve land use change and may cause shifts in social and economic conditions. The value of carbon sequestration in an international emissions trading regime may be enough to stimulate significant reforestation in areas of degraded land, but may also compete with traditional agriculture and grazing economies. Where traditional agriculture is declining, however, the carbon sequestration credits can provide an economic boost, encouraging reforestation and associated employment opportunities.

Figure 2. A series of age classes of forests, can be managed both for timber production and as a carbon sequestration pool.

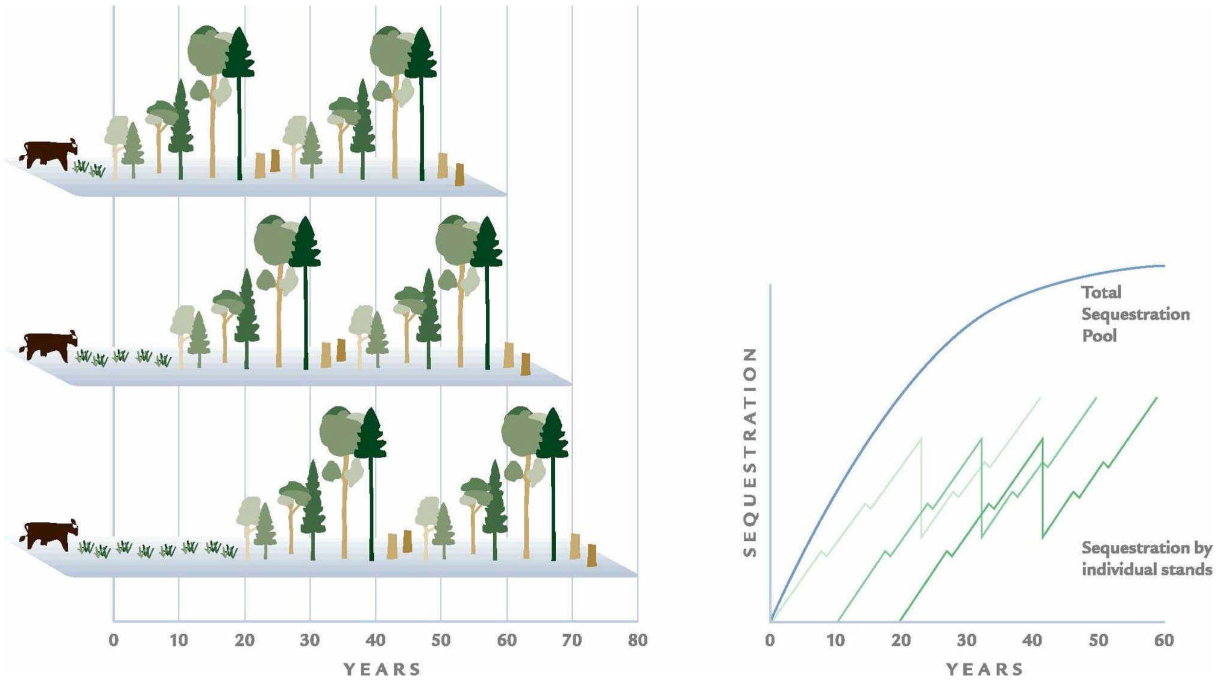
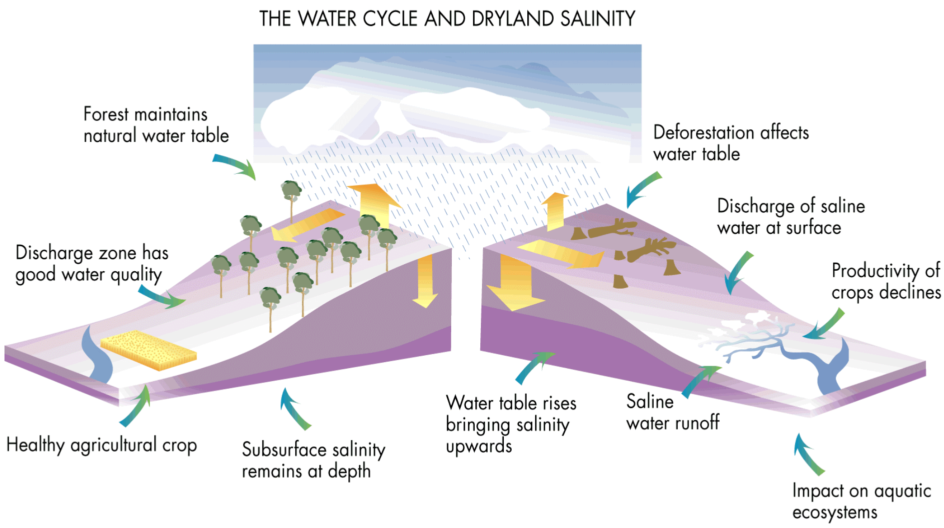


Figure 3. Past clearing of forests and woodlands has led to rising saline water tables and threatens water quality in the Murray Darling Basin. A large scale reforestation program will need to be part of the solution to this problem.



In many areas of the world reforestation is a critical need for rehabilitation of degraded areas, improvement of water quality, prevention of soil erosion or landslides, management of soil water tables or soil chemistry or any of a variety of other values. In Australia, for example, long term clearing of forests and woodlands for agriculture has led to a growing recharge of soil water, elevating saline water tables and leading to a saline discharge into the river systems (MDBC 1999) (Figure 3). This threatens community water supplies, downstream irrigation-based agriculture, and critical wetland ecosystems.

Without large scale reforestation in this region, there will be a decline in both socio-economic and environmental systems across the key agricultural region of Australia.

Much of the Murray Darling basin has precipitation levels below 700 mm, which has been the traditional limit for commercial forestry. This salinity crisis, however, has led to the piloting of a salinity control credit scheme, based on downstream water users paying a fee per Megalitre of transpiration from new planted forests. Combining the potential for carbon sequestration payments with these salinity control credits will be a major impetus for the reforestation programs needing to be undertaken. This will require that the community determine the level of salinity that they are prepared to live with and then letting a market evolve for these salinity credits.

The new forests being established for carbon sequestration and other benefits can also contribute to the expansion of renewable energy systems. While biomass energy has been one of the most widespread energy sources for subsistence energy and home heating, it has not been seen as an alternative to fossil fuel based electricity generation. A carbon tax or emissions trading regime would narrow or remove the cost advantage of fossil fuel based energy systems. Forest biomass can also be used as a reductant in metal smelting and as a basis for liquid or gaseous fuels.

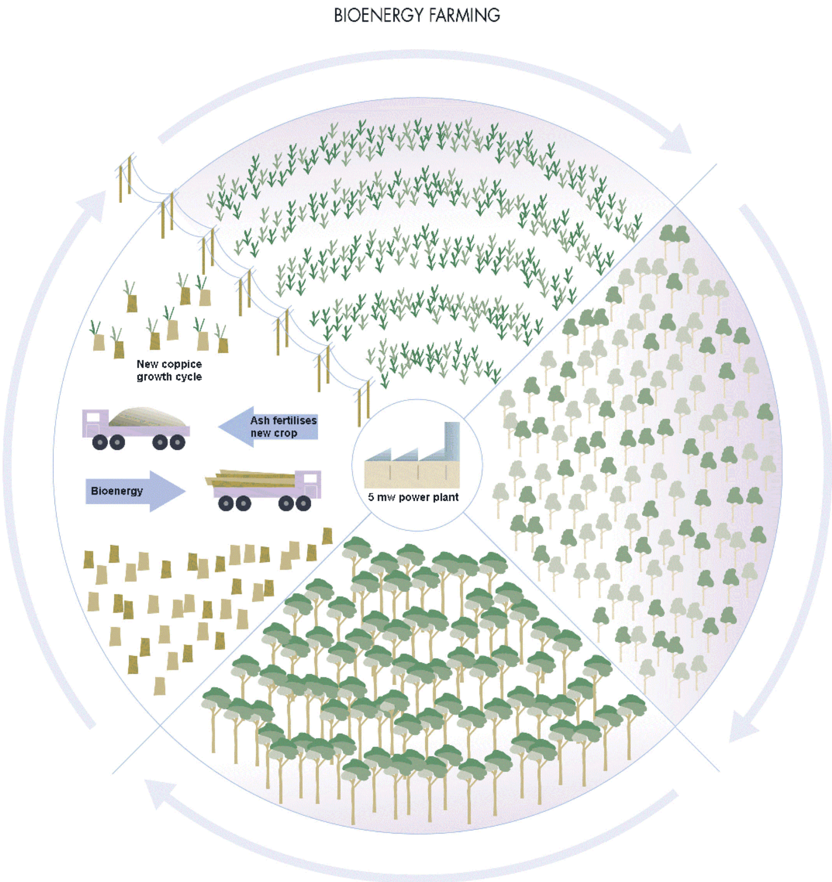
Past attempts have been made to introduce the concept of energy farming, but again, the cost of biomass has not been able to compete with fossil fuels. With carbon sequestration credits and a commercial boost to biomass energy systems through emissions trading, it is now becoming apparent that we need to develop highly efficient systems for growing forest biomass, almost like a solar harvesting system. Recent work in Australia points to a current delivered price for biomass of $25.00 per tonne, but a growing, harvest and delivery cost of $30.00 per tonne. If carbon credits and emissions trading systems can bridge that gap, forests can be used to support smaller, regional power plants. Current estimates are that a 5 MegaWatt electricity plant would utilize about 3,700 ha of forest on a continuous rotation basis (Figure 4)

Bringing together the carbon sequestration, salinity control credits, new energy farming systems and the enhancement of biodiversity is a concept with widespread support in Australia. These packages of environmental goods and services may actually expand regional economies and create new jobs. Similar approaches could be developed in every region of the world.

Conclusion

Forest management faces a period of opportunity, but also of challenge, as we witness the emergence of one or more envrironmental markets. In some ways carbon sequestration is the perfect global commodity, as the world has only one continuous atmosphere. The absorption of carbon dioxide from the atmosphere in Australia, paid for by a greenhouse gas emitter in Japan, will be an ever more common scenario. But following now behind the market for carbon sequestration credits are other environmental credit markets for watersheds and biodiversity enhancement. Markets create incentives and rewards to those who can successfully respond, and these new forces will shift the objectives of forest management. If the global challenge of managing atmospheric carbon dioxide spurs a large scale reforestation in many regions of the world, it should be undertaken in a way that is also contributing to rural social and economic systems. Focussing reforestation in areas of marginal agriculture or regions with soil degradation may create significant benefits for the environment and for rural economies.

Figure 4. Energy farming may become a reality if the value of carbon sequestration and fossil fuel emissions offsets are factored into the price.



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Perspectives for Environmentally-Friendly Management Systems in Tropical Forestry

by
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Abstract

At CATIE, long-term research has focused on development of technologies for sustainable management of natural tropical forests and their biodiversity. Forests cut using sustainable practices can have higher seedling regeneration, and also higher understory biodiversity than forests cut using conventional methods. Post-harvest silvicultural treatments increase the diameter growth of potential crop trees though the consequences for sustainability of their effects on forest composition, through the elimination of non-commercial competitors, remain to be evaluated. Different management operations affect plant diversity in different ways, over different time scales, but there is no evidence for drastic changes of diversity during the first felling cycle even in stands whose structure is radically altered by refinement/liberation treatments. Patterns of seed dispersal and germination can also be affected as a result of defaunation and changes in the forest microenvironment.

CATIE researchers are also involved in the design of systems of diversified forest management, involving studies on the ecology and management of non-timber forest species. Many forest management practices are best suited to small farmers, farmer cooperatives, or to community forest users. Some farmers'cooperatives in Costa Rica manage the forests for eco-tourism and non-timber forests products, while they cultivate other portions of their land, and reforest degraded land with native species, often in mixed-species designs. Tropical plantations can supply wood products, contribute to carbon accumulation, land reclamation and acceleration of natural regeneration. Domestication of promising species for plantation forestry involves selection of outstanding trees, evaluation of genetic variability, trials of seed germination and storage, evaluation of the performance of species under different silvicultural systems, and the development of seed orchards for the production of genetically improved seeds.

Key words: Biodiversity, Diversified forest management, Ecosystem restoration, Genetic improvement, Mixed plantations

The Kyoto Protocol and Forestry Practices in the United States

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Abstract

Forestry may play an important if not critical role in the ability of the U.S. to meet its greenhouse gas emissions target under the terms of the Kyoto Protocol. Given the low rate of change in the U.S. forest land area, the major anthropogenic influences on the current net forest carbon flux are forest management and protection activities that have resulted in continuing increases in forest carbon storage. Natural disturbances such as fire, insects, and diseases are locally important factors, but when all U.S. forests are considered, they are small relative to the effects of harvesting and growth. Carbon in U.S. forest ecosystems, wood products, and landfill wood was estimated to account for an annual net sequestration of about 300 TgC/yr during the 1980's, and are projected to comprise at least 200 TgC/yr over the next several decades. Proposed accounting rules under the Kyoto Protocol article 3.3 may render most of this C sequestration unaccountable towards the U.S. emission reduction target unless additional activities are accepted under article 3.4. Forestry practices that are likely to result in a positive C sequestration in the U.S. include afforestation of marginal cropland and pasture, improved forest management, adjustments in harvest timing, establishment of short-rotation biomass plantations, improved utilization of harvested biomass, and tree planting in urban and suburban areas.

Keywords: Kyoto Protocol, forestry, carbon sequestration

Introduction

The United States signed the Kyoto Protocol[1] on November 12, 1998, reaffirming America's commitment to meeting our most profound environmental challenge -- global climate change. Under the terms of the Protocol, the U.S. must reduce net emissions 7 percent below 1990 levels by the first reporting period, 2008-2012. This reduction is substantial given that emissions are expected to rise during this period due to population growth and economic expansion.

The role of forestry and land use change has been controversial throughout the international negotiation process. There are differing opinions around the world on whether forestry activities should be counted. A country's position depends on factors such as whether its forests are currently or prospectively a net source or sink for carbon dioxide (CO_2), whether carbon (C) stock changes in forests can be measured and verified, and the relative emphasis that should be placed on reducing emissions versus increasing sequestration. Some countries express concern that forest responses to "natural" factors such as increased atmospheric CO_2 (which may increase growth) would allow a country to claim credit for greenhouse gas reductions that are not associated with specific activities.

The Kyoto Protocol attempted to reconcile the diversity of viewpoints on land use change and forestry. According to Article 3.3 of the Protocol, land-use change and forestry activities that can be counted toward the emissions reduction target include afforestation, reforestation, and deforestation since 1990 if the changes in stocks can be verified. Some interpretations of the definitions of terms under article 3.3 exclude managed forests with harvest and regeneration cycles from counting toward the emissions reduction target. However, article 3.4 provides an opportunity for nations to propose including additional activities such as forest management, and the agreement does include sustainable forest management as part of a general statement supporting sustainable

[1] http://www.unfccc.de/resource/protintr.html for the full text of the Protocol.

development and protection and enhancement of sinks.

The language, terminology, and accounting methods contained in the agreement are somewhat vague, and can be interpreted in different ways. Definitions of key terms such as reforestation are not stated, which becomes a problem for implementation of the Protocol because there are many different definitions in use throughout the world (Lund 1999). The proposed accounting system is vague. For example, it is not clear whether harvested timber should be counted as a forest sink and if so, under which circumstances it could be counted.

To address these issues, the United Nations Framework Convention on Climate Change (UNFCCC) asked the Intergovermental Panel on Climate Change (IPCC) to establish an expert panel to develop a special report on the land use change and forestry provisions of the Kyoto Protocol. The panel is reviewing definitions, accounting issues, and activities that could potentially be included within the terms of the Protocol, and will document the various options for eventual reconciliation during the ongoing Conferences of Parties. This paper reviews the status and trends in U.S. forests as revealed by long-term monitoring, and explores the potential to increase carbon storage in forests as a contribution to the emissions reduction requirements of the Kyoto Protocol.

Trends in U.S. Forest Resource Statistics

The area of forest land in the U.S. has not changed significantly since the early 1900's. The area of forest land in 1907 is estimated as 307 million hectares, and in 1997 the area of forest land is estimated as 302 million hectares (*from preliminary statistics of the 1997 Resources Planning Act Assessment*). However, changes for the whole U.S. mask divergent regional trends. For historic and physiographic reasons, we speak of four regions in the U.S.: the North, South, Rocky Mountains, and Pacific Coast (Fig. 1). Since the 1900's, the North has been gaining forest land area, with the other three regions each losing forest land area (Fig 2). There have been significant shifts between land use categories, such that gains in forest land area from afforestation of agricultural land approximately offset losses of forest land area to development. There has also been a significant shift from natural forests to planted forests. The area of plantations in 1997, mostly in the South, is approximately 33 million hectares, or 11 percent of the total forest land area.

Figure 1. Regions used in the analysis

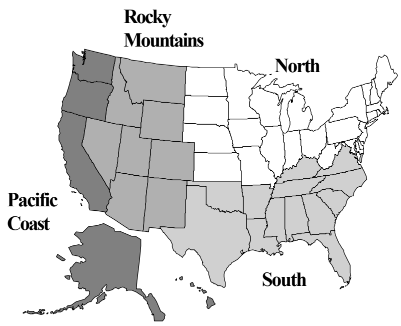
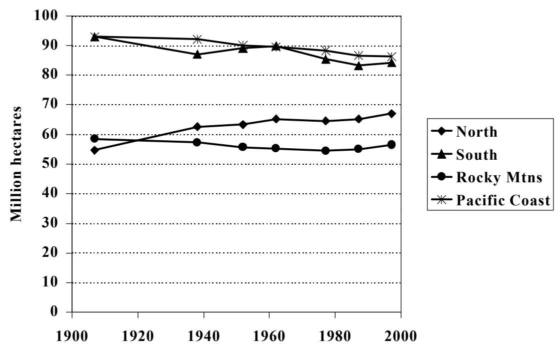
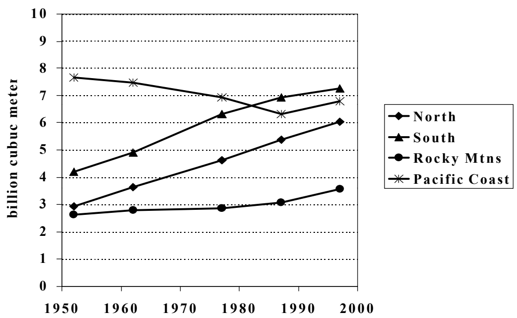


Figure 2. Forest land area in the U.S. by region, 1907-1997 (from Review Draft, 1997 RPA Assessment of the Nation's Forests)



The net volume of softwood growing stock increased by 12 percent between 1952 and 1997 to a total of 14 billion cubic meters. During the same period, the net volume of hardwood growing stock increased by 90 percent to 10 billion cubic meters. As is the case with forest land area, these changes differ by regions. The North, South, and Rocky Mountains each gained growing stock volume, while the Pacific Coast lost growing stock volume (Fig. 3).

Figure 3. Volume of growing stock in the U.S. by region, 1952-1997 (from Review Draft, 1997 RPA Assessment of Nation's Forests).



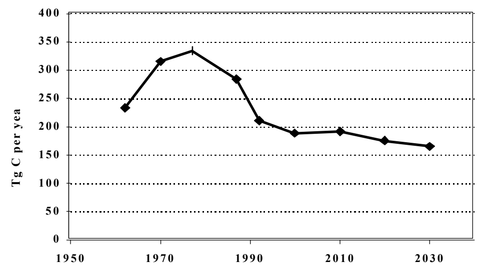
Differences in forest land area and growing stock volume trends reflect long-term changes in land use and harvesting. Millions of hectares of forests in the North, particularly in the Northeast, have regrown on agricultural land that was abandoned to forest land prior to 1900, causing a long-term increase in growing stock volume. These regrowing forests are now maturing, and therefore the rate of increase in growing stock volume is expected to slow substantially. The historical pattern is similar in the South, but the intensive utilization of southern forests for wood products over the last few decades has effectively halted regional gains in growing stock volume, as growth and removals have come into rough balance. Forest land area has not changed much in the Rocky Mountain region, where removals have been low relative to growth. Fire suppression and low removals have caused a substantial buildup of growing stock volume, and a corresponding increase in the potential for catastrophic wildfire in the region. In the Pacific Coast, growing stock volume has declined as old-growth forests have been harvested and converted to young regrowth. Growing stock volume is expected to continue the recent increase as more area of forest land has been reserved from timber harvesting operations.

Trends in Carbon Storage of U.S. Forests And Wood Products Under

A Comprehensive Accounting System

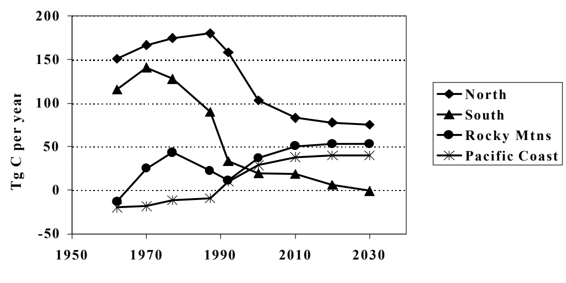
Forest inventory statistics can be converted to estimates of ecosystem C using known relationships between volume and mass for different species and regions. Ecosystem C pools are usually separated into several components: above- and below-ground live biomass, coarse woody debris, litter, and soil organic matter. Estimates of ecosystem C show that increases in biomass and organic matter in U.S. forests from 1952 to 1992 added 281 Teragrams of carbon per year (TgC/yr) to forest ecosystems, enough to offset 25 percent of U.S. emissions of CO_2 for the period (Birdsey and Heath 1995). Baseline projections using the U.S. carbon budget model FORCARB show additional increases of approximately 177 TgC/yr in forest ecosystems through 2040 (Fig. 4). This "baseline" carbon budget refers to long-term trends in forest carbon storage using economic assumptions from the 1993 RPA Assessment (Haynes et al. 1995), in the absence of major forestry policy changes or changes in forest productivity or species distributions as a consequence of climate change. The projected baseline includes forest policies in effect at the time the projections were made; in particular, reduced harvest levels on National Forest lands, decreases in clearcutting and increases in partial cutting practices, and continuation of federal cost-share programs at recent historical levels.

Figure 4. Past and projected carbon sequestration in U.S. forest (from Birdsey and Heath 1995)



There are significant regional differences in historical estimates and projected C storage in forest ecosystems (Fig. 5). These differences reflect the influence of many factors including variations in species composition and natural growth rates, and long-term changes in land use, management intensity, and harvesting practices as described earlier. A negative number indicates more carbon is being emitted to the atmosphere than being sequestered into forests.

Figure 5. Past and projected carbon sequestration in U.S. forests by region (from Birdsey and Heath 1995)



The amount of carbon in forests that are harvested and re-grown underestimates the total carbon sequestered in the forest sector. The amount of carbon sequestered in wood products and landfills is in long-term storage, and continues to increase because removals are projected to increase. Heath et al. (1996) estimated that by 1990, about 3,600 Tg of the 10,700 TgC removed from U.S. forests since 1900 remained sequestered in products and landfills. The quantity of C sequestered in wood products and landfills is increasing at about 37 TgC/yr, equivalent to 40 percent of the annual increase in forest biomass.

Possible Trends in Carbon Storage of U.S. Forests Under Article 3.3

Article 3.3 of the Kyoto Protocol states that only verifiable C changes due to afforestation, reforestation, and deforestation activities since 1990 may be credited or debited as part of a country's emissions reduction target. The trends in C storage will depend greatly on the adopted definitions of these activities. For example, under a narrow interpretation of the definition of reforestation, the only land on which carbon changes would count is land that changed use between forest and nonforest categories. This is projected to be a very small quantity of C in the first reporting period (2008-2012) based on area change data. Table 1 displays an estimate of gains and losses in forest land, calculated on an average annual basis (personal communication, Bryan C. Murray, and U.S. Department of Agriculture, Natural Resources Conservation Service 1996).

The estimated total non-Federal forestland area in 1982 was 162,296,000 ha. Thus, the annual gain in forest area is approximately 0.37% of the total forest area base, and the annual loss in forest area is even smaller. If these trends continue, approximately 10,890 hectares will be considered area increases in forest use by 2008, which is about 6% of the total forest area in 1990. Although the losses and gains are fairly close in absolute magnitude, the changes in C storage will be quite different because much of the area loss is to the land use categories of developed and miscellaneous uses. Land use changes to development are often more of a reclassification based on use rather than loss of tree cover. The net result of reclassification generally has very little effect on terrestrial C storage.

It is also unclear how deforestation will be counted in the future (Heath and Smith, 2000).

Carbon will be emitted as forest becomes cropland, but after a number of years, the farmer may switch to "no-till" practices that sequester C as compared to traditional tillage practices, or perhaps the land may revert to forest use again. In other words, the deforestation may be afforested. Keeping track of these possibilities may be confusing.

Under a different interpretation of article 3.3 definitions, changes in carbon stocks on a much greater area of forest land would be counted during the period 2008-2012. A common definition of reforestation includes land areas that were previously classified as forest, but were disturbed or harvested and are being re-grown as forest. Forests in the U.S., particularly the South, are actively managed, and this interpretation would therefore result in a much greater area on which carbon changes would be counted during the first reporting period. However, even this area would be substantially less than the total forest land area of the U.S. because only part of the forest land area would be disturbed or harvested between 1990 and the first reporting period.

Management Practices to Increase Carbon Sequestration

Article 3.4 of the Kyoto Protocol allows countries to propose additional activities that could be credited toward emissions reduction targets. Several categories of management practices that could have a positive carbon sequestration benefit in the U.S. are reviewed below. Not all have been studied thoroughly, but where possible, estimates of the gains in C storage are presented (summarized from Birdsey et al. 2000).

Afforestation of Marginal Cropland and Pasture

Many studies have estimated potential gains in C storage from afforestation in the U.S. A few examples are reviewed here. Moulton and Richards (1990) estimated that offsetting U.S. emissions by 10 percent (about 160 TgC/yr) would require about 29 million ha at an average cost of $12 million per TgC or $1.7 billion per year. Parks and Hardie (1995) estimated that converting 9 million ha of land to forest would increase C accumulation by 44 TgC/yr and cost $21 million per TgC. These two studies did not include effects of increased supply of timber on the forest sector, which may partially offset C gains by reducing prices and increasing demand. Parks and Hardie (1992) used FORCARB and forest sector models to develop two reforestation scenarios and compared the results with a base run (Heath and Birdsey 1993; U.S. Environmental Protection Agency 1995).

The average annual increase in C flux (including C in wood products and landfills) over a 50-yr period is projected to be 14.3 TgC for a 0.5 million ha/yr program costing $220 million/yr, or approximately $15 million per TgC. These costs include only the direct costs associated with tree planting and payment of subsidies.

Table 1. Estimates of changes in forest land use between 1982 and 1992 (1000 ha/yr). Federal ownership is not included.

Type of forest change:	Cropland	Pastureland	Rangeland	Developed and miscellaneous	Water	Total
Loss to--	59.9	116.9	46.5	281.6	19.1	524.0
Gain from--	129.5	337.6	62.8	67.8	7.5	605.2

Projections using a forest/agriculture sector model (FASOM) suggest that efforts to expand forest C flux should have a rather different geographic and species focus than that proposed in past studies (Adams et al. 1999). In contrast to both Moulton and Richards (1990) and Parks and Hardie (1995), FASOM projections suggest a greater emphasis on hardwood species in minimum cost strategies. FASOM simulations indicate that the bulk of the projected afforestation and management changes should occur in the North, mostly in the Lake States region. This is an area of large concentrations of hardwood forests in which hardwood stands can yield significant rates of C uptake. Although the FASOM model recognizes the rapid growth potential of afforested stands in the South just as in previous studies, broader measures of costs and inclusion of welfare trade-offs across markets and regions act to shift the minimum cost solution away from the customary prescription of pine plantations on marginal Southern agricultural lands. In reality, all of the land considered in these studies that could support trees may not be available. Even if the land were available, the infrastructure may not be in place to provide seedlings and assure regeneration for all available land. Additional technical assistance must also be provided to landowners for the planting programs to be effective.

Improved Forest Management

Timberland in the United States amounts to 198 million hectares (66% of the total forest land area) and includes a diversity of ownership objectives, forest types, site productivities, and stand conditions (Powell and others 1994). There are opportunities to sequester additional C on some portions of this large area of forest. Of particular interest are opportunities to increase the density of trees on non-stocked or poorly stocked forestland, and to apply silvicultural treatments to stocked forestland so as to increase the average biomass per unit area. Forest management practices in the U.S. to increase C accumulation may include: (1) restoration of poorly stocked forestland by clearing and regenerating if current productivity is well below average, (2) application of intermediate stand treatments (thinning or timber stand improvement) if the current stand is overstocked, and (3) management for longer rotation lengths (Birdsey 1992b). Including the value of C along with the value of timber increases the optimal economic rotation (Plantinga and Birdsey 1994; van Kooten et al. 1995).

Many silvicultural practices are designed to increase the production of growing-stock volume in desirable species. Gains in C storage are not necessarily proportional to gains in growing-stock volume because: (1) unmerchantable trees will also accumulate C, (2) stocking will increase naturally in poorly stocked stands, and (3) some management practices may remove biomass or disturb the site, resulting in loss of stored C. Studies have shown that thinning, for example, reduces total C storage compared with unthinned plantations (Dewar and Cannell 1992). Nevertheless, intensive forest management can increase total C accumulation over time relative to unmanaged forests, especially if the additions to wood product and landfill pools are counted. Row (1996) presented several case studies illustrating the potential gains from intensive forest management. Loblolly pine (*Pinus taeda*) plantations that are 30 years old contain on average 87 percent more C than natural stands on comparable sites. Gains of more than 100 percent over natural stands are possible with intensive management and genetically improved planting stock. Similar gains were found from converting natural aspen-birch forests in the Lake States to red pine (*Pinus resinosa*) plantations. Vasievich and Alig (1996) estimated that implementing economic opportunities on 82 million hectares of timberland could yield gains in C storage of approximately 140 Tg C/yr in vegetation, wood products, and offset fossil fuel C.

Conversion of mature or old-growth forest to young forest, which may have a faster growth rate, will reduce C storage until the harvested C remaining in products and landfills, plus additional C in the forest ecosystem from renewed growth, reaches the pre-harvest level. This may take 200 years or more in the case of old growth forest (Harmon et al. 1990), depending on site productivity and on how wood burned for energy is accounted for. Marland and others (1997) analyzed the effects of forest management on C in forest ecosystems, wood products, energy substitution, and product substitution. Results of their model (GORCAM) suggest that over long time periods, sustainable management for forest products on highly productive sites will yield a larger C offset than simply protecting the forests intact. They note the difficulty of estimating the magnitude of the substitution effects, and of attributing the C offset to particular projects because the indirect effects of any given project are spread widely and are likely to be partly claimed as a credit elsewhere.

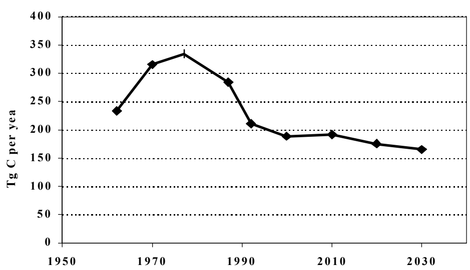
Adjustments in Harvest Timing

Reducing the area harvested can cause an immediate short-term increase in the amount of C stored in forests because losses of C to the atmosphere during the removal of biomass and processing are avoided. On average, only about half of the live biomass is removed from the site, while logging debris (leaves, twigs, branches), stumps, roots, and unmerchantable biomass is left behind to decompose, transfer to another C pool (e.g. litter or soil), or become part of the new stand of trees (Birdsey 1992a). Of the biomass that is removed, about 35 percent ends up in durable products or landfills (based on removals since 1900 and historical patterns of utilization and disposal), while the remainder is burned for energy or emitted to the atmosphere (Heath and others 1996, Skog and Nicholson 1998). Combining the estimates of on-site and off-site losses, only about 20 percent of the forest biomass ends up in long-term storage after harvest, and the remainder may be emitted to the atmosphere. Avoiding this loss by reducing harvest can be a short-term strategy to sequester additional C; however, over the long term, a continuous cycle of harvest, efficient utilization of biomass, and regrowth can sequester more C than not harvesting since the accumulation of C in the forest will eventually slow or stop, while it is possible to accumulate C in wood product and landfill pools for a very long time (Row 1996).

The effects of reduced harvest on C storage are evident in the estimated past and prospective C flux for National Forest lands (Fig. 6, Birdsey and Heath 1995). High rates of harvesting in the 1970-1990 period caused emissions of 50 Tg C/yr or more, while the significantly reduced harvest of the 1990's, if sustained, will cause a prolonged addition of C to National Forest lands, more than 80 Tg C/yr. In the unlikely event that all harvesting were stopped in the U.S., public and private timberlands could sequester an additional 328 Tg C/yr over a 50-year projection (Heath and others 1993).

Reduced harvest in one ownership category or region may be offset by increased harvest elsewhere, by substitution of energy-intensive non-wood products for wood products, or by changes in wood processing technology. Depending on the exact response, apparent gains in overall C storage may be lessened. The U.S. Environmental Protection Agency (1995) concluded that reducing National Forest harvest by 21 percent would be fully offset by increased harvest from private timberlands and increased imports. Adams and others (1996) concluded that reduced harvest on public lands in the West could be largely offset by substantial private forest investment and increased harvest on private lands in the South. Martin and Darr (1997) found evidence for increased imports from Canada as a consequence of reduced National Forest harvest but inconclusive evidence for substitution of nonwood products or increased harvest on private lands.

Figure 6. Past and projected carbon sequestration in U.S. National Forests (from Birdsey and Heath 1995)



Short-Rotation Biomass Plantations

Short-rotation woody crops could be established specifically for biomass production on marginal cropland and pasture. Current average dry biomass yields for short-rotation crops (rotations less than 10 years) are approximately 12 t/ha/yr, with higher rates attainable (Wright and Hughes 1993). Very high rates of C sequestration are possible over longer periods in forests that are managed for biomass production. For example, the average C storage in biomass (including cut and dead trees) for 40-year old hardwoods in the Lake States under different management intensities was 331 Mg/ha (Strong 1995). This is equivalent to an average annual C accumulation of 8.3 t/ha/yr over the entire 40-year period.

Conversion of productive forestland to short rotation biomass crops may result in a decrease in ecosystem C storage that would have to be offset over several rotations by counting the substitution of wood biomass for fossil fuel energy. Cropper and Ewel (1987) compared C accumulation under existing forestry practices for slash pine (*Pinus elliottii*) and found that annual C storage decreased by more than half in some cases, due to reduced tree biomass and soil C.

The U.S. Congress, Office of Technology Assessment (1991) estimated that a program to plant about 1.25 million hectares of biomass plantations per year for 20 years would eventually produce 30 TgC/yr of harvestable biomass. The study estimated that about half of the harvested C would offset fossil fuel C.

Improved Utilization of Harvested Biomass

Heath and others (1996) estimated that of the 10,700 TgC harvested in the U.S. since 1900, 35 percent remained in products and landfills, 35 percent was burned for energy, and 30 percent emitted to the atmosphere without producing energy for consumption. Improved utilization of removed biomass could reduce losses of C to the atmosphere. For example, if the percentage of C in wood products were increased by 50 percent the annual C storage in products would increase by about 10 TgC/yr, while the other disposition categories (landfills, wood burned for energy, and emissions) would each be reduced by about 3.5 TgC/yr (Heath and others 1996). Also, retention in landfills could be increased as documented by Micales and Skog (1997).

Increased recycling of wood products may have two effects: keeping the C sequestered in usable products longer, and reducing the timber harvest. The U.S. EPA sponsored an analysis of recycling that concluded that each ton of recycled paper increased forest C sequestration by 0.73 tons (U.S. Environmental Protection Agency 1997). This estimate was derived from a cluster of U.S. Forest Service models including FORCARB and associated economic models of the pulp and paper industry. Another study estimated that rapidly increasing paper recycling to 45 percent of total fiber used would sequester an average of 10 TgC/yr (Heath and Birdsey 1993).

Plant Trees in Urban and Suburban Areas

Urban and suburban trees store C and can reduce energy use in buildings if the correct species are properly placed. Rowntree and Nowak (1991) estimated that urban areas in the U.S. have an average tree cover of 28 percent, and store an average of 27 t/ha. McPherson and Rowntree (1993) estimated that a single 7.6 meters tall tree could reduce annual heating and cooling costs of a typical residence by 8 to 12 percent, which both saves money and avoids the use of energy generated with fossil fuels.

Nowak (1993) concluded that planting an additional 100 million urban trees and maintaining them for 50 years would cumulatively store approximately 75 TgC in biomass and offset 275 TgC due to energy conservation. This is an annual average of 7 TgC/yr over the 50-yr period. The rate of sequestration would be very low for the first 2 decades, and higher toward the end of the period as the trees reach maturity (more than 10 TgC/yr). Assuming a cost of planting and initial tree maintenance of $5-25/tree, such a program would cost from $50 to $250 per ton of C after several decades (McPherson 1994).

Summary and Conclusions

If the U.S. is to meet the emission target, forestry could play an important, if not critical role, in this reduction. Globally, the most important activity that affects carbon fluxes is deforestation. However, in the U.S. the amount of forest land has remained fairly constant during the last several decades at approximately 298 million hectares or 33 percent of the total land area. Given the low rate of change in the area of forest land of the U.S., the major anthropogenic influences on the current net carbon flux are forest management and protection, forest product processing, urban tree planting, and research and transfer of environmentally sound policies and practices. Natural disturbances such as fire, insects, and diseases are locally important factors that affect forests and C storage.

The Kyoto Protocol establishes an accounting system that includes only part of the carbon attributable to forestry and land use change. The forestry baseline as described under article 3.3 would account only for forest lands that have been or will be affected by reforestation, afforestation, and deforestation since 1990. The exact definitions of these activities are not given in the Protocol. Additional activities such as forest management would not likely be counted unless accepted as additional activities under article 3.4 of the Protocol.

The net sequestration of C in U.S. forest ecosystems and wood products (including disposal in landfills) from all activities during the 1980's was about 300 TgC/yr, and is projected to be at least 200 TgC/yr for the next few decades. The causes of continued net sequestration in forests are varied. Forest management practices that may increase carbon storage include regeneration of harvested natural pine and oak-pine in the South to fast-growing plantations, increasing use of genetically improved planting stock, and maintenance of optimal stocking density for growth. Some areas of maturing forest in the North and some areas in the West are unlikely to be harvested, allowing stored carbon to reach higher levels than recent decades as long as natural disturbance rates are low. Increased use of partial harvesting methods that minimize impacts on stored soil carbon will increase retention of carbon on forest sites. Improved efficiency in converting roundwood to products, and increasing product's useful lifetime, will also contribute to net forest carbon sequestration in the U.S.

Regardless of how the Kyoto Protocol or any other international agreement to limit greenhouse gases may be implemented, forestry in the U.S. offsets a significant percentage of CO_2 emissions, and will continue to do so for a very long time. The value of forests for C sequestration should be widely recognized, and efforts to manage and protect this and other values of healthy forests continued.

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Sub-Plenary Session : C2

Changes in Environment and Society:

Societal Change and Forests

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New Public Management and the Change of Forest Institutions

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Abstract

The forestry sector, public forest policy and forest administration in many countries are currently involved in a process of change. Public budget crises, inefficient and obsolete administrative structures, changes in social requirements with respect to forests and low timber prices have all given rise to persistent requests for fundamental administrative reform in the forestry sector. New Public Management (NPM) has been gaining acceptance as the most common concept in this context. Originally developed in New Zealand, this concept has been the inspiration behind widespread reform in all kinds of countries in East Asia, North America and Europe. We would like to present reforms implemented by forest authorities in Germany and Switzerland as examples of such authorities which have already gained experience with elements of New Public Management. By doing this, we will show that the concept of NPM can cover a wide range of proposals and that the projects in Germany and Switzerland are examples of how different aspects of this approach have been implemented. With respect to the outcome of these reforms, at this point in time, it is only possible to put forward hypotheses on their efficacy and efficiency as the evaluation of effects will be the subject of further research.

Keywords: New public management, Reorganisation, Administrative reform, Forest administration

Pressure for Reform of the Forest Sector

The pressure for reform of the forest sector has increased in recent years for a number of reasons. Some of these reasons can be identified in areas associated with the sector itself, for example, financial crises and public budget deficits in OECD states, which in many countries have resulted in the implementation of widespread cost-saving measures, from which the forest authorities have not been spared. Other reasons include timber prices and increasing global competition. The demands of citizens with respect to the state and the administration have also changed. In many of the old democracies, there is a negative attitude to over-regulated and bureaucratised administrative structures and decentralised, efficient and effective administrative action - the very values promoted by New Public Management - are now in demand. The need for “de-bureaucratisation” is particularly obvious in the case of younger democracies which are in the process of completely dismantling former centrally-planned economies (Krott 1999).

In addition to these general and non-forest-specific causes, specific administrative problems can be identified within the forestry sector which are also behind the attempts at reform. These include, for example, the outdated and strongly hierarchical administrative structures in this sector. In Switzerland, for example, the political authorities were responsible for decisions concerning the implementation and organisation of the forest administrations. Administrative structure - right down to the level of the forest rangers - was defined by the federal legislator. Although the tasks assigned to the state have changed over time, it is still possible to find administrative structures in the forest sector which were established over one hundred years ago. The administration can be described as an authoritative police organisation firmly based on the principles of hierarchy and territory. Most jobs are still filled by uniformly trained specialists. The original tasks, which were mainly authoritative, were complemented with social and economic tasks. The extension of forest tasks resulted in overlaps and hence double-tracking with other policy areas which, of course, gives rise to inefficiency. Moreover, an analysis of forest legislation in Switzerland also shows that although there has been a significant increase in regulations, clear objectives are still lacking. Thus, the suspicion that the control is directed at the input and ignores criteria such as efficiency and efficacy is gathering credence. Distant and obsolete administrative structures, ossified decision-making processes, the absence of success monitoring and the more or less non-existent evaluation of forest transfer practices all underline the absolute necessity for the modernisation of the administration in this sector.

The Central Elements of New Public Management

New Public Management is something of a buzzword for which no clear definition exists and a wide variety of versions and interpretations can be found throughout the world. As a starting point, we would like to select one definition which identifies the salient characteristics of NPM and distinguishes it from other models: "New public management can be understood as a comprehensive management approach which replaces those elements of the political-administrative system which hinder performance and motivation with modern management systems, structures and instruments. The basic element is the shifting of control from the instruments (input) to the performance (output) and effects (outcome, impact). This creates an improved basis for decision-making by the political and administrative leadership" (Schedler 1995a, 17).

On the basis of the above definition, it is possible to identify the main objective of NPM as the reorganisation and transformation of the administration into an effect-oriented administration. NPM is in a better position to fulfil this objective than any new or old reform efforts because it tailors familiar management modules to each other and directs them towards a new general target (Reichard 1995, 66). (Reichard 1995, 65) summarises the general direction of this approach as follows: "In contrast to the rationalistic planning concepts of the '60s and '70s, which were aimed at the optimisation of the planning capacities of state actors, NPM-related reforms have a wider scope in that they strive to complement the improvement of state management patterns with economic (strengthening of the "market") and social (strengthening of "self-help forces and third sector") regulative forms".

Two observations of the above observations are particularly relevant in this context: firstly, NPM should not be understood as simple deregulation to the point of privatisation as practised in the 1980s by the neo-liberal governments of the UK and USA. On the contrary, the state and the administration continue to play an important role under NPM. Secondly, reform approaches which incorporate the principles of NPM are not limited to actual administrative structures, as was sometimes the case in earlier processes; they include and affect the entire political system.

Based on this albeit very general perspective, within the theoretical discussion it is possible to identify central elements of NPM which affect the political process (final control and division of tasks), which are based on economic factors such as the market and potential customers (creation of markets and effect control) or which directly relate to the internal organisation and structure of the administration (organisation/management/culture).

With respect to the political process, the NPM concept proposes the clear separation and differentiation of executive and administrative tasks. The effect-oriented administration tries to distribute the roles and **tasks between the actors of the political-administrative system** in a new way. The objective is to reinforce strategic management at political level and, thus, create a clearer distinction from operative responsibility. Thus, in its role as legislator, parliament should define the basic features of policy by means of final programs or framework laws and fix the relevant allocation of funds to policy areas by means of global budgets covering several years. In concrete terms this means that the legislature defines the product groups to be produced by the administration and guarantees their funding. The government in turn decides which offices and departments shall be commissioned to provide the relevant services. As a result of this differentiation, the administration has significant scope for action in the operative implementation of tasks. End control and the corresponding differentiation of tasks between the administration and political control authority is necessary for the implementation of the above-described ideas. At instrumental level this means an integrated service and financial planning, extensive organisational competence for the executive, global budgets and contracts between the executive and the relevant administrative units (Schedler 1996, 160ff).

The central elements of **internal control of the administration** include organisational proposals which are aimed at the decentralisation and simplification of structures and, where possible, perhaps even privatisation (agency) and improved implementation through possible administrative self-organisation. At the level of the management concept, the aim is a leaner administration which is mainly based on quality assurance. Moreover, the new and modified administrative culture should increasingly concentrate on the requirements of potential customers and employees. Furthermore, all administrative action must be directed at effect control. Hence, controlling and periodical evaluation are also necessary to establish whether targets are being achieved. Correspondingly, extensive scope will only be provided in the area of operation if the administration has a global budget at its disposal and is free to decide on the mode of production while being under contract for a range of services.

The concept of New Public Management also includes an economic perspective in that the target groups of a policy are increasingly perceived by the administration as **customers** and the services provided are increasingly tailored to their requirements (cf Schedler 1996, 158f). The idea is also to create markets, and hence competitive pressure, both within and outside the administration. The aim is to achieve a cost-effective provision of services based on a defined range of products with the corresponding product budgets. This can be achieved through competition within the administration, the awarding of contracts to private external suppliers (outsourcing) or through the generation of competition between service providers. A distinction should be made between those who finance a service, buyers and service providers. Customer surveys can be used to ensure that production is tailored to the actual needs of customers.

With respect to the economic calculations, effective and efficient state action requires the implementation of instruments to **control** it. Important activities in this context include: controlling, the corresponding quality assurance and cost calculation and the periodic monitoring of efficacy and efficiency.

This list of management elements shows how the initiatives to modernise the public sector make it possible to introduce new trends. From an international perspective, the modernisation of the public sector is not a homogenous and linear process. It is possible to identify a range of regulative regimes here which also make it impossible to make a precise statement about the optimum direction or corresponding assumptions with regard to efficiency.Table 1 contains a summary of the central elements of NPM linked with its objectives.

Examples of the Reform of Forest Administrations in Germany and Switzerland

As an illustration of reform efforts in forest administrations, we shall present two modernisation projects in Germany and Switzerland. These projects specifically involve structural reform in the Federal German *Laender* of Rhineland-Palatinate and Lower Saxony and the federal Swiss administration's EFFOR 2 and VAFOR projects.

Table 1: Central Elements of NPM

Element	*Content*	*Objectives*
End control	Replaces conditional control	Elimination of excessive control
Division of tasks	Separation of strategic and operative levels	Elimination of excessive control Degree of freedom in implementation of tasks
Organisation	Decentralisation Privatisation Self-organisation	More efficient and flexible administration
Management	Lean administration, Quality assurance	Service-oriented service companies
Administrative structure	Customer and employee orientation	More service orientation, willingness to take decisions
External/internal markets	Competition between service providers	Efficiency
Effect control	Testing of effects, evaluation	Increased efficiency, efficacy

Source: Schedler 1995b, 18-21

The forest administrations in most of the German *Laender* were reformed during the 1990s and a variety of trends were set which reflected the extensive competence at *Land* or regional level in the forest sector. The pressure to reduce costs can be identified as the main motive behind all of the reform measures. In general terms, the scope and nature of task fulfilment was examined and this resulted in the reform of the organisation and function of the administration (Schmithüsen 1998).

In Switzerland, the cantons also have generous scope for action in the area of forest management. As modernisation efforts at federal level are more advanced than the cantonal administrative reforms, we shall present the pilot project on forest subsidy policy (EFFOR 2) and a federal project which is directly aimed at the owners of forests and has set out to promote a stronger customer-oriented focus in forestry operations and the marketing of forest services (VAFOR).

The Rhineland-Palatinate Control Model

Elements of a "New Control Model" are being introduced over the period from 1996 to the year 2000 in the West German *Land* of *Rhineland-Palatinate,*. In this case, the action taken was strongly influenced by administrative reform in the Dutch town of Tilburg, a European NPM Mecca for administrative reformers. The regional forest administration will implement the administrative reform as part of a pilot project for further reforms in the Rhineland-Palatinate administration and is being supported in this task by a commission for the modernisation of the administration, which reports directly to the regional government, and by external business experts. The most important elements of this administrative reform project in Rhineland-Palatinate are:

> Forest policy targets were defined and hence important strategic issues were clarified (Martini 1997, 285). The main objective was defined as "the maximum possible total social utility of forest services for today's society and future generations". In addition to this emphasis on the welfare functions of the state and sustainable use, partial commercial targets were also defined for the so-called "profit area" of the timber industry (Leonhardt *et al*. 1997, 289). In general terms, the

definition of targets and development of a model meant that the focal points for action by the forest administration could be redefined and extended in the direction of forest maintenance, environmental protection and nature conservation. This also enables the separation of the strategic and operative levels and the delegation of operative implementation to the forest authorities.

Similarly, conditional control is replaced by end control due to the definition of new service-oriented and target-oriented budget specifications. Administrative action is no longer controlled via the input (existing resources to be implemented) but via the output (the expected services and targets). Finances are managed by the director of the forest authority who is also responsible for keeping within the allocated budget. Incentives for the economic use of resources were created by a system whereby part of any excess earnings or savings are injected into the budget for the following year (Härtel 1997, 286).

Controlling is of central importance. The budget can be agreed by the ministries and directors of the forest authorities during planning on the basis of the comprehensive data available from all of the forest authorities. Controlling also serves in helping to verify that targets are being fulfilled (Nick 1997, 294). As budget control and controlling can only function if the individual activities and their costs are recorded in detail, both instruments give rise to the increased cost transparency of services (Temme 1997, 298).

With respect to organisational change, the 106 forest authorities in Rhineland-Palatinate were amalgamated to form 88 authorities. This mean an average rise in the area managed by each authority from 7,500 ha to 9,100 ha.

In addition to the clearer definition of targets and the use of end control, incentives for efficient production and customer orientation, the reform in Rhineland-Palatinate also involves the restructuring of the forest authorities.

Structural Reform in Lower Saxony

Reform in *Lower Saxony* was initiated in 1994. As in Rhineland-Palatinate, reform of the forest administration was part of a regional administrative reform programme, although in this instance more impulses came from directly within the forest administration (Janssen 1997, 1116). The main elements of the reform programme in Lower Saxony included the streamlining of the administration and the introduction of a leaner administration through the decentralisation of tasks:

Previously, the organisational structure was divided into three levels and as part of the reform measures the central “district” level (or *Bezirksebene*) was completely abolished. Some competencies were transferred to the lower level, for example matters concerning operative forest management tasks. In contrast, specialised tasks, such as consultancy, surveying, personnel management and marketing, were transferred to the relevant ministry at regional or *Land* level. This meant that the distance between the forest authorities and the ministry was increased, making co-ordination with other instances which were still organised at district level more difficult. However, the advantages of the new system included savings with respect to basic administration, a reduction in the number of official channels and the elimination of bureaucracy. Specialist activity was intensified as a result of the centralised concentration of resources. In terms of personnel, this resulted in more specialists in environmental protection and nature conservation being employed in the ministry (Rijpken 1997a, 1997b).

The increase in the size of the forest authorities heralded even greater change. Of the existing 80 forest authorities, 70 were abolished and 40 new authorities created. The forest territories were also reduced in number and increased in area. The purpose of these changes was to reduce expenditure (Schmithüsen 1998, 3).

Another feature of reform in Lower Saxony was the alteration of the system for the payment of forest workers. In contradiction to what might be expected under the heading of service-oriented administrative form, the service-related component of the forest workers' wages and piecework payments were replaced by a fixed monthly salary. The rationale behind this reform was that it allowed greater flexibility in assigning forest workers to new tasks which are less focused on timber production and also reduced the administrative cost involved in the calculation of the piecework payments. This may have also reduced productivity incentive but another positive by-product of this reform was a reduction in the number of work accidents caused by overmanning (Behrndt 1997).

The services and authoritative functions provided by the regional forest administration were also examined. This reflects the increased target orientation of administrative action and serves in the analysis of unnecessary routines and the improved differentiation of tasks. The instruments of budget control and controlling were not implemented, as was the case in Rhineland-Palatinate.

New Forestry Subsidy Policy in Switzerland

In Switzerland, approximately 200 million Swiss francs are paid by the state to forest owners as forest indemnities and financial aid each year. And the cantons contribute the same amount of public money again (Poffet 1998). As part of an assessment of financial compensation mechanisms between the state and the cantons, in the mid-1990s a group of financial experts were commissioned to examine the efficiency and efficacy of the use of public finances (Frey *et al.* 1996). The following factors emerged as sources of inefficiency, particularly in the forest sector:

Very high indemnities: the payments are so high that they give recipients the impression that the service is cheaper than actually assumed. The perception of the actual costs of a project is, therefore, distorted (fiscal illusion) and which restricts the possibilities for the more efficient use of resources. An average 80% of costs are covered by the state and canton.

Excessive differentiation and detail in regulations: approximately twelve subsidy categories with provisions for different measures exist for the forest sector. This level of differentiation gives rise to complex administration and high transaction costs. Moreover, the distribution of finance is regulated in the Forests Act, the forests decree and more than a dozen *Kreisschreiben* (circulars from the Swiss Forest Agency to the individual offices). In some cases, the cost of administration and monitoring bears no relation to the actual level of contributions.

Unclear targets: the myriad facts relating to subsidies and detailed regulations cause the targets of forest policy to be pushed to the background. There is no clear target formulation for the individual measures which would enable their evaluation.

The Swiss Forest Agency is fully aware of these deficiencies and is hence participating in a pilot project which is aimed at the differentiation of federal tasks and increasing the efficiency of subsidies. EFFOR 2 is a forestry pilot programme for the new regulation of financial federalism. Unlike the old subsidy policy, which financed individual projects on the basis of applications from the cantons, as part of this new financial equalisation, subsidy allocation shall be decentralised, the strategic and operative levels separated and incentives set to achieve more economic use of resources. The keywords for this programme are, therefore, subsidiarity, efficacy and efficiency. The old system of providing subsidies shall be replaced by a system involving contractual agreements or partnership-based relationships. Fulfilment of contracts, and hence the achievement of the target-efficacy of measures, is crucial for the flow of finance. In addition, the costs of individual projects will no longer be reimbursed but the political willingness of the executive to pay for specific projects or forest policy aims shall be established and incentives created for the rational use of resources. The targets, services to be defined, the level of finance and evaluation criteria shall be defined by means of a service agreement between the state and canton. The pilot programme "Nature

Conservation in the Forest" which is being implemented in the canton of Aargau and aims to restore 650 ha of forest area by the year 2001 is an example of such an agreement. A further service agreement exists between the forest authority and the canton of Valais in the area of the "Protection against Natural Hazards".

The advantage of such package solutions is that the canton must provide certain services as part of the fulfilment of targets but it can also decide which projects it finances and how the money is used (Effor2 1997f).

VAFOR

The VAFOR (*valorisation des forêts* = valuation of the forests) project was launched by the Swiss in 1994. The main aim of this project is to provide help and support to forest owners in the marketing of forest products and services. This has been deemed necessary as subsidies and income from timber sales are no longer sufficient to cover the cost of forestry operations. Taking into account the legal and economic framework conditions, VAFOR aims to establish the marketing potential of forest goods and services and to encourage the development of an innovative approach by the owners. The aim of this pilot project is to increase the income of forestry operations from the sale of non-timber products to 25-40% by the year 2010 (Kocher 1997, 192).

In ideal terms, VAFOR is based on the idea that in the past most of the non-market-benefits of the forests were barely remunerated and additional sources of money could be obtained in forestry operations through the marketing of external effects and the redesign and alteration of the characteristics of goods, e.g. the creation of club goods or the use of eco-sponsoring (Kissling-Näf 1999). VAFOR services encompass, therefore, the overall forest service offered by a forestry operation, but not including raw timber production. VAFOR has not only drawn up long lists of potential products and studied the legal and economic environment for the marketing of such products, as part of 15 test operations, it has analysed whether innovative managers can succeed in operating in a service-oriented manner and develop new competitive and cost-effective products. The profitable and marketable VAFOR services exist, however many companies lack the expertise required to market such services (Buwal 1998).

Initial experiences indicate that the direct marketing of private goods is difficult because most of these profitable products are public products and services, e.g. road maintenance etc., which are required by public corporations. Existing use and property rights in Switzerland have emerged as a further restriction (Kissling-Näf 1999). The Swiss Forestry Management Association (*Schweizerische Waldwirtschaftsverband*) was commissioned to continue this pilot project in 1996. The intention is to support the managers of forestry operations and owners of forests by means of further training courses and teach them to respond more actively to users and inquirers and help them gain the necessary expertise in the area of marketing and cost calculation.

Discussion

The most conspicuous feature of the German modernisation projects is the amalgamation of forest areas and the resulting reduction in jobs. In contrast to Germany, forestry in Switzerland has not jet been affected by amalgamations and large-scale job cuts, despite the fact that the small size of forestry operations lies at the root of the inefficiency.

As the two German examples show, the verification of the fulfilment of tasks by the state is linked with organisational reform. End control, differentiation of tasks, leaner administration, decentralisation and increasing economic incentives are also planned. The reform in Rhineland-Palatinate seems to be particularly strongly based on the NPM model and to incorporate the ideal central elements of NPM. The reform processes described in Switzerland are, in contrast, less comprehensive and relate to specific sub-areas in the effect-oriented public management. VAFOR is trying to bring about a stronger emphasis on customer wishes and target groups in local forest operations. EFFOR 2 is concerned with political decision-making processes and allocation of public funding. The efficiency and target orientation of state funding will be improved through end control by means of service contracts. The fact that the full potential for reform of the forest sector in

Switzerland is not covered by these initiatives is obvious. There is further need for reform at the level of company structures, the division of tasks between the different political levels, the differentiation of tasks and control of effects (Kissling-Näf and Zimmermann 1996). The extent to which these issues have already been tackled as part of the cantonal administrative reform initiatives must remain open.

Conclusions

It is not yet possible to ascertain whether the desired effects are actually being achieved by these reforms. It will be necessary to carry out the relevant evaluations in order to establish this. It is, however, possible to formulate the following hypotheses with respect to the effects of NPM:

> For a range of reasons, mentioned at the beginning of this paper, forest authorities in many countries are being forced to implement savings, which in some instances could be described as drastic. As the example in Germany shows, in many cases this results in restructuring and extensive job losses, the social costs of which are very high. The elements of New Public Managements offer the possibility of implementing at least some of the cost-cutting measures without job losses while simultaneously increasing the operational scope for action of the forest administrations (Krott and Sohns 1999).
>
> The clear division of tasks between the actors of the political-administrative system will prompt the forest administrations to describe many of their services as products. By showing what they do, the forest administrations can improve their legitimation with respect to the public and policy in the long term.
>
> The definition of the products and product groups will result in greater transparency with respect to costs. This will make it possible to establish, for example, whether timber production by public companies is cost efficient and how much other services, e.g. nature and landscape protection, tourism and sport, cost. As public services can no longer be cross-subsidised by timber production, the forest administrations must seek new sources of income, for example through increased consultancy activities or joint political lobbying with groups from the nature and environmental protection sectors.
>
> This shift in focus will result in the forest administration working more closely with groups from nature and landscape protection and the leisure and tourism sectors. This will also change the composition of the forest administrations with respect to personnel. The highly specialised staff trained in the forest schools and universities currently found in forest administrations will be replaced by persons with more general qualifications in the areas of biology, the environment and economics.

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The Dynmic of International Forests Regime by the Example of the Intergovernmental Forum on Forests

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Abstract

Despite the failure of the United Nations Conference on Environment and Development and the Intergovernmental Panel on Forests to reach a consensus for a global forests convention, by the start of the twenty-first century a global forests regime is in place. The paper uses regime theory as a tool to explain the formation of the regime. It is argued that the formation of the regime can be traced to 1994 when actors involved in intergovernmental negotiations sought to engage in integrative bargaining rather then the distributive bargaining that characterised forest negotiations in the early 1990s.

The forest regime does not however embrace solely governments and intergovrnmental actors. The normative framework of the regime, which is best seen as a mix of hard provisions (namely international legal instruments with a forest-related mandate) and soft provisions (namely non-legally binding options) both shapes and is shaped by non-governmental organisations and business actors.

Keywords: International forest regime, Intergovernmental forum

Fragmentation of Forest Resource Agencies and Programs: Challenges Facing State and Federal Governments in the United States

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Abstract

Confirming the integrity of large forest ecosystems and ensuring their ability to provide for a sustained and integrated set of goods and services is of increasing concern to managers and users of forests. Troublesome, however, is the reality that public programs focused on forest ecosystems are often fragmented among many levels of government and among many agencies within any one level of government. To appreciate the nature and extent of this fragmentation, one needs only look at the large number of government agencies (state and federal level) in the United States that have influence over the use and management of forests. Needed is research that will enable the diverse landscape of government agencies to better connect in a holistic sense with the forests they are attempting to sustain and the services they seek to provide.

Keywords: Forests, Organization, Government, Agency, Coordination

Ecosystem and Institutional Consistency

Confirming the integrity of large forest ecosystems and ensuring their ability to provide for a sustained and integrated set of goods and services is of increasing concern to managers and users of forests. Troublesome, however, is the reality that public programs focused on forest ecosystems are often fragmented among many levels of government and among many agencies within a particular level of government. To appreciate the nature and extent of this fragmentation, one needs only look at the large number of government agencies in the United States that have influence over forests (for example, pollution control agencies, departments of commerce, environmental quality boards, departments of agriculture, economic development agencies, departments of health); the differences in agencies' authority to influence forest use, management and protection (for example, protection of endangered species, management of air pollutants, regulation of forest practices, certification of pesticide use); the variation in agency capacity to exercise authority over forest conditions and to serve various clienteles (for example, size of budgets, type of program authority); and the diverse sets of interests that struggle to secure, often for individual gain, an agency's programmatic attention (for example, timber, wildlife, water, recreation).

A major theme in the literature of public administration is that government agencies should be organized and coordinated in manners that enable them to function effectively (Denhardt 1991, Dresang and Gosling 1999, Galbraith 1973, Garnett 1980, Gibson *et al*. 1994, Reitz 1987). Over the years, however, public environmental and natural resource agencies have become fragmented in their missions and organization, often looking at forests and the opportunities they represent as ecosystems that are easily divisible and readily amenable to a large number of often unrelated programmatic activities (Haskell and Price 1973, General Accounting Office 1996, Jenks and Wright 1993, Rabe 1986). This fragmentation is not the result of any master plan. Rather it occurs incrementally as new agencies are created and reorganized, new policies and programs are established, and additional levels of government (federal, state and local) focus attention on the use and management of forests. Although compelling cases have been made for more integrated approaches to safeguarding the integrity of forest ecosystems, forceful and conceptually sound arguments have yet to be articulated for a more integrated institutional setting – a setting that would complement the holistic approaches being suggested for sustaining the physical attributes of forest ecosystems (Cortner *et al.* 1996, General Accounting Office 1994a, Rabe 1986). Useful research actions in this direction would be to secure an understanding of the existing institutional landscape and then to suggest a modest but meaningful research agenda.

Government Organizational Patterns

State Government Agency Landscape

States have a long tradition of establishing government entities (variously identified as agencies, bureaus, offices, departments, commissions and councils) through which public programs are focused on forest resources. Fostered initially by federal-level forest resource laws in the 1920s (notably the Clarke-McNary Act of 1924), and subsequently augmented by a variety of state and federal forest and environmental laws in the 1970s, states have generated an especially rich assortment of government organizations that are responsible for programs involving forests. Consider *state government organizations* in the *executive branch of government* whose policies and programs have potential for *statewide influence* (however large or small) over the use, management and protection of forests

<u>Frequency and Type of Entities</u>. Cabinet level entities are generally the highest organizational level in state government and are variously labeled as agencies, commissions, departments or offices. In 2000, states had seen fit to create nearly 320 cabinet-level entities that are responsible in some manner for influencing the use and condition of forest resources (Table 1). The average number of cabinet-level entities per state is approximately six, with states in the West having, on average, the most per state, namely 7.4. The most common name assigned to cabinet-level entities is "department."

Cabinet-level entities have been divided into at least two organizational tiers through which cabinet level legal mandates and missions are accomplished. At the first tier sub-cabinet level, states have created nearly 591 entities that implement programs affecting the use, management and protection of forests (Table 1). Official names assigned these entities are diverse and include "division," "office," "bureau," "department," and "program." The most commonly used name is "division," followed by "bureau." The second tier organizational level involves more than 200 government entities, most of which have been assigned names that duplicate labels assigned to first-tier entities.

State governments have also seen fit to establish governing or advisory entities. Responsibilities assigned to such bodies can range from providing advice on program development and implementation, to being legally responsible for directing and managing a particular unit of government. Often, but not always, they are composed of interested citizens appointed by a state's governor or by the chief administrator of the entity to which the body is to provide advice or exercise governance. In 2000, states had created 204 governing or advisory bodies, variously labeled as boards, councils, committees or commissions (Table 1).

<u>Functional Orientation of Entities</u>. Executive branch units of state government that implement polices and programs affecting forests can do so in a number of ways depending on their functional orientation. Some are responsible for long-standing policies and programs that have a very direct focus and impact on forests. An example is a state's Division of Forestry within a Department of Natural Resources. Others entities have broader functional responsibilities that can directly as well as indirectly involve forests. For example, the water quality division of a state's pollution control agency may exercise authority over forest practices to the extent that the division directly affects water quality, while the strategic planning division of a state's department of economic development may only indirectly influence expansion of wood-based enterprises through broad planning processes that affect business development statewide.

Table 1. Governing or Advisory Bodies to Executive Branch Units (all levels) of State Government Affecting the Use, Management or Protection of Forests in the United States, by Region, Name and Number of Units. Year 2000.

Executive Branch Unit	Region			Total
	North	South	West	
• **Cabinet Level**				
Agency				11
Commission	7	1	3	14
Department	2	9	3	211
Office	66	47	98	57
Other	27	14	16	25
Total	9	10	6	318
• **Sub-Cabinet Level** (first tier)	111	81	126	
Department				34
Division	12	16	6	377
Bureau	128	95	154	51
Office	46	4	1	62
Program	37	18	7	16
Section	1	1	14	7
Service	5	1	1	5
Survey	4	-	1	3
Unit	3	-	-	2
Other	2	-	-	34
Total	11	11	12	591
• **Sub-Cabinet Level** (second tier)	249	146	196	
Bureau				56
Division	41	-	15	94
Office	49	38	7	28
Other	25	2	1	23
Total	17	-	6	201
• **Governing-Advisory Bodies**	132	40	29	
Board				77
Council	42	11	24	37
Committee	23	6	8	17
Commission	9	5	3	68
Other	26	12	30	5
Total	3	2	-	204
	103	36	65	

For purposes of furthering understanding of the primary functional orientation of state government entities having influence over forests, functions can be categorized as involving resource use and management; service, assistance and enforcement; promotion and development; health and safety; and environmental and resource protection (Table 2) Within any one of these broad categories there may exist a host of more specific functions.

Of 341 cabinet-level entities identified, 44 percent engaged in functions involving resource use and management, while 21 percent (next most frequent) involved promotion and development activities (Table 2). Within the former, agriculture (45 entities so involved) and conservation and natural resource cabinet level units (35 entities) are most common. In the promotion and development major category, tourism units (11 units) and business promotion and economic development units (51 entities) dominate. At the first-tier sub-cabinet level, resource use and management functions also dominate (42 percent of 635 entities), with environmental and resource protection functions (25 percent of entities) being the second most common functional orientation. Within all major functional categories, the most common orientation of entities at the sub-cabinet level (first tier) is (in descending order) fish and wildlife (71 entities), business and economic development (46 entities), parks and recreation (43 entities), water quality and pollution prevention (41 entities), recycling and waste management (35 entities) and information, information management and public affairs (35 entities).

Governing and advisory bodies are heavily oriented toward functions involving resource use and management (61 percent of 204 such bodies) (Table 2). For all functional orientations, most common were boards, councils or commissions that focus on soil conservation (27 bodies), with the next most frequent orientations being fish and wildlife (17 bodies), business and economic development (17 bodies), environmental protection (16 bodies) and forests and forestry (14 bodies).

The crosscutting nature of state government agencies focused on forests can be further highlighted by the diversity of entities implementing programs to monitor landowner and timber harvester compliance with state required or suggested (voluntary) forestry practices. Of 54 state government organizations involved in compliance monitoring in 1997(in 34 states with compliance monitoring programs), 43 percent (23 agencies) were other than a state's lead public forestry agency – most commonly a state's environmental or pollution control agency. In the North and West regions of the United States, the category of "other organizations" actually exceeded the number of lead state forestry entities engaged in compliance monitoring. In only 20 states was the state's lead forestry entity identified as the only entity involved in the monitoring of compliance with recommended forest practices (Ellefson *et al.* 2000).

Gathering and management of information also suggests diverse entity (public and private) involvement in some aspect of managing and protecting forests. In 1999, nearly 400 public and private entities at the state level were engaged in gathering, managing or distributing information about forests (National Association of State Foresters 1999). An average of eight organizations per state were so engaged, with some states identifying 18 or more different entities exercising an information role pertaining to forest resource use or management. Commonly focused on by these many entities was information about protected lands, insects and diseases, timber harvest rates, types and size of forestry programs, educational activities, enforcement actions, legal requirements (laws), and forest practice applications. The various entities were most consistent in their information gathering activities when they focused on basic forest resource information (area and forest type) and on agency implemented forestry programs (budgets, personnel). Least consistent across agencies were information gathering efforts associated with social, economic, legal, and institutional conditions involving forests.

Federal Government Agency Landscape

The federal government also has a varied organizational landscape that expresses the national interest in the use, management and protection of forests. As occurs at the state level, the organizational landscape of the federal government is also composed of many departments, bureaus, divisions and commissions that are large in number and have varying degrees of influence over forests (Government Printing Office 1999, National Research Council 1998). To date, a careful and holistic examination of this landscape has yet to be completed. However, informative examples depicting important parts of the federal organizational landscape involve wetland programs, federal land management, strategic and program planning, and rural development initiatives.

Table 2. Executive Branch Units of State Government Affecting the Use, Management and Protection of Forests in the United States, by Primary Functional Orientation and Organizational Level. 2000.

Primary Functional Orientation	Cabinet or Sub-Cabinet Level Executive Branch Units			Governing or Advisory Bodies to Executive Branch Units
	Cabinet Level	Sub-Cabinet Level First Tier	Sub-Cabinet Level Second Tier	
• Resource Use and Management				
Agriculture	45	9	1	8
Conservation, Natural Resources	35	17	3	13
Fish, Wildlife	22	71	26	17
Forests, Forestry	11	32	11	14
Mines, Minerals, Reclamation	3	6	9	3
Natural and Historical Heritage	4	8	8	9
Parks and Recreation	14	43	10	9
Public Land, Real Estate	6	17	8	5
Soil Conservation	4	17	5	27
Water Resources, Watersheds, Wetlands	5	28	11	14
Other	1	17	1	5
Total	150	265	93	124
• Service, Assistance and Enforcement				
Administration, Personal, Operations	3	16	5	-
Information, Education, Information Management, Public Affairs	6	35	17	5
Law, Legal Counsel	51	21	3	-
Occupational Licensing	1	2	3	4
Planning, Budgeting, Review, Analysis	1	14	13	1
Regulation, Permits, Enforcement	-	24	9	4
Other	3	14	2	2
Total	65	126	52	16
• Promotion and Development				
Business, Economic Development, Community Affairs	51	46	5	17
Revenue and Taxation	6	4	-	-
Tourism	11	28	3	3
Transportation	2	-	-	-
Other	-	-	-	-
Total	70	78	8	20
• Health and Safety				
Public Health	9	8	-	-
Employment & Work Conditions	3	2	-	-
Other	-	-	-	-
Total	12	10	-	-
• Environmental and Resource Protection				
Air Quality, Pollution Prevention				
Energy Conservation	-	30	11	9
Environmental Protection, Management	3	11	4	4
Protection (pesticides, fire, insects)	40	19	1	16
Recycling, Waste Management	-	16	3	3
Water Quality, Pollution Prevention		35	9	7
Other	-	41	12	5
Total	1	4	4	-
	44	156	44	44
Total	341	635	197	204

Forest and Related Wetland Management. At least 36 federal agencies implemented wetland management and protection programs from 1990 through 1997 (General Accounting Office 1998). In many cases, these programs involve forested wetlands or mitigation activities involving forests. Specific program activities involved acquiring, regulating, restoring, enhancing, mapping, inventorying, delineating and conducting research related to wetlands. Annual average total funding (1990 through 1997) of the 36 programs ranged from a low of $508 million to a high of $787 million (in constant 1997 dollars), while each year's staffing ranged from 3,300 full-time equivalents to more than 4,300 full-time equivalents. Six of the 36 agencies accounted for 70 percent of the funding and 65 percent of the staffing.

Federal Land Management. Federal agencies are responsible for management and protection of 262 million hectares of land (82 million hectares forested) or about 30 percent of the total land area in the United States. Six federal sub-cabinet level entities are responsible for most of this federal land, namely the USDA-Forest Service, DOD-Corps of Engineers, USDI-Bureau of Land Management, USDI-Bureau of Reclamation, USDI-Fish and Wildlife Service, and USDI-National Park Service.

The laws directing these entities require them to implement quite different land management strategies. In specific agency cases examined in 1995, 31 different land management and related programs were being implemented (with little commonality), even though the entities were responsible for fundamentally similar federal interests in natural resource management, habitat conservation, and rangeland management (General Accounting Office 1997). Examples of similar resource and management issues often receiving quite different program approaches were ecosystem planning and monitoring, wild fire management, fish and wildlife habitat management, watershed improvement, environmental education, riparian area management and protection of threatened and endangered species.

Strategic USDA-Forest Service Plan. The extent of federal multi-agency responsibilities involving forests is also highlighted by the USDA-Forest Service's Strategic Plan 2000 (draft) and the agency's intent to coordinate (at an appropriate level) with 31 other federal entities that have crosscutting responsibilities important to the Plan's successful implementation (USDA-Forest Service 1999) (Table 3). Coordination at the cabinet level will involve five departments, at the Office of the President level two entities, at the bureau level 17 entities, and seven independent agencies. These departments, offices, bureaus and independent agencies are identified by the USDA-Forest Service as important entities with which to coordinate because of their programs' capacity (however large or small) to influence the use, management and protection of forests. The complex organizational landscape facing plan implementation is obvious, and becomes even more so given that entities may be engaged in more than one functional area. For example, implementation of the agency's Clean Water Action Plan will involve coordination (at the appropriate level) with 15 different entities, namely three departments, 10 bureaus, and two independent agencies. The forest health aspect of the Plan's implementation will involve 14 entities, namely one department, 10 bureaus, and three independent agencies.

Rural Development Programs. Rural forested regions of the United States are frequently of concern because of their need for economic development. The entities and programs established to address the latter provide an additional example of the organizational diversity influencing the condition and use of forests. Between 1983 and 1992, rural forested and agriculture areas in the United States received rural development assistance from about 800 different programs administered by five different cabinet-level departments, and the Small Business Administration and the Appalachian Regional Commission (General Accounting Office 1994b). The intent of these programs was to influence economic well-being by focusing on issues involving agriculture, natural resources, human resources and infrastructure development (e.g., roads, communication). Of the approximately 800 programs, 109 focused directly on natural resources and agriculture and involved an investment of $288 billion over the 10-year period.

Table 3. USDA-Forest Service Coordination with Selected Executive Branch Entities of the Federal Government on Functions Concerning Strategic Plan Implementation Affecting Forests in the United States, by Functional Orientation and Level of Entity Engaged in Coordination. Year 1999.

Functional (Program) Orientation of Coordination Effort as Defined by USDA-Forest Service	Level and Number of Executive Branch Entities		
	Department	Bureau	Independent Agency
• Air and Water Resources			
Air Quality			
Clean Water Action Plan	1	7	1
Riparian Areas	3	10	2
Safe Drinking Water	2	13	1
Water Studies (MOU)	-	-	1
Watershed Protection and Restoration	-	2	1
Wetlands	-	2	1
• Recreation and Tourism	-	4	-
National Recreation Reservation System			
National Scenic Byways	-	4	-
Recreation Fee Demonstration	-	2	-
Recreation Information	-	4	-
Recreational Fishing	-	3	1
Tourism Planning	1	4	1
• Information, Planning & Monitoring	-	2	-
Conservation Planning			
Ecological Monitoring	1	6	2
ECOMAP	-	2	-
Forest Inventory Analysis & Forest Health Monitoring	2	9	2
Global Change Research	-	2	-
Long-Term Ecological Research Network	1	3	3
Wilderness Research (Leopold Institute)	-	1	1
• Special Uses and Sustainable Management	-	5	-
Environment & Natural Resources (committee)			
Sustainable Forest Management	2	4	4
Wilderness Management	-	6	1
Wild and Scenic Rivers	-	4	-
• Protection	-	4	-
Amphibian Declines and Deformities			
Forest Health Protection	3	7	5
Invasive Species	1	10	3
Wildland Fire (Interagency)	1	10	1
• Reclamation and Maintenance	1	5	2
Abandoned Mine Reclamation			
Minerals Management	-	2	1
Road Construction & Maintenance	-	4	-
	-	2	-

Note: Bureau information includes the USDA-Forest Service. USDA-Forest Service may coordinate with the same executive branch unit on more than one functional area.
Source: Adapted from *Draft USDA Forest Service Strategic Plan (2000 Revision)* by USDA-Forest Service, Washington, DC. FS-652. November 1999.

Potential Avenues for Future Research

The organizational landscape affecting forests is at times a confusing array of agencies and programs that have been fostered by overlapping legal mandates which often do not holistically connect government agencies with broad interests in the ensuring integrity of forest ecosystems. Needed is further understanding, through research, of the organizational patterns involved in the delivery of forest resource policies and programs. Such research should be designed to foster organizational structures that are less fragmented and more capable of effectively interfacing with societal interests in the sustainability of forest ecosystems at both large and small scales. Potential strategic directions for such research include:

Catalyst for Establishment of Organizations. What factors stimulate interest in establishing a government entity which has potential to influence the condition and use of forests (for example, state response to citizen demands, organized interests, or federal initiatives) (Hanf and Scharpf 1978)?

Rationale for Establishment of Specific Organizational Designs. What processes and criteria determine the specific structure of an entity (for example, overarching department versus a landscape of many fragmented entities) that potentially can affect the condition and use of forests(Zumeta and Ellefson 1999)?

Linkages Between Various Levels of Government. What organizational mechanisms (involving, for example, finances, regulations, technical assistance) might better link organizations at various levels of government so as to improve program efficiency and yet accomplish local, state, regional and national interests in forests (Wright 1982)?

Mechanisms for Coordinating Same or Similar-Level Entities of Government. What structures or processes (for example, formal boards and commissions, comprehensive planning processes, memorandums of agreement) are most effective in focusing the forestry activities of disparate entities operating at a specified level of government (Bardach 1998, Kilgore and Ellefson 1992)?

Conditions Fostering Innovation in Organizational Structure. What conditions (for example, presence of leaders-innovators in government, access to new research-generated information) foster the establishment of especially creative and effective organizational entities focused on forests (Galbraith 1973)?

Organizational Development over Extended Periods. What learning experiences result from long-term actions (many decades) involving the design, establishment, implementation and possibly abandonment of various organizational structures used to delivery certain programs to forests and those that depend on them (for example, forest protection, forest planning)?

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Forest Policy Development between Globalisation and Localisation

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Abstract

Forest policy development is presently caught between two contradictory tendencies. On the one hand forest issues are increasingly becomiong globalised with concomitant calls for global governance through international conventions, regulations and programmes. At the other hand there is put much emphasis on the need to enhance local participation in the management of forest resources and to formulate location-specific forest management plans on the basis of negotiated consensus of the various stakeholders concerned.. At a first glance these tendencies seem to be inconsistent. In this paper it can be argued that the two tendencies can be reconciled. The paper summarizes the major developments concerning global forest policies and indicates how these incorporate the principle of local community involvement. Such involvement is predicated on the creation and empowerment of local institutions for governance and control over forest resources. Forest policy makers often assume that the implementation of the global policies proceeds in a linear process, but forest policy researchers increasingly consider that in transferring policy decisions to local levels interface situations occur. Such interfaces are often of a conflicting nature with policies being reshaped into new meaning by the local actors. In order to understand the nature and outcome of such interface situations, forest policy researchers should focus on empirical reality rather than define normative principles as well as develop new theories for better understanding of the processes involved.

Keywords: Global forest policies, Decentralisation, Institutional change, Policy interfaces

Introduction

Forest policy development is presently caught between two contradictory tendencies. On the one hand we are witnessing a globalisation of issues, and a call for concomitant global governance through international conventions, regulations and programmes. On the other hand there is put much emphasis on the need to enhance local participation in the management of forest resources and to formulate location-specific forest management plans on the basis of negotiated consensus of the various stakeholders concerned. Such participation is predicated on the creation and empowerment of local institutions for governance and control over forest resources.

At a first glance these tendencies may seem to be inconsistent. However, it can be argued that the two tendencies are not necessarily inconsistent, but that they can be reconciled provided that they are applied in a mutually consistent manner. The aim of this paper is to summarise the major developments concerning global forest policies and to indicate how these incorporate the principle of local community involvement. Also interfaces between such global policies and local action will be indicated. Finally it will be discussed how the increased interest in stimulating both globalisation and localisation processes poses new challenges to forest policy research.

Trends Towards Globalisation of Forestry Issues

In the past the formulation and implementation of forest policies were mostly considered to be national tasks. Since the last two decades, however, many international initiatives to stimulate effective forest conservation and development have been undertaken (Grayson 1995; Humphreys 1996; Mayers & Bass 1999). For instance in 1983 the International Tropical Timber Agreement was negotiated which resulted in the establishment of the International Tropical Timber Organisation (ITTO). And in 1985 the Tropical Forests Action Programme was launched. A major event crystallising international concerns on forestry was the 1992 UN Conference on Environment and Development (UNCED). During this conference serious consideration was given to the need to formulate an International Convention on Forests. No agreement on such a convention was reached, but instead a (legally) Non-binding Statement of Forest Principles was formulated. Furthermore, two conventions (the UN Convention on Biological Diversity and the UN Framework Convention on Climate Change) were adopted at the UNCED; both of these conventions include elements on forest conservation and management. After the UNCED many international meetings have been held to further elaborate the UNCED agreements and to review their implementation, e.g. by the Intergovernmental Panel on Forests (IPF) and the World Commission on Forests and Sustainable Development (WCFSD 1999).

This growing international concern about forests is predicated on three major global concerns:

- Concerns about global environmental problems and need for environmental and biodiversity conservation;
- Concerns about just international economic relations and international trade;
- Ethical concerns as reflected in the principles of human rights, fulfilment of basic human needs, international development assistance and good governance.

Each of these concerns impacts on thinking on forestry and together have resulted in the formulation of international norms for forest management (Table 1). For instance, the environmental concerns resulted in increased international attention to the need for forest conservation and their sustainable management. The concerns about a just regulation on international trade resulted in the formulation of the International Tropical Timber Agreement, the first international trade agreement explicitly incorporating the notion that the production of internationally traded goods should be done in an ecologically sustainable way. As a result of this Agreement the idea of the need of certification of internationally traded timber having been produced in a sustainable way became accepted. The implementation of this idea was strongly stimulated when in 1993 an international NGO coalition formed the Forest Stewardship Council as an independent organisation to accredit timber certification programmes.

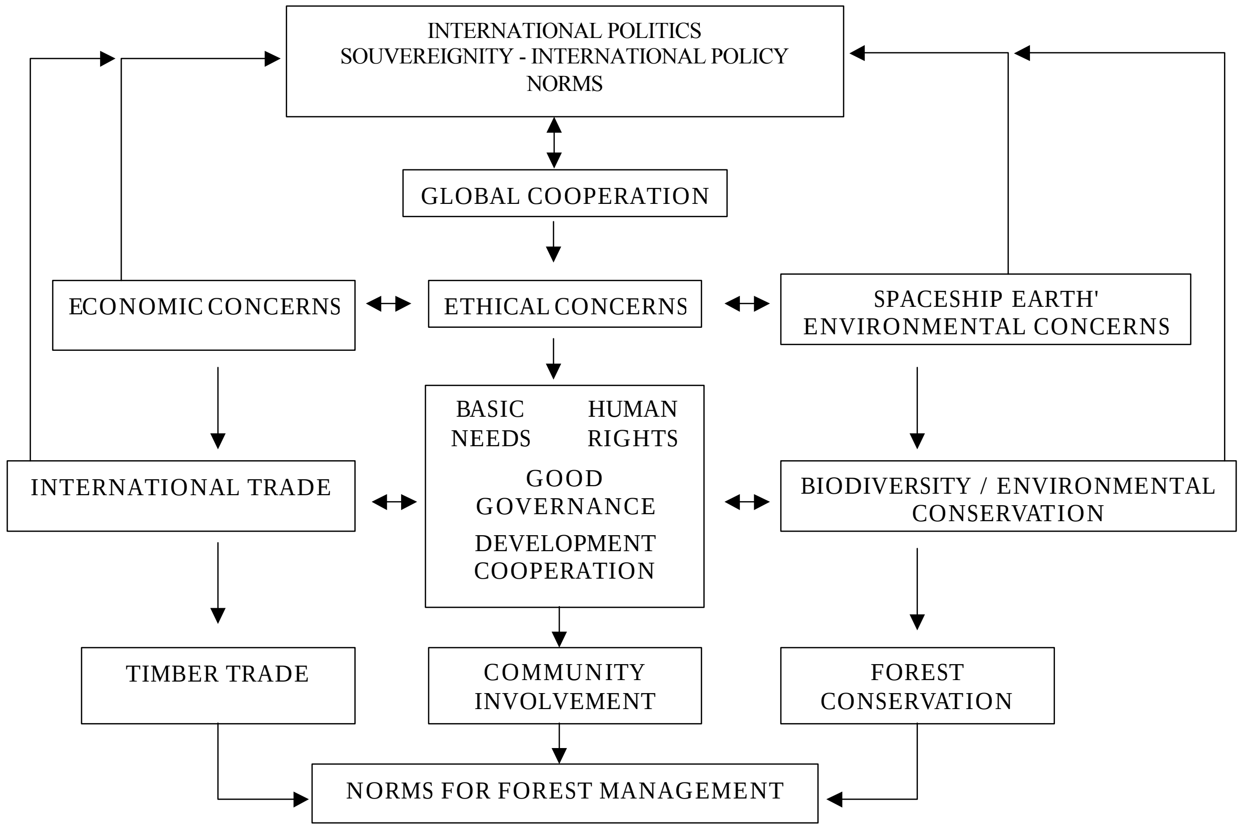
In addition to these global concerns regarding the state of forests, forest policy is also confronted with other trends towards globalisation. In this respect, the trend towards globalisation of markets is a major issue. The discussions within the World Trade Organisation (WTO) on trade liberalisation illustrate this trend as well as the many questions about how to balance environmental concerns with the principle of free trade.

Trend Towards Localisation of Forestry Issues

In addition to this trend at globalisation of forestry issues also a trend towards localisation of forestry issues can be discerned. In fact, the need to adjust forest management to local conditions is an explicit issue in many of the global discourses regarding forestry development. This trend towards localisation is predicated on global ethical concerns regarding fulfilment of basic needs, human rights and good governance. These concerns resulted in increasing attention being given to the need for community development and participation of local people in forest management. As a result, most global forest policies recognise that

- Forest management should maintain or enhance the flow of benefits from forest resources, with access generally perceived as just by all stakeholders;
- The voice of all stakeholders must inform forest management with all stakeholders having an acknowledged right and means to participate in equitable forest management (Pierce Colfer *et al*., 1995).

Table 1 Concerns resulting in the formulation of global principles for forest management



These perspectives are demonstrated by the following examples of principles incorporated in international agreements on forestry:

> "Indigenous people and their communities, and other local communities, have a vital role in environmental management and development because of their knowledge and traditional practices. States should recognise and duly support their identity, culture and interest and enable their effective participation in the achievement of sustainable development" (Principle 22 of the Rio Declaration on Environment and Development).

> "The legal and customary rights of indigenous peoples to own, use and manage their lands, territories, and resources shall be recognised and respected". (Principle 3 of Forest Stewardship Council principles for sustainable forest management)

These perspectives are not only based on normative commitments, but also on the understanding that sustainable forest management is only feasible in where all concerned stakeholders are involved. For instance, in a recent policy review seven desirable processes to achieve good forest policy, were identified (Mayers & Bass 1999). These policy processes included:

> A forum and participation process aimed at understanding multiple perspectives and needs, negotiating 'deals' between the needs of wider society and local actors, and initiating partnerships.

> Devolution of decision-making power to where potential contributions for sustainability is greatest, because decisions are best made and implemented at the level where the trade-offs are well-understood and there is capacity to act and monitor.

It is important to recognize that the formulation of such global principles take place in an international political arena. In this arena the parties are often concerned with questions about international relations, e.g. how to balance the setting of international norms with the principle of national sovereignty. The agreements which are reached are mostly primarily based on international political considerations (e.g. see Kolk 1996) rather than on operational considerations. Consequently, the agreed principles are often of a general nature and they need to be further elaborated before they can be applied in practice.

Decentralisation of Forest Management Control

As a result of the global agreement on the need of forestry becoming more responsive to the forest-related needs of local communities and at enlisting active community involvement in forest management, these ideas have by now been incorporated in many forestry development programmes. These developments have been most pronounced in tropical countries (Mayers & Bass 1999; Wiersum 1999), where they have been stimulated by both national governments and international funding agencies for development co-operation. A basic consideration in many development programmes focusing on the stimulation of community participation in forest management is often that such local involvement can only become accomplished by decentralisation of forest management control. This reflects the general view of considering decentralisation as an essential means to achieve sustainable development. This view was described as follows in the Brundtland Report (World Commission on Environment and Development):

> "The pursuit of sustainable development requires a political system that secures effective participation in decision-making... This is best secured by decentralising the management of resources upon which local communities depend, and giving these communities an effective say over the use of these resources. It will also require promoting citizen's initiatives, empowering peoples' organisations, and strengthening local democracy “(WCED, in Hobley 1995).

Various common policy assumptions support the view that decentralisation is a major prerequisite to improve sustainable forest management:

- Governments often lack the personnel and financial means to effectively control and manage all forests areas, and therefore they should enlist the assistance of local communities for doing so.
- Considering the great variety in ecological and socio-economic conditions, forest conditions are nowhere exactly the same; local people can best take account of such specific local conditions.
- Local communities who are directly dependent upon forests products and services; therefore they can be expected to have a greater interest to carefully manage these forest resources than government officials who do not have such relations of direct dependency on forest resources.
- Community control of forest resources and their accountability in managing these resources will increase in the case that local communities have the rights to use and manage the forest for their own purposes.
- A more equitable distribution of the benefits of forests can best be assured by involving the people who are most dependent on forest resources directly in the process of decision-making on and implementation of forest management plans.

In general these assumptions reinforce each other, although they are not necessarily based on similar normative perspectives. For instance, in the first assumption local involvement is mainly considered as a pragmatic instrument to fulfil management decisions which have already been made by the government. In contrast in the last assumptions local involvement is not considered as a tool for more effective forest management, but rather as a basic objective for community development.

In addition to such different perspectives on the reasons to stimulate decentralisation, there also exist different interpretations on what decentralisation precisely involves. The concept of decentralisation may be interpreted in the following ways (Mayers pers.com.):

Deconcentration:	transfer of decision-making powers within the administrative structure, i.e. downwards extension of authority to the "grass roots".
Delegation:	transfer of authority from an administrative service to a semi-public, non-governmental organisation (NGO) or private company.
Deregulation:	(partial) lifting of regulations imposed by a public authority on a sector or activity.
Devolution:	transfer of power from a larger to a smaller jurisdiction, e.g. transfer to local communities of decision-making over forest resources on their lands.
Privatisation:t	ransfer of ownership or management of resources from public to private entities, either directly or through parastatal institutions.

From these different interpretations of the meaning of decentralisation, it can be concluded that decentralisation involves two major institutional dimensions. In the first place it involves Deconcentration or organisational change by extending the governmental structure downwards. Such Deconcentration should enable the officials to be more responsive and more adaptable to community needs than is the case with a concentration of administrative power and responsibility in a central government. However, the downward extension of state bureaucracy does not automatically bring with it such adjustment to local realities. Instead, it may lead to the consolidation of state power over local communities (Hobley 1995). Consequently, in order to involve local communities better in the process of decision-making on forest management, not only a deconcentration of government bureaucracy is needed, but also a bureaucratic reorientation regarding the tasks, roles, attitudes and behaviour patterns of the government officials. Such reorientation will involve a (partial) devolution of government power of decision-making on forest management to local communities, as well as the deregulation of government regulations regarding forestry. It may also involve a certain amount of delegation of authority from the forest service to other organisation such as non-governmental organisations (NGOs).

Interfaces between Global Policies and Local Action

As discussed above, internationally the idea is gaining ground that local communities must participate more actively in the process of decision-making on community forestry development. In order to implement this idea, it will be necessary to decentralise state government control over forest management. However, the globally agreed principles do not indicate what form of decentralisation should take place and it is left to individual governments and/or forestry development programmes to decide how to implement the process of localisation.

In trying to operationalize the global principles into local action, an important factor to be considered is how one envisages the relation between policy formulation and implementation. In the circuit of international forest policy and development often there is the view that there exists a linear process in policy formulation and implementation. According to this view policy decisions are formulated at (inter)national level and transferred through some stages of geographic-administrative echelons to the local 'target groups' or 'beneficiaries'. Policy researchers increasingly question whether this view regarding policy implementation does justice to reality. Increasingly they consider that in transferring policy decisions interface situations do occur. Such interfaces are "critical points of intersection or linkage between different social systems, fields of social order where structural discontinuities, based upon differences of normative value and social interest" (Long 1989). This arena of interactions is often of a conflictive nature: the interfaces reflect differing and often conflicting life worlds. At such interfaces the international or state development policies are reshaped into new social meanings by the interpretation and strategies of local actors (Long 1989). In this view, local actors are not perceived as mere 'beneficiaries' of development policies, but people having their own values, interests and frames of reference, a world endowed with a diversity of interests and differential responses to external influences. These worldviews are unlikely to fundamentally coincide with the world of the international organisations or government bureaucracies. Consequently, policy interventions may take a very different shape to those which might be expected from linear translations of policy to. And instead of focusing on linear continuities one should rather focus on the discontinuities resulting from the interactions of the different parties involved and the need to effectively reshape global policies into local practices based on social values of local actors. implementation (Long & Van der Ploeg 1989).

When considering the process from global policies to local action at least two major interfaces can be identified: (i) national policies, (ii) field level government staff.

As demonstrated by the discussion on decentralisation, a first critical point between global principles and local action occurs at the level of national states. It is at the level of national policy that major decisions have to be taken which local groups should be involved in the implementation of community forest management and how to implement such schemes through a process of decentralisation. For instance, it needs to be decided whether the process of decentralisation should primarily involve a deconcentration within government administration, a delegation of government power to other organisations, or a devolution of power to community groups. It also needs to be considered to which groups in society control over forest utilisation and management should be transferred, and whether the process of devolution of power needs to be accompanied by a process of deregulation. This all means that for the implementation of global principles they have to be elaborated and incorporated into national policies (Mayers & Bass , 1999).

The elaboration of a proper national policy system indicating which groups of people should be entitled to participate in the process of forest management decision-making and control is of special importance, because effective forest management requires that not only clear objectives are set for forest management, but also that proper control is exercised over the utilisation of forest resources and their management. In order to be able to exercise such control, decisions must not only to be taken on how many forest products can be collected and on which management practices should be implemented, but also on who is entitled to the forest products and who is responsible for carrying out the management practices. The basic assumption for stimulating community involvement in forest management is that proper forest management can best be assured by effective linking of entitlements to forest with responsibilities to maintain these forests (Borrini-Feyerabend, 1996). A major prerequisite for this assumption to come true is that it must also be identified who holds no entitlements to forest utilisation and what means can be used to effectively control these (groups of) people from (mis)using forests. Local communities are often not in a position to realistically address such issues, and it remains a major government task to tackle them.

The second major critical point between global principles and local action concerns the position of the field level staff of the forest service (Wiersum & Lekanne dit Deprez, 1995). When considering the process from policy making to implementation as a linear one, the local forestry agent is normally perceived as the link between the service and the local population. His task it is to strengthen community participation in forest management by 'educating' villagers to carry out the management practices as deemed needed by the professional staff of the forest service. In this linear model local communities are considered as a "target group" whose awareness about the need for forest conservation and management needs to be raised through extension. The conceptualisation of relations between government officials and local communities in such unilinear terms brings with it that the concept of decentralisation being interpreted in terms of downward extension of the state bureaucracy. And the tasks of the forestry agent are therefore to act as a technical implementator of government policies.

A quite different view on the role of the forestry agent emerges from the notion of the process of policy formulation to implementation being characterised by interfaces. This view put less emphasis on the forestry agent in his capacity as implementor of the policies of the forestry service - including the donor-sponsored projects - and more on his role to negotiate conflicts which arise of the different values and interests between the state officials and local communities (Wiersum & Lekanne dit Deprez, 1995). In this view the task of the forestry agent is essentially related to the assumption that the development of community forest management involving a process of democratisation and the recognition of customary rights. The local population is perceived is that having a world of its own, with its own values, interests and frames of reference, which do not necessarily coincide with those of the government bureaucracies. Consequently, the role of the forest agent should not be one of 'educating' local communities, but rather to facilitate local decision-making on who should be involved in forest utilisation and management. In this case, the role and tasks of the forestry agent are defined by the notion of the decentralisation process incorporating the aspect of devolution of power rather than only Deconcentration of state authority.

Conclusion

Forest policy development is presently caught within two seemingly contradictory tendencies. On the one hand we are witnessing a globalisation of issues, and a call for concomitant global governance through international conventions, regulations and programmes. On the other hand there is put much emphasis on the need to enhance local participation in the management of forest resources and to formulate location-specific forest management plans on the basis of negotiated consensus of the various stakeholders concerned. Such participation is predicated on the creation and empowerment of local institutions for governance and control over forest resources.

Although, at a first glance, these tendencies may seem to be inconsistent, a closer assessment of both trends indicate that they can be reconciled. To allow for such reconciliation, it is essential that the process of implementation of global policies is not conceived of as a linear process, but as an interface process. In this process the role of national governments is of utmost importance with better adjusted national policies being essential to to establish proper links between global policies and local action. The principles embedded in the global policies require the creation of a new policy environment which enables community involvement in forest management and the reorganisation of state forestry organisations as facilitators for community management. For this purpose the following national policy actions are needed:

- Formulation of flexible forestry legislation
- Adjustment of forestry organisations including reformulation of roles of field level personnel
- Selection and empowerment of relevant stakeholder groups for using and (co)managing forests
- Creation of credible power relations, which allow the control of forest (mis)use by non-entitled outsiders.

The increased interest in stimulating both globalisation and localisation processes as a means to stimulate sustainable forestry development poses new challenges to forestry policy research. In the past, much of this research was of a normative nature. It was primarily based on the idea of scientist developing the most appropriate forestry strategies on the basis of their academic knowledge (Glück, 1995). Much of these efforts were based on the idea that the implementation of such scientifically-designed policies would proceed along a linear process. However, when it is accepted that the road of policy formulation to implementation is characterised by interface situations, the task of forest policy researchers cannot be any longer be viewed in such a normative way. Rather, their task becomes one of analysing where and why such interfaces do occur, and how they could be dealt with under specific conditions. As a consequence, in forest policy science new approaches towards understanding the nature and working of the policy process are being developed. For instance, increased attention is given to the concept of policy networks, and to the question how multi-level governance may assist to mediate interests of stakeholders from global to local level (e.g. Hogl, 1999).

These developments also imply, that forest policy scientists should look at the underlying processes of forest policy formulation and implementation rather than restrict themselves to the development of norms to be applied in forestry policies. This means that they should increase efforts to bring enlightenment about the nature of normative pluriformity concerning forest resource management and to identify the relative values of the various tools such as state regulation, market regulation or social negotiation to overcome conflicting demands on those resources (Wiersum, 1999).

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Changes in Forest Work in the Nordic Countries

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Abstract

The mechanization of agriculture during the 1950s resulted in rural depopulation and a subsequent shortage of human labour and work horses in forestry. It therefore became necessary to develop working methods in the forest. The introduction of chainsaws was poorly controlled and resulted in occupational diseases and accidents. Ergonomic research, the development of better equipment and work methods, and mechanization eased these problems.

The fully mechanized cut-to-length system is today the globally known trade mark of Nordic forest technology. Independent highly-motivated entrepreneurs, typically owning a harvester and a forwarder, or one or two heavy trucks, have become responsible for the implementation of timber procurement to the industries. Consequently, the number of wage earners has diminished radically, but the remaining work force enjoys a greatly improved working environment, and the rate of accidents is only a fraction of the former level. As capital-intensive technology has replaced labor-intensive technology, the physical strain on workers has decreased but the mental strain on machine owners and operators has increased.

The efficiency and cost of logging and trucking has been reduced substantially, and work methods have also been developed successfully with respect to the demands of environmentally sustainable forestry and good management practices. However, Nordic forestry has not fully met the requirements of social sustainability with respect to job opportunities in rural communities.

Keywords: Forest work, Harvesting, mechanization, Productivity, Forest energy, Nordic countries

Background

Of the five Nordic countries, Iceland does not have any commercial forests. Denmark, Finland, Norway and Sweden possess a total area of productive forests of 50 million ha and the annual cut is almost 150 million m^3 (Table 1).

The last decades of the 20th century witnessed fundamental changes in forest work in the Nordic countries. As the infrastructures developed and the societies changed, the concepts of forest work and forest operations broadened accordingly.

The definition of the discipline by Sundberg (1988) portrays the Nordic approach: "The discipline of Forest Operations and Techniques is the study of the interaction of labour and machines with the forest. It involves an understanding of the relationships between labour, technology, the forest resource, forest industries, people and the environment. It becomes an approach to other, traditional subjects and disciplines rather than a subject itself. Yet, it is an academic discipline and a subject in forest science conducted with scientific rigour, and the approach has important practical applications"

During the second half of the 20th Century the Nordic countries were consistently in the forefront of the research, development and commercialization of improved techniques for forest work. It is not surprising that they also played an active role in the development and implementation of IUFRO's research program within the frame work of Division 3 and its predecessor Section 32.

Table 1. The area of productive forests and the annual cut of timber in the Nordic countries.

	Productive forest area, mill. ha	Annual cut million m³/annum
Denmark (Miljöminist. 1993)	0,4	2
Finland (Finnish… 1999)	20,1	61
Norway (Statisk… 1996)	7,4	8
Sweden (Skogstyrelsen 1998)	22,6	73
Nordic countries, total	50,5	144

Among the great Nordic forest technologists with an outstanding career in the service of IUFRO are IUFRO President Ivar Samset from Norway, Division 3 Coordinators Ulf Sundberg (Section 32), Bengt Ager and P.O. Nilsson from Sweden, and Deputy Coordinator Kalle Putkisto from Finland. Their active involvement in IUFRO's work, combined with the strong interaction between science and practical forestry, is undoubtedly one of the key factors behind the global success of Nordic forest technology

The Nordic Cut-To-Length System

Up to World War II, timber harvesting all over the world relied on simple hand tools, human labour and draught animals. In the Nordic countries, farm work in the summer time and forest work in the winter time balanced the seasonal fluctuation of rural employment. The mechanization of agriculture led to rural depopulation which resulted in a shortage of loggers, horses and horse drivers. In the 1950s it became necessary to start mechanizing forest operations as well.

The appropriateness of a procurement system is highly dependent on the environment and infrastructure in which the timber is produced. Although the tree-length system was found economical in North America, it was not satisfactory in the Nordic countries, where logging was performed not only for the exploitation but also for the management of small, non-industrial private forest holdings.

To meet the concern over the forest environment and sustainability of wood production, it became necessary to develop a completely new technology for these specific conditions. The key characteristics of the technology which evolved are the bucking of stems to assortments at the stump and subsequent transportation to the road side in load-carrying tractors, i.e. forwarders, completely off the ground. This technology was first called the shortwood system, but as the length of pulpwood logs gradually increased, forest engineers started to call it the product-length system, log-length system and finally the cut-to-length system. The reasons northern Europe developed its own technology include:

- In the boreal forests trees seldom reach large dimensions. The productivity of skidders is low when trees are small, whereas the forwarders are less sensitive to tree diameter.
- Thinnings are a central tool in the Nordic forest management system. Less tree damage occurs with the cut-to-length system.
- Soil compaction reduces the growth potential of forests. The forwarders have a larger number of wheels and more balanced load distribution, apply lower tractive forces, travel less, and are able to travel on a protective bed of logging slash so as to reduce the disturbance of soil.
- The vibration-induced health problems are less serious with forwarders due to a better load balance, larger number of wheels, and slower traveling speed.
- Small private forest holdings are short of landing space. Forwarders stack the logs at the road side into 3—4 m high piles, thus saving space.

- The forwarders sort the timber in conjunction with unloading. The value utilization of timber is improved and criss-cross transportation is reduced.
- Road side piles facilitate truck loading and free the trucks from a hot operation schedule.
- Load-carrying forwarders help to keep the timber clean.

With the introduction of the cut-to-length system, the North American and Nordic technologies diverged. The two systems evolved apart, until they as a result of the globalization process, began to converge in the 1980s. At present, of all wood raw material used globally in the forest industries, about a quarter or 400 million m^3/annum is harvested using the cut-to-length system. Finland and Sweden together are the world leaders in this ergonomically and environmentally advanced technology.

The Chainsaw Period

Logging is typically carried out in isolated places far from home. In the Nordic countries, most of the timber is harvested during the harsh winter season. Work sites are changed frequently, and the employment fluctuates seasonally.

Logging has always been a strenuous and hazardous task which has lacked the respect of “modern” society. The great Finnish philosopher and statesman, J.W. Snellman, otherwise known for his far-sightedness, stated in the mid-19th century: “It is doubtful whether the cutting and hauling of timber can hardly support anybody for a single day a year. It is work that requires no mental exertion and only ignorance and brutality are its consequences”.

The shift from traditional hand tools to chainsaw raised the status of logging, but the uncontrolled introduction of new technology in the 1960s resulted in unexpected health problems. Workers were seriously affected by damaged hearing, vibration-induced white finger disease, and injuries caused by muscular-sceletar strain from unsuitable working positions. The exposure to deep snow and cold accelerated the consequences.

Comprehensive programs were launched to fight these problems. In the 1970s, systematic ergonomic research probably played its strongest role ever in the field of forest operations. The occurrence of occupational diseases was reduced, and the frequency and severity of accidents was brought down. Among the means used were:

- The ergonomic properties of chainsaws were improved. Safety chain, automatic chain brake and isolation of handles from saw vibration were introduced. The performance of the saw was improved while the total weight was reduced radically.
- Protective equipment and clothing were developed and made more comfortable for the users. New safety regulations were brought into force.
- Machines and work methods, such as techniques for manual bunching of heavy logs, were adjusted in accordance with the capabilities of forest workers.
- In Sweden particularly, the piece rate system was replaced by time-based salary.
- Workers training, including refresher training, was intensified.
- Finally, the transition from motor-manual to fully mechanized technology moved the man from the ground to a protected harvester cabin.

Figure 1 shows an example from Finland of the development of the accident rate in all forest work from 1983 to 1996. Although the harvest increased, the amount of accidents was reduced by 73 %. Proportional to the amount of timber produced the reduction was 77 %. However, proportioned to the total work time, the reduction was less, 42 %.

Mechanization of Cutting

Few people could have anticipated the rapid increase in the productivity of harvesting. In addition to the mechanization and introduction of the modern logging machines, the work was also rationalized, changed and reduced by several other means, including:

- Work, for example debarking, was moved from the forest to the mill.
- Forest roads were built. In Finland alone, almost 130 000 km of permanent forest roads, i.e. 6,5 m/ha of forest land, were constructed in half a century.
- Future conditions of logging were improved through precommercial thinnings and the increased role of regeneration cuttings.
- The skills and motivation of the chainsaw operators, machine operators and foremen were developed through intensified training.
- Work organization and logistics were improved throughout the timber procurement schedule.

During the first half of the 20th Century, one of the hardest jobs in the forest was the manual debarking of timber. Debarking was the first phase of logging which was moved from man to machine. The next step was the mechanization of off-road transport through the development of the forwarder (Figure 2).

The mechanization of cutting was begun in the late 1960s using processors. They were followed by harvesters, which initially were used in clear-cuttings only. As the technology developed, mechanized logging became possible in thinning cuttings as well. Within two decades the cutting work was almost fully mechanized. In 1998, 82 % of thinnings and 95 % of regeneration cuttings were performed with harvesters in Finland (Figure 3). In Sweden the percentages were even higher.

Today, the harvester operator selects the trees, fells and delimbs them, bucks the stems to optimum logs, and measures the volume of timber with great accuracy. He can also protect the stumps against the root rot fungus, as well as pile the residual biomass from tree tops and crowns for subsequent recovery for energy. The operator of a modern forest tractor works in much improved and controlled environment in a comfortable cabin which is effectively isolated from noise and vibration, working temperature is convenient year around, and the visibility through panoramic curved windows is good. The man in the cabin is not only a machine operator but also responsible for the silvicultural management of the stand.

Figure 1. Relative change in the rate of accidents in forest work in Finland. Year 1983=100 (data from Finnish Statistical... 1998).

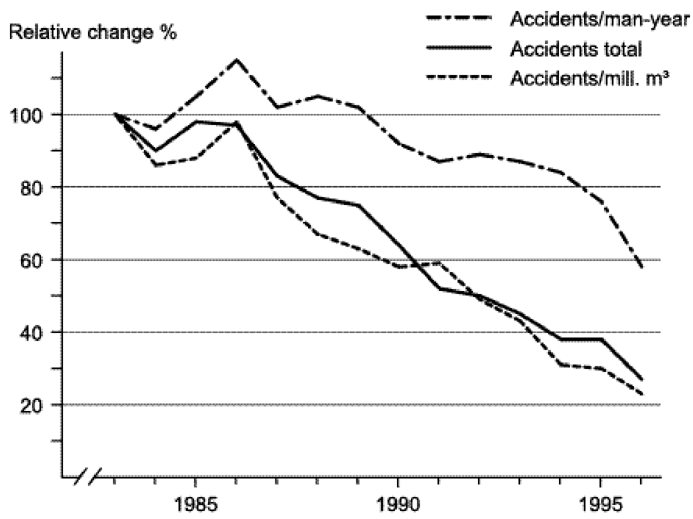


Figure 2. The development of timber harvesting technology in the Finnish forest industry companies since 1940.

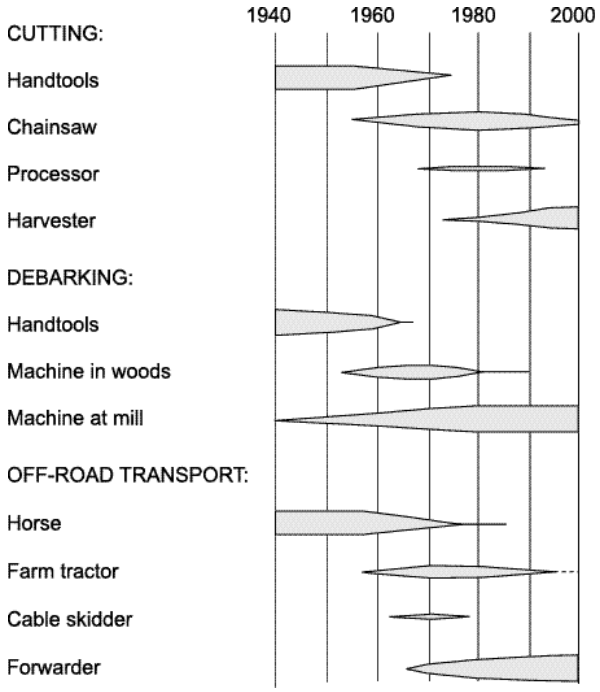
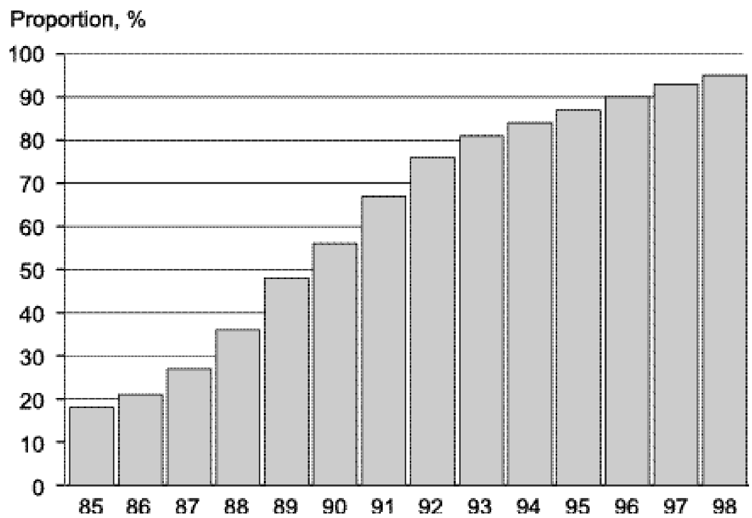


Figure 3. The share of mechanized cutting in the logging operations of the forest industries and Forest and Park Service in Finland (data *Sateri et al.*).



The following quotation from Tom Burch gets to the very heart of recent development of forest work in the industrialized world (Drushka and Konttinen 1997): "We don't know what hard work is since mechanization is like it is now. --- Logging's just not that kind of work any more. But it takes a lot smarter man to be able to run the kind of equipment we run today. Especially on the cut-to-length machine. On something like that, you gotta have a man that's really up on what he's doing, well trained, to be able to run cut-to-length machines. --- A man's hand never touches the timber. There's no manual labor, when I think of mechanization. A man, he sits up here running the machine, punching buttons. He gets that tree on the truck and hauled to the mill without any sweat. I call that mechanization."

However, the machine operators are exposed to a multi-stress situation. Rapid selection of trees, optimizing the timber value, protection of the remaining trees and environment, maintenance of an expensive machine, and responsibility for the profitability of the operation, all serve to create a great mental work load. At the same time, the static work load and long work days tend to cause stress and injuries to neck, shoulders, arms and cervical spine. There is still need to improve machine design, working techniques and work organization.

In the XXth IUFRO World Congress, Staudt (1995) summarized the ongoing changes in the working environment. His conclusions describe aptly the state of forest work also in the Nordic countries at the turn of the millennium:

- The modern worker is no longer a subordinate object, but a grown-up partner in the organization;
- The modern worker is increasingly his/her own supervisor;
- Transfer towards horizontal organizations is taking place, with fewer management levels, fewer supervisors, and workers with a wider range of tasks;
- Forest workers are becoming contractors and owners of the machinery;
- Mechanization and automatization is replacing heavy physical work;
- The operators have to meet higher demands of knowledge regarding the silvicultural, environmental and working conditional consequences;
- Higher demands for knowledge are often combined with an increase in mental work load;
- The need for continued training and education is increasing;
- The need for certification and qualification of the worker is increasing.

Development of Truck Transport

In the Nordic countries, distances from forest to mill are long and the cost of transport high. Land transport was originally only complementary to water transport. As the rail and road networks and equipment developed, the shift from water to land took place only gradually. Public funds were used to promote forest road construction on private lands. Because of the Nordic public right of access, these roads can be used free of charge for recreational activities as well. On the other hand, the high road density has been criticized for the disturbance of nature.

In the 1950s, trucks were still loaded by hand, and the driver had one or several assistants. When the hydraulic cranes appeared in the 1960s and became standard equipment in timber trucks in the 1970s, the use of assistants was abandoned. Improvements of the road network made it possible to use heavier trucks throughout the year. In half a century, the vehicle length was doubled, the engine power was increased fivefold, the total weight was increased sixfold and the load capacity was increased tenfold (Table 1, Figure 4).

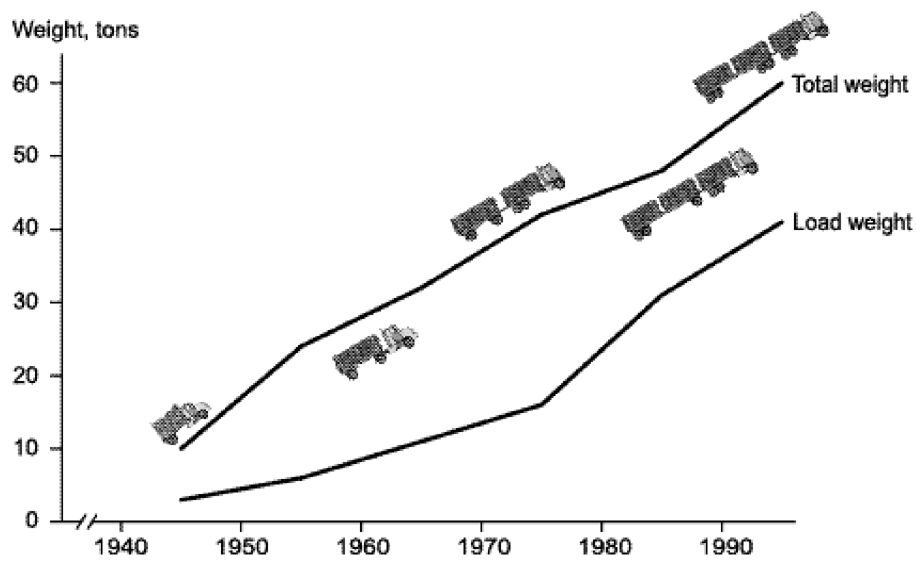
Truck transport became feasible over longer and longer distances. In Finland, the average trucking distance of timber in the 1940s was less than 20 km, but at the end of the 1990s it was 100 km. The productivity increased and is now 33 000 m^3 per annum per truck.

The cabin of a modern Nordic timber truck is like a small office equipped with air conditioning, refrigerator, phone, microcomputer and communications with the timber procurement organization, customer mills and the truck services. Satellite navigation technology enables the procurement organization to send the truck information on the location of timber inventories on digital road maps, and instructions concerning the daily timber orders to different mills by assortments. The application of information technology and efficient logistics speeds up the flow of timber from stump to mill, promotes the value utilization of the raw material, and improves the productivity of trucking.

Table 1. Development of the timber trucks in Finland. Typical truck properties at the end of each decade during the second half of the 20th century (adapted from Köhler 1998 and Karhu 1999).

Property	1940s	1950s	1960s	1970s	1980s	1990s
Engine power, hp	100	150	250	350	400	500+
Number of axles	2	3	3—5	4—5	5—6	6—7
Max. vehicle length, m	..	14	18	22	22	25
Maximum weight, t	10	24	32	42	48	60
Load capacity, t	3	6	11	16	31	41
Load/total weight, %	30	25	34	38	65	68
Productivity, m^3/a	..	..	10 000	15 000	21 000	33 000
Loading	Manual or Winch	Manual or Mech. crane	Mech. or Hydr. crane	Hydr. crane	Hydr. crane	Hydr. crane

Figure 4. The maximum allowable total weight and load of timber trucks in Finland (data from Karhu 1999 and Köhler 1998).



Loss of Job Opportunities

The economically active population consists of three main sectors: agriculture including forestry, industry including construction, and the services. While the productivity of labour increases continuously, the possibilities to expand the production of agriculture and the consumption of agricultural products are limited. Consequently, jobs move from the agricultural sector to industry and, as the society develops, to the services. In 1950, Sweden lagged 30 years behind the USA and Finland 30 years behind Sweden in this development. In the mid 1980s, Sweden lagged only 10 years behind the USA and Finland 20 years behind Sweden. Today the differences are small (Figure 5). The industrialized world is becoming ever more similar.

Although the demand for labour has reduced and the work environment has improved, the shortage of forest labour is becoming a serious threat in post-industrial societies. Despite forestry's great importance for the national economics of Finland and Sweden, only a small proportion of the jobs in the agricultural sector are in forestry. Within forestry the number of wage earners and self-employed farm owners harvesting timber in their own forests has been steadily declining (Figure 6).

The number of chainsaw operators particularly has decreased radically, while the reduction in the salaried permanent staff, such as office personal and forest technicians has decreased more moderately. Work has been moved from wage earners to independent machine entrepreneurs and their drivers. In Finland, about 1 % of all employed people work in forestry, but in the other Nordic countries the percentage is still smaller. The social sustainability of forestry has suffered.

Renewable Energy - A New Challenge

Climatic change caused by the greenhouse gases from fossil fuels is considered to be the most serious global environmental threat. The industrialized countries have agreed under the Kyoto Protocol to reduce emissions of greenhouse gases by an average of 5.4 % from 1990 levels during the period of 2008—2012. In the Nordic countries, the reduction obligation is 21 % for Denmark, whereas for Finland it is sufficient to maintain the 1990 level. An increase of 1 % is allowed for Norway and of 5 % for Sweden. Since the greenhouse gas emissions presently exceed the level of 1990 in all countries, the task is in reality greater than the percentages above show.

One way to reduce the emissions is to substitute renewable energy for fossil fuels. Biomass from agriculture, forestry and municipalities accounts for a large proportion of the potential of renewable energy. In countries with large forest resources and well developed forest sectors small-sized trees and logging residues from conventional forestry form a major source of biomass. This is particularly the case in Sweden and Finland, but even Denmark with its much smaller forest area places great importance on biofuels.

Figure 5. The proportion of labour force employed by the agricultural sector in the USA, Sweden and Finland (data from Heikinheimo 1987 and Finnish Statistical…1999).

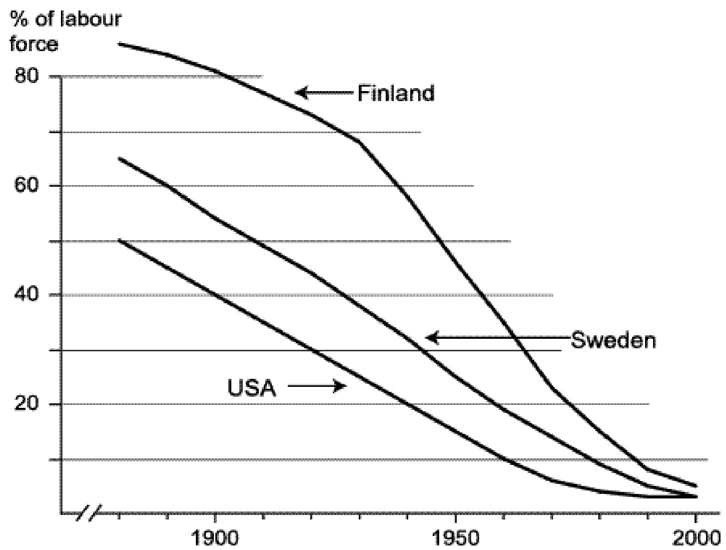
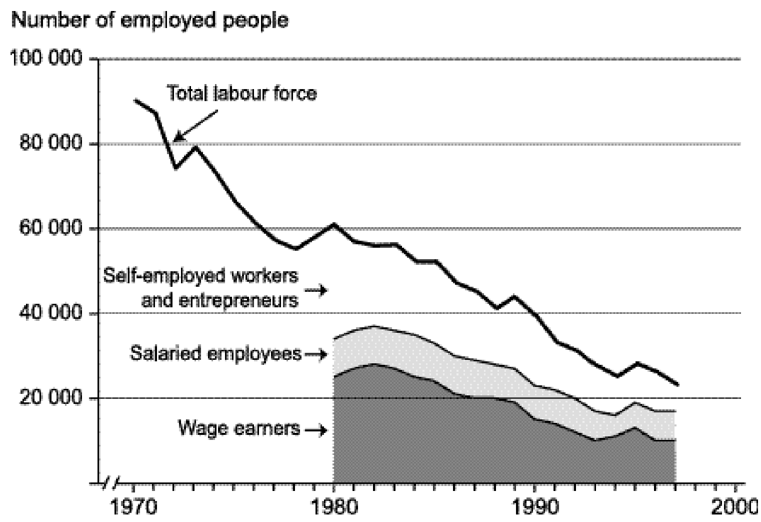


Figure 6. Labour force in the Finnish Forestry (data from Finnish Statistical... 1999).



The appearance of modern energy harvesting on an industrial scale adds a new dimension to forestry operations(Björheden 1999). Erratic variations of quality, low energy intensity, distant location, and poor distribution systems have been the drawbacks of forest fuels which must be overcome. The sustainability of the forest ecosystem must be maintained while the recovery of biomass is intensified.

The increased use of forest energy enjoys the support of the green movement, nature conservation organizations and most of the society. But forest fuels must be economically competitive, and the customers require comfort, convenience and automation. The Nordic solution is to reduce the biomass into chips, to build district heating systems in areas of dense settlement, and to combine the production of heat and electricity from chips.

The demand for stemwood as an industrial raw material is good in the Nordic countries. On the other hand, of all above-ground biomass more than one fourth is crown mass for which there is no commercial demand. It follows that the harvesting of energy from conventional forestry often means the recovery of crown. Logging technology must be adapted accordingly.

It was earlier thought that the main source of forest energy in the Nordic countries will be whole-tree chips from early thinnings, and this is still true in Denmark. In Sweden and Finland, logging slash from regeneration areas has become a more important source of forest energy. This shift reduces the effectiveness of forest energy as a silvicultural tool, and the number of new job opportunities remains smaller than originally expected.

Forest biomass has a high priority in the energy policies of Nordic countries, while the forest industries see in it an opportunity to improve their environmental image. The production of clean renewable energy will make a considerable impact on the social and environmental position of the Nordic forestry. In the year 2000, the production of forest chips for fuel will be over 5 million m^3 in Sweden, almost 1 million m^3 in Finland and 0.4 million m^3 in Denmark. In Norway, which is a large producer of hydroelectric power and fossil fuels, the role of forest energy is less important.

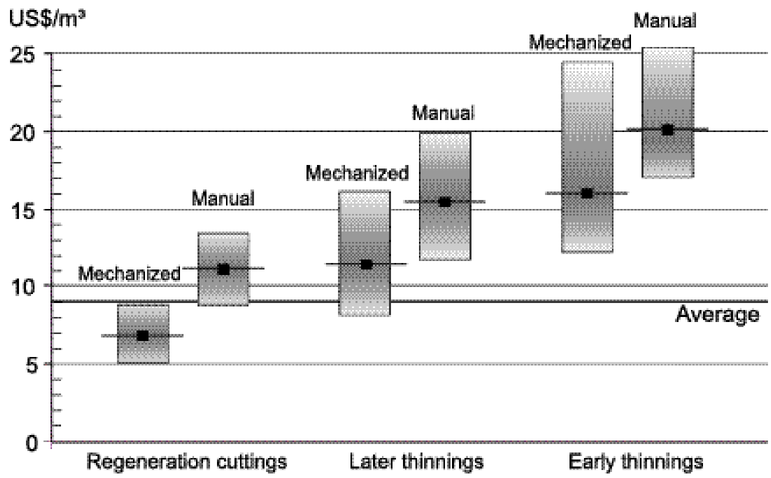
Effect of Mechanization on Management Practices

In the early 20th century, the marking of trees for selective cutting was made by a team often led by a university-trained forester. When the cost of manual labour increased, the job was "downgraded" first to forest technicians, then to on-the-job-trained tree markers, then to chainsaw workers, and finally to the harvester operators with a machine technical background. Since the harvesters frequently work in two shifts and during the night, the operator has sometimes to select trees in conditions where the tree crown cannot be seen properly. The silvicultural result may then suffer.

Forests cannot be managed on the terms of logging alone. Compromises between the needs of silviculture and logging technology are necessary. Because the reach of the harvester crane is seldom more than 10 m, the distance between the strip roads in thinning cuttings has been reduced to 20 m. The strip roads cover up to 20 % of the forest area. However, due to the edge effect, the growth loss is only a fraction of the ground area loss. Nevertheless, the loss of increment adds in the Nordic countries up to millions of cubic meters annually. On the other hand, many studies show that the cut-to-length system results in less tree and ground damage than the tree-length system (Sirén 1998).

Mechanization made year-around logging not only possible but also economically necessary. Job opportunities were distributed more evenly over the year. This improved the living conditions of the loggers who remained, but summer-time logging created environmental problems such as the increased risk of the root rot fungus.

Figure 7. The cost of manual and mechanized harvesting of timber from stump to road side in Finland in 1999 (data from the Finnish Forest Industries Federation, US$=5.50 FIM).



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Ergonomic Research in Developing Countries as a Contribution to Increase Productivity and Social Development

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Abstract

This paper is part of a research carried out by a team which also includes Manuel Gutiérrez, Silvia Lagos, Fabiola Maureira, Felipe Meyer and Jorge Espinoza. The purpose of this communication is to illustrate how appropriate technologies aimed at improving safety, health and wellbeing of the workers lead to higher productivity and to show that when a certain technique for forest work is adopted, ergonomics research can help to highlight how much a worker can produce according to the characteristics of the ground, the climate, the stand and the level of physical work load that he should not exceed to avoid fatigue. Examples are discussed of a proposal to calculate salaries and incentives using tables of standard performance based on this criteria. Finally, a case study is presented in which it is shown how the use of these concepts helps global work organisation with beneficial effects for contractors and workers

Keywords: Ergonomics, Productivity, Physical work load, Rest pauses, Job rotation, Working sequences, Organization of labour.

Introduction

Increasing productivity without harmful effects on the working population is one of the most important goals of ergonomic research. This is the way in which ergonomics contributes to development of labour. However, the approach centred only in tools, machines, work places and work organisation seems not to be the right model for developing countries. The final aim should be not only to make forest work safe and more profitable but also to find strategies for making the social environment of the workers and their families of better quality.

In other words, the small communities living around the large forest companies, should have access to good housing, health and education. Although these changes in communal organisation requires a global approach through governmental policies, one way to help these changes is through increments in salaries allowing the workers to satisfy their family needs. However, the efforts that they should do to get fair salaries should be without fatigue or other risks for their physical and mental health. In this respect, ergonomics research may help to demonstrate that better work design and organisation leads to more profits and that all the actors involved should be benefited from the increments in efficiency.

One urgent need in developing countries is to analyse the convenience or not to change traditional working methods for sophisticated technologies. There are experiences showing that machines can sometimes bring more harm than wealth to populations who earn their daily living from forest work. Furthermore, in not few cases, well organised methods using manual tools and simple machines can lead to higher productivity than capital intensive methods. However, high productivity in the forest sector, specially when the work is performed using labour intensive methods, can only be achieved if the whole working system is designed to be compatible with human capabilities and limitations. It is important to highlight that a job cannot be safe and efficient when carried out by people physically and/or mentally overloaded due to excess work.

Although knowledge and common sense to face manual and mechanised work should lead to well-designed jobs, to get into practice is a difficult task. Planners, managers and engineers are not easy to convince. Their aim is to keep production at the highest possible rate with the lowest cost and with the means they have available. Normally, because human beings are very flexible and in developing countries labour is cheap and easily available, they do not pay much attention to the workers. The consequence is low productivity, high accident rate, work related diseases and low salaries, which in the end contributes to the circle of poverty increasing the social problems.

One of the aims of this paper is to communicate simple examples on how to improve performance in some forest operations carried out with basic techniques, through the application of simple ergonomics research methods. The idea is to show how this approach can be used for the selection of tools, machines and also for work organisation.

Consequently, the overall objective of this communication is to illustrate how appropriate technologies aimed at improving safety, health and wellbeing of the workers leads to higher productivity, which is a need in every country, especially in those fighting for real development. However, the most important goal of this paper is to show that when a certain technique for forest work has been adopted, ergonomics research can help to highlight how much a worker can produce according to the characteristics of the ground, the climate, the stand and the level of physical work load that he should not exceed to avoid fatigue. Examples will be discussed of a proposal to calculate salaries and incentives using tables of standard performance based on this criteria. Finally, a case study which shows how the use of these concepts helps global work organisation, will be analysed.

Material and Methods

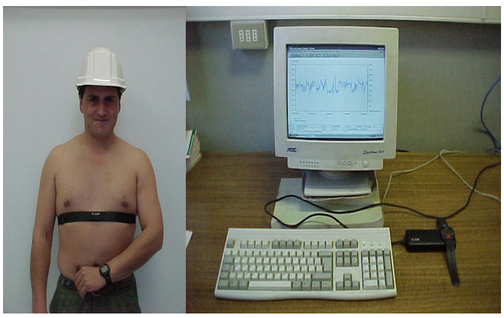
The workers included in the different studies which will be described were selected to be representative of the Chilean forest workers, according to standards already developed in the country by Apud and Valdes (1988), based on aerobic capacity, body composition, body mass and stature. During field studies, evaluations of the climate, ground, stand, physical work load and time distribution were evaluated according to the following procedures:

Physical Work Load

As our purpose was to evaluate the dynamic work load, cardiac frequency was measured, because it is a simple, non invasive and practical method to evaluate the strain imposed by a job without interfering with the activity of the subject. A detailed account of these methods is given in an ILO book entitled "Guidelines on ergonomic study in forestry" (1989). In our studies we used a POLAR VANTAGE monitor which is illustrated in figure 1. As it can be seen, the worker has a sort of “belt” around his chest which has incorporated a transmitter. This sends the signal of cardiac frequency to a receptor, which is used as a watch in the wrist of the worker, where the information is stored. Afterwards the data can be transferred to a computer where it can be analysed.

In Chile, we accept that, as average for an 8 hours shift, the cardiovascular load should not exceed 40 %. This is because, if the work is carried out in a temperate environment, there is a good relationship between cardiac frequency and energy expenditure, so one can assume that workers will perform as average under their anaerobic threshold. In case that the work is done in a hot environment, this limit seems also a reasonable load for the cardiovascular system, in spite that the work is performed with lower pace due to the heat. Cardiovascular load is calculated as follows:

Figure 1. Polar Vantage System for recording cardiac frequency in the field



$$\% \text{ C.C.} = \frac{\text{fC at work - fC at rest}}{\text{fC maximal - fC at rest}} \times 100$$

where:
C.C. = cardiac cost or cardiovascular load
fC = cardiac frequency
fC maximal = 220 - Age

Cardiac frequency corresponding to about 40 % cardiovascular load for different age groups are as follows:

AGE RANGE (years)	CARDIAC FREQUENCY (beats per minute)
20 – 25	115
26 - 30	112
31 - 35	110
36 - 40	108
41 – 45	106
46 - 50	104

Evaluation of the Stand

All our studies have been carried out in plantation forestry of radiata pine. Although, we have worked in forests with only one specie, the characteristics of development of the forests varies according to the area and climate in which they grow. The result is trees with a variety of sizes, forms, growth of the branches, etc. For that reason, in each study, specific measurements of the trees were made. As it will be too long to define all the measurements of trees or branches, those which appeared related to specific tasks will be explained when discussing the results.

Characteristics of the Ground and Climate

The slope of the ground and the roughness index were measured. The roughness index is defined as the quotient between the time taken to cover a distance walking without obstacles and the time to walk the same distance with obstacles. It ranges between 0 and 1. The degree of difficulty for displacement, based on the roughness index, is usually classified as follows:

High: Range between 0.01 and 0.33
Medium: Range between 0.34 and 0.66
Low: Range between 0.67 and 1.00

With regard to the climate, dry, wet and globe temperature were measured every half an hour during the shifts using conventional thermometers

Work Studies

Continuos time recordings were performed as proposed by the ILO (1989). The usual procedure is to establish first the work cycle and afterwards to divide the activities as principal and secondary. Principal activities are specific and they will be explained in detail when analysing different forest tasks. Within the secondary activities are included all those with low or relative periodicity. The following is the classification used in most of our studies:

Material: Time devoted to maintenance and repair of tools and machines.
Personal: Time devoted to personal activities, e.g. physiological needs.
Waiting: Time in which the machine or the worker stops because of the

operation itself, e.g. waiting for one or more members of the crew to complete the job.

Detention: Spontaneous breaks and rest pauses carried out during a normal shift when everything is in order.

General: Unpredictable situations interrupting the normal cycle of work when all the resources are available. Normally they do not last more than 5 to 10 minutes.

Others: Major interruption of the work cycle, e.g., due to rain or break-down of machines. They usually last more than 10 minutes.

To facilitate the collection of the information, each activity, being principal or secondary, was assigned a code. This simplified not only the work of the controller, but also the digitation of the information for posterior analysis.

Results and Discussion.

The results will be presented in such a way that first will be discussed the effects of isolated organisational factors will first be discussed and by the end it will be shown how these can be integrated to improve working conditions and productivity.

Number of Workers Per Activity

Through different studies we have been able to demonstrate the importance of the balance within working groups. For example, studies performed by Apud y Valdés (1995) showed that when power saw operators work with only three axe workers the work load for this last group can be extremely high, so the recommendation was to work with four persons debranching the trees with axes per each power saw worker felling the trees.

During this year, we conducted surveys where it was shown that power saw operators could increase their level of production within reasonable levels of work load if the crews were organised with the correct number of workers. For example, as shown in figure 2, power saw operators increased their production by 36% (from 11.1 to 15.1 cubic meters per hour) when they worked with 4 instead o 3 axe workers. This also allowed a proportional increment in performance of the logging machine employed in this case, which was the most expensive component of the job.

Scheduled Rest Pauses

It is not easy to demonstrate the importance of rest pauses for recovery. However in different studies we have found that rest pauses can help recovery and maintenance of good performance. Although the example that follows was not found in forest production but in pruning which is a silvicultural treatment, the effect was so clear as to help motivate contractors doing final cut activities to introduce scheduled rest pauses. In figure 3, a follow up of trees pruned per hour and cardiovascular load for the equivalent period is shown. As can be observed, the general trend is that work in the first hour in the morning starts with a high level of production and a relatively intense work load. As time goes by, the number of trees pruned per hour tends to decrease but the work load is maintained. In the last hour of the morning, the cardiovascular load increases significantly but the output of the workers decreases. In general terms, an increment of cardiac frequency with a reduction in the level of performance is a signal of fatigue due to the shortness of rest. A very common error is not to schedule the rest in such a way that the workers can take at least a 15 minutes break after two hours work. Depending on the type of work it is even convenient to give ten minutes of rest per hour. As a general rule, short and frequent breaks are more adequate than long and spaced pauses. Of course, the decision has to be evaluated in the field

As an example of the positive effect of rest pauses, a study was conducted in a group of workers debranching with axe in summer time. The workers debranched without any rest during the whole morning. To see the difference, rest pauses of 15 minutes duration were introduced at mid morning and mid afternoon. As it can be seen in figure 4, the output of these workers increased 16 %, from 2.6 to 3.2 cubic meters per hour, while the cardiovascular load diminished from 35 to 33%. In other words, the good recovery allowed the workers to do more work with a lower physical work load.

Job Rotation

Another aspect which has been demonstrated very conveniently, when working conditions allow it, is to introduce job rotation. Changing activities may as reduce the work load for those doing the heavier part of the job and output can be even duplicated.

A clear example was found in a study in which the work of power saw operators felling trees in the forest was compared with that of workers cross-cutting in the logyard. The first activity is far heavier than the second. Therefore, two ways of rotating the job were proposed. The first was according to the simplicity of operation and for that reason it was done at lunch time. The second was a physiological consideration based on the fact that recovery after heavy work is faster the sooner that the rest is taken.

For that reason, essays were carried out in such a way that the workers changed every second hour. They started working at 8 A.M. and they rotated after 10 minutes rest at 10 o'clock. Then they had 1 hour for lunch at 12 noon when they changed again and finally after another 10 minutes rest they rotated at mid afternoon.

In figure 5 it can be clearly seen that with both forms of rotation the physical work load was much lower than when the workers were only felling trees. In the same figure it can also be seen that the output increased both in the number of trees felled per hour and also when expressedin cubic meters. It is necessary to mention that when carrying out research to evaluate real work it is almost impossible to standardise the conditions. In this study, when 3 rotations were evaluated, the trees were smaller and that was why the number of trees was much higher. However, normally when working with smaller diameters the amount of wood in terms of cubic meters is less. As it can be observed in the figure, this was not the case, because even if the conditions were not favourable, when rotating jobs the amount of cubic meters worked increased.

Figure 2. Performance of the power saw operator felling trees when working with 3 or 4 axe workers debranching.

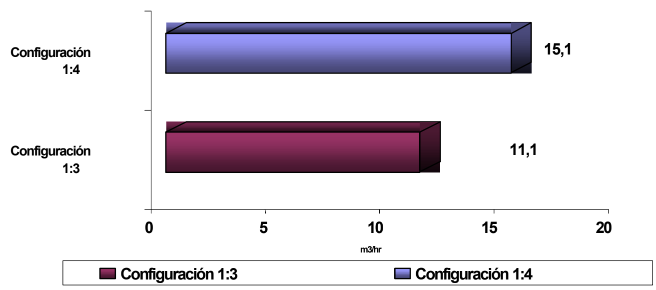


Figure 3. Average number of trees pruned per hour and % cardiovascular load as average of a follow up of 10 workers controlled during the first 4 hours in the morning

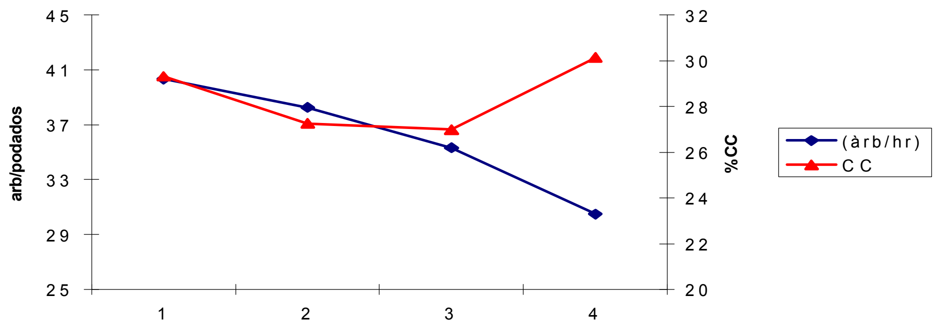


Figure 4. Average output (m^3/hr) and cardiovascular load (%CC) in a group of axe workers debranching with and without schedule rest pauses.

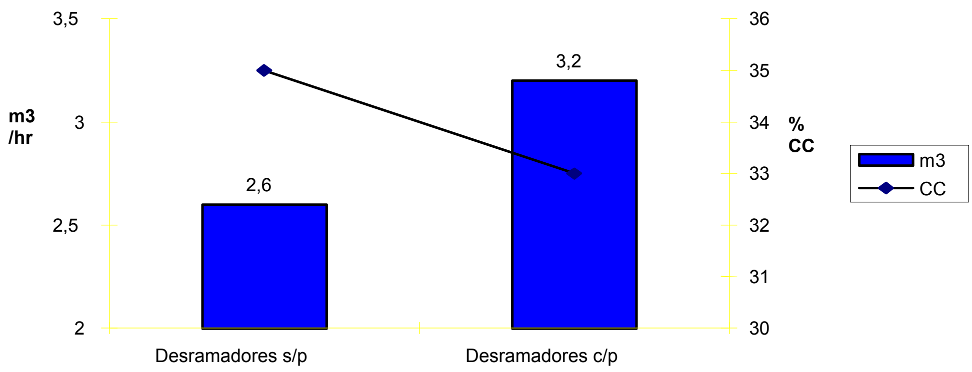
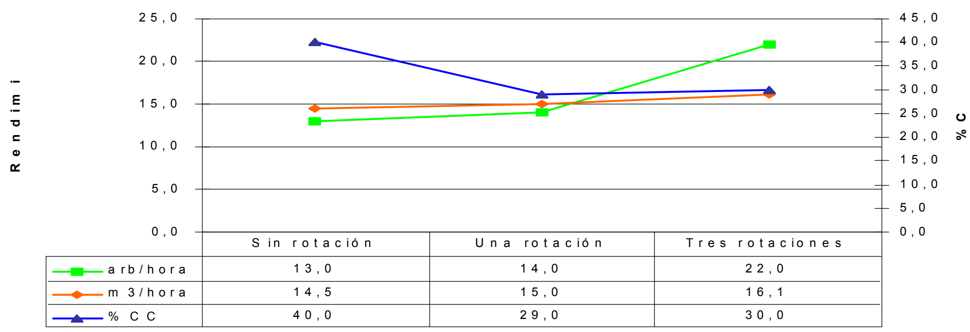


Figure 5. Average output (m^3/hr y trees/hour) and cardiovascular load (%CC) for a group of power saw operators felling trees during the whole shift and rotating job with the power saw operators doing cross-cutting in a logyard. Rotation was done once a day (lunch time) and 3 times per shift (10 A.M., lunch time and 3 P.M.)



Working Sequences

When the physical work load is evaluated simultaneously in all the workers of a crew, it can be observed, in many cases, that the distribution of work could be changed, increasing output, without an excessive increment in work load. For example, in one of our studies it was possible to demonstrate that the way in which power saw operators felling the trees organised their job, can have an important impact on performance. We had the chance to evaluate this effect by comparing two crews within the same company. In the first alternative, which we called, continuos work method, the power saw operator worked with four axe workers in two felling areas. In such case, when he was felling in one area, the axe workers, at a safe distance were debranching in area. The a second alternative is the so called discontinuous method. The work is performed only in one area in such a way that when the power saw operator is felling, the axe workers remain idle at a safe distance. Afterwards, when the axe workers start debranching, the power saw operator has to stop the dangerous job of felling trees.

As shown in figure 6, the follow up of these two forms of organization, demonstrated that when work is performed in two separate areas, the output of the axe workers increased 35%, because the waiting time is reduced from 42 to 19%. It is important to mention that the 19% waiting time with the continuos system is mainly rest pauses allowing human good recovery.

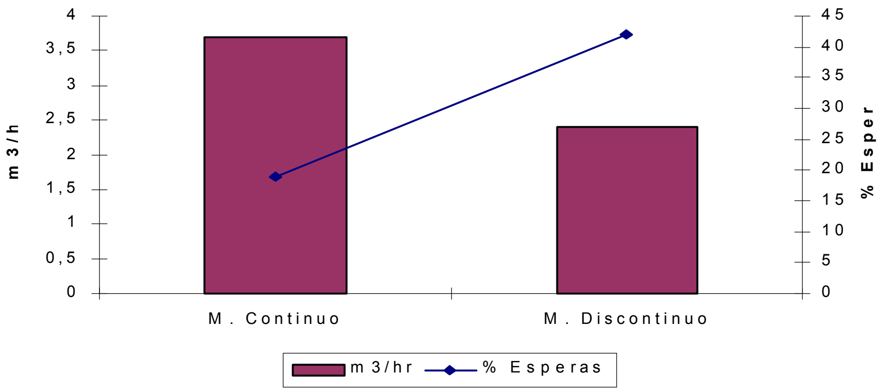
Standard Performance as a Basis for the Calculation of Salaries and Incentives

On most occasions we know that forest work is a heavy task. However, the question is: how much is too much?. To answer this question we have been developing, over many years, a model in which the output depends on the physical work load that a worker can sustain during his working life without fatigue or other risks and on the difficulties he meets in his job. In other words, in forestry there is great difficulty in expecting the same amount of output from a worker all the time. This makes it difficult to calculate incentives and salaries, especially when workers are paid by piece rate. Apud and Valdes(1995) and Apud *et, al*.(1999) have presented several functions to calculate output of different forest activities. We have followed standard procedures for the studies carried out in the field in which we have measured performance as well as physical work load, characteristics of the forests, ground and climate. As it will be too long for the purpose of this text to go into details only a brief example will be given related to power saw operator cross-cutting in a logyard. After a detailed statistical analysis it was found that around 75% of the variation in output of these power saw operators could be explained by the average volume(AV) of the trees they cross-cut, the time devoted to the principal activities(PT) and the effort they expended as judged by the cardiovascular load(%CL), according to the following formulae:

$$\mathrm{OUTPUT}(m^3/\mathrm{hour}) = -7.5 + 0.16*CL + 0.23*PT + 8.1*AV$$

The idea of these tables is to show to the companies and contractors that when salaries are paid according to the amount of work that the workers can do, they should consider carefully how much work can they really expect to be done. In our experience it is mostly the case that the demands imposed on workers will tend to be higher than what they can really achieve. In a practical sense, with these tables a company demanding the service of a contractor and the contractor himself can plan the job considering part of the difficulties that the worker will face in the field. We are promoting a system in which it is recommended. For example, if a previous sampling of the forest shows that the average volume of the trees is 0.9 cubic meters, an average worker with a cardiovascular load of 30%, devoting 70% of the time to principal activities, should produce around 20 cubic meters per hour. To reach this production a fair salary shoud be paid allowing the worker to fulfil his and his family needs. Of course, a motivated worker can still do more work without risks. If as is observed in the table, for the same forest with 0.9 cubic meters average per tree, the labourer devotes 80% to the principal activities with a higher effort at the limit of 40% cardiovascular load, he may produce 24.2 cubic meters per hour, which is nearly 20% more.

Figure 6. Output (m^3/hr) and waiting time (%) for a group of axe workers working with power saw operators using different working parameters.



On this basis a table for easy calculation of performance was prepared as follows:

AV (m^3)	CL 30%		CL 40%	
	PT		PT	
	70 %	80 %	70 %	80 %
0.1	13.9	16.1	15.4	17.7
0.3	15.5	17.8	17.1	19.3
0.5	17.1	19.4	18.7	21.0
0.7	18.7	21.0	20.3	22.6
0.9	20.3	22.6	21.9	24.2
1.1	22.0	24.2	23.5	25.8
1.3	23.6	25.9	25.2	27.4
1.5	25.2	27.5	26.8	29.1

So to motivate the labourer incentives should be paid. Although to work at that level is still safe, we are talking of the higher limits of physical performance and that is not possible to obtain if the worker does not feel that his effort is recognised.

It has to be warned that incentives should be discontinued beyond the higher levels proposed in the tables since there are serious risks of fatigue, accidents and work of poor quality at thesefore. On the other hand, the main limitation of the system is that we are talking of an average worker and not every human being is alike. The tables cannot therefore used in a rigid way. However, our experience indicates that forest workers doing heavy manual work tend to have a good physical fitness irrespective of age. For the reader interested in this topic, Apud *et. al.* (1999) published a book in which standard performance tables are presented for most of silvicultural treatments and harvesting activities.

An Integrated Study

Until now, examples have been presented on how simple considerations in the organisation of work can help to improve performance. On the other hand, we have discussed how to use tables for the estimation of the expected output in isolated activities. However, what it is fundamental is to demonstrate that the integration of this knowledge can help to balance good working conditions with productivity. The study which is described below was precisely carried out for this purpose.

The work evaluated was final cut. Labour was organised in such a way that a power saw operator felled the trees and 3 axe workers did the debranching work. Afterwards a choker setter fixed the logs to a cable crane for aerial transport. This work was done over two days. Afterwards, the same workers went to the logyard where the trees, previously moved with the help of oxen, were cross-cut by the same power saw operator and piled by the axe workers. The work in the logyard lasted one to one and a half days.

After field studies, a new work organisation was proposed because there was a clear imbalance and in some cases the work load was too high and risky. The problem started with the power saw operator felling trees who devoted too short a time to principal activities. However, it was not possible to increase his performance if the bottle-neck caused by the high work load of the 3 axe workers was not solved. As a consequence it was proposed that an additional axe worker was added to the team. At the same time, considering the expected increment in production, it was also recommended to include a second choker setter.

With respect of manual piling of logs, this task has to be eradicated from the forest. The illustration of the back of the worker in figure 7 is self explanatory . Therefore, the work of piling and ox skidding was taken over by a machine (triloader). Furthermore to ensure a possible increment in production it was necessary to consider using 2 choker setters to handle the increased workload.

With the addition of two assistants needed in the log yard, the crew grew from 7 to 12 workers, showing that with this kind of technology mechanisation does not necessarily means reduction in the number of workers. It has to be pointed out that with this new organisation the work in the forest was simultaneous to that in the log yard and not done on different days by the same workers as in the original organisation.

The new organisation included 15 minutes rest pauses at mid morning and mid afternoon. During this scheduled rest, the workers were provided with a soft drink and fresh fruit. Both the rest and the snack were very much appreciated by the workers.

Figure 7. The workers pick the logs from the floor and load them on the shoulder. As can be seen the shoulder on which they load is about 10 cm lower than the other shoulder.

Information provided by the contractor and by the large company for which he was providing services confirmed that production increased from 700 m^3 to 1.500 m^3 per month with the new form of work. Of course there was more investment and expenses but the economic analysis which will be discussed also showed good benefits. Although a detailed economic analysis was made, for the purpose of this paper only some briefs comments of the most important points will be made. The fact that with the new organisation the number of workers increased and a machine was introduced to the system, there were new incremental costs. These were considered in the economic evaluation of both systems.

As a summary although the contractor had to pay the rent of the triloader, he had a real increment in earnings of 60%. The workers increased their salaries as follows:

Machine operators (tower and triloader)	47 %
Choker setter	26 %
Power saw operators	19 %
Axe workers	1.5 %

The situation analysed was calculated for a forest surface of 55.6 ha and a density of 398 cubic meters per hectare. This means that about 22.000 cubic meters of wood more harvested. Projecting these figures, it would have take the original crew 32 months to complete the task whereas with the modified organisation, it would have taken only 15 months. From this summarised analysis the following benefits can be seen:

The work was more balanced so the work load was more evenly spread

The dangerous activity of manual piling was eliminated

The was an increment in employment

Most of the actors had better earnings

Time was left available to start a new job

The company obtained the product required in a shorter time.

As a conclusion two important facts should be highlighted:

It is possible to innovate successfully without big investments

To keep the positive changes for the long run, salaries have to be improved. After the study everybody was satisfied with the new system, except the axe workers doing the demanding job of debranching the trees. Their salaries remained about the same during the whole process. Therefore the recommendation to the contractor was to increase the salaries of the axe workers.

Final Remarks

In this paper an attempt was made to show how performance could be improved with simple organisational changes. However, although examples always show good results, it is very important to mention that to get improvements in productivity there are a number of other factors such as hygiene and facilities for workers living in forest camps, food according to nutrient and energy needs, safety equipment and training not only in technical aspects but also in safe behaviour. The study we have described in this paper shows that should be given serious consideration the application of the broad concept of ergonomics can help in the development of a society.

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Changes in Environment and Society:

Interaction between Environment and Urban Society

Coordinators:

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Forestry in Urban and Urbanizing Areas of the United States: Connecting People With Forests in the 21st Century

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Abstract

Resource managers worldwide face challenges in responding to expanding urbanization and its effects on forest resources. These challenges can be met head on if managers work toward: (1) comprehensive management of forest resources in urban and urbanizing areas, and (2) connection of urban people with forests and their management. Opportunities exist for accomplishing both of these goals through involvement of a broad spectrum of urban residents and organizations in collaborative management of forest resources in urban and urbanizing areas. Comprehensive and adaptive management of forests in urban and urbanizing areas is outlined, and efforts to involve individuals and groups in that management are discussed with examples from the Chicago, Illinois, area. Involving urban citizens in resource management can have implications for forest resource management across the urban to wilderness landscape.

Keywords: Urban residents, Forests, Collaboration, Involvement, Partnerships.

Introduction

Urbanization is having increasing implications for forest resource management around the globe. Urban expansion is displacing or transforming significant forest resources and changing the interactions between residents and forest resource management. In the process of urbanization, conflicting demands for resources emerge, as do different perspectives on resource management. Diverse values -- including functional, economic, recreational, wildlife, esthetic, and symbolic values -- must be considered in resource management decisionmaking. Land ownership across the urban to wilderness landscape is becoming more complex and fragmented. The decisions on resources management near a community are now influenced not only by the people who live there, but also perhaps by seasonal and part-time residents, casual visitors, and others whose only involvement with the forest may be reading about it.

Experiences to date suggest that while there is substantial public support for the protection, restoration, and management of urban forest resources, there can be controversy over particular management practices such as removal of trees and brush, use of herbicides, burning, and control of deer populations. Controversy can revolve around the appearance of an area. "Good forest management" is not always pretty. Research has found that native landscaping may look messy and overgrown to certain segments of the population, signaling an area is being neglected rather than managed (Nassauer 1995). In addition, controversy may involve how and where specific management practices are planned and carried out, how much and what type of information is made available to the public, how the public is involved in decisionmaking and planning for management activities, and how or if they are informed of proposed changes to the landscape (Gobster 1997). Implementing comprehensive and adaptive management of forests in urban and urbanizing areas, as well as connecting urban people with forests and their management will help address these challenges.

Urbanization transforms lands uses, ownership patterns, distributions of people and settlements over the landscape, and changes the social/political environment of the affected areas. The people who move to these new developments largely come from urban areas. Compared to those who already lived in the affected area, these new residents may have different values and preferences for the management of forest and associated resources. Previously rural communities may experience substantial growth in population, businesses, and industry. Smaller tract sizes and higher population densities may reduce availability of timber and increase the costs of harvesting it. Important recreation areas on private and public lands may be lost or rendered inaccessible by developments. The altered landscape is likely to bring changes in ecological processes. Development brings new challenges to managers such as increased risk of introduction of exotic weeds and pests, heightened conflicts between people and wildlife, increased threat of fire, and altered movement and control strategies for pest populations. An increased number of landowners, including a significant portion of absentee landowners, will complicate the management of landscapes to provide opportunities for outdoor recreation and esthetics, wildlife and wildlife habitat, and water and flood control. Planners and developers face new challenges, as do existing communities and businesses in the affected area (e.g., farms surrounded by homes).

Defining the boundaries of the urban forest is becoming increasingly complex in a country where the population continues to sprawl across the landscape. In the past the definition has depended on a relationship between the geographic location of the forest and its proximity to a large population center. As the United States increases in population, the boundaries of populated areas are rapidly expanding and constantly changing. It is difficult to determine where the rural forest ends and the urban forest begins, but even more difficult to designate resource management practices as being more appropriate in an urban forest rather than a rural forest. Given this integration, comprehensive and adaptive management at the regional scale is critical

Comprehensive and Adaptive Management

Several implications for the planning and management process begin to emerge, given that U.S. urban forests are substantial and growing; are complex ecosystems with diverse resources that are owned and influenced by a number of important groups; are connected to other urban and natural systems; and undergo significant change over time.

The diversity of urban forest resources and their extension across land uses, property lines, and political boundaries calls for management programs that bridge jurisdictions and employ multiple disciplines. Among the fields that may be involved in urban forest planning and management are forestry and arboriculture, ecology and wildlife management, entomology and pathology, hydrology and soils, meteorology and atmospheric science, landscape architecture and recreation management, psychology and sociology, planning and economics, and political science.

Given the unique character of urban forests found in particular settings, effective management also requires different forest management strategies within an urban environment (for example, by land use, land ownership, degree of development, and population density) and among urban areas (with different ecoregions, populations, and other attributes). Because of the complexity of land uses, ownership, and resources, a “one-size fits all" urban forest management scheme is not appropriate.

A key element in managing urban forests in a regional context is the coordination of activities among different owners and managers across jurisdictions, as well as the acceptance of different management goals. The participation of multiple stakeholders in urban forest management requires a forum to help link forest structures and their management throughout and beyond the urban system. Such collaborative stewardship should include not only owners, users, and managers of natural resources; but also individuals and groups involved in the management of other urban components (for example, commercial developers, city planners, utilities, and residents). Collaboration among a wide range of decisionmakers who affect urban forest resources provides opportunities for those involved to identify common interests, resolve potential problems, and coordinate efforts to meet multiple objectives. Our subsequent discussion of the Urban Resources Partnership, Chicago Wilderness, Volunteer Stewardship Network, and TreeKeepers illustrates such collaboration.

The diversity and connectedness of urban forest resources demand comprehensive approaches to their planning and management (Dwyer et al. in press). The complex interrelationships between urban forest components and air and water quality, wildlife habitat, utilities and other infrastructure, and the overall aesthetic character of the community point to the need for an ecosystem-based approach to policy, planning, and management.

Because urban forests are dynamic systems, their management must also accommodate rapid changes in the extent, health, and use of resources over time. Implicit in adaptive management of urban forests is the ability to monitor progress and evaluate the effectiveness of management decisions. By monitoring the effects of program activities on the extent, health, and use of the resource, by identifying areas for improvement, and by modifying management plans to address problems, adaptive management provides the flexibility necessary to sustain and enhance important forest resources in changing urban environments.

The advantages of comprehensive and adaptive planning and management are clear; however, implementing this approach to planning and management poses difficult challenges to urban forest managers (Dwyer and Nowak in press, Dwyer et al. in press). Specific emphasis areas for the future that will facilitate the implementation of comprehensive and adaptive management include improving: comprehensive health of urban vegetation; ecological restoration techniques; inventory and monitoring of the urban forest resource; dialogue among urban forest owners, users, and managers; collaboration among agencies and groups; understanding of how forest configuration influences forest use and benefits; knowledge about urban forest health; and the dissemination of information about urban forests, their benefits, and their management.

Involving Individuals and Groups in Resource Management

Urban populations in the United States have diverse incomes, education, racial/ethnic backgrounds, lifestyles, and associations with and views of resource management. It is important to recognize and embrace this diversity when dealing with urban populations. It is also important to recognize that many urban residents, as individuals or members of groups, have existing or potential ties to urban natural resources and their management. Efforts to connect urban residents to resource management should take advantage of the existing infrastructure for linking people and natural resources in urban areas.

Urban residents may obtain natural resource experiences in settings different from what a natural resource manager is accustomed to. Their involvement in natural resource issues may not be active -- they may not purposely feel, touch, and explore nature. However, they may be involved in less direct ways. Urban residents may behold nature (view it from a window) or derive pleasure from just knowing it is there. They may read about it, vote on issues related to it, write letters to the editor, join organizations that impart a philosophy in tune with their own, donate time or money to a cause, protest an activity, attend city council meetings and public hearings, etc. Urban residents experience nature not only by vacations to faraway forests but also by walks in a neighborhood park or by visits to zoos, museums, libraries, web sites, and nature centers. This diversity of experiences with nature shapes how urban people value the forest and view forest management.

Overall, the effectiveness of forest resource management in urban and urbanizing areas in the years ahead is likely to hinge on collaborative partnerships among a wide range of public, private, and not-for-profit groups; the expertise from a large number of scientific disciplines; and perhaps most important of all -- the involvement of citizens in planning for, implementing, and monitoring the results of resource management.

The results of comprehensive management of urban forest resources, including collaborative approaches and the dialogue with citizens about forest resources and their management, are likely to have influence across the urban to wilderness landscape as urban residents purchase, use, and care about forest and associated resources. The success of the extension of the urban experience to rural areas is likely to hinge on the extent to which urban natural resource management issues are linked to their rural counterparts, the involvement of urban people in planning and carrying out management, and the ties made among resource management, resource use, and environmental education.

In the subsequent discussion we will examine two forms of involvement in natural resources management: (1) citizen participation, and (2) urban coalitions or partnerships.

Citizen Participation

A key to enhancing the management of forests in urban and urbanizing areas and connecting urban people with forests and their management is the involvement of urban residents in comprehensive and adaptive forest resource management. To illustrate this involvement, we have drawn examples from the urban forestry and ecological restoration movements in the Chicago area. These efforts provide useful models for more effective connections between urban people and forest ecosystems in the 21st century.

Both the urban forestry and ecological restoration movements have developed in response to loss of valuable urban natural resources. Each has evolved into a strong movement that significantly influences resource management in urban areas and beyond, but each has developed a different strategy for involving people in natural resources management. There are important similarities, differences, and opportunities for synergism between these two movements (Dwyer and Childs 1997, 1998). Both contain important elements of comprehensive and adaptive management in urban and urbanizing areas. Our subsequent discussion focuses on the Chicago area and draws heavily on USDA Forest Service work with the Openlands Project's TreeKeepers urban forestry program, as well as with the ecological restoration efforts of the Illinois Nature Conservancy's Volunteer Stewardship Network (Ross 1994, Westphal 1993, Westphal and Childs 1994).

Urban forestry in Chicago has grown and gained strength partly in response to the catastrophic loss of trees, including the loss of elms to disease, and the loss of trees, forests, and greenspace to urban development. Given significant past losses and a high level of interest in trees by citizens and public officials, urban forestry has received significant attention in the Chicago area. Early urban forestry efforts focused on maintaining the trees along streets and in parks and forest preserves, but the scope has broadened over time to include comprehensive management of trees, forests, and associated greenspace across the urban environment and adjacent areas. Many urban forestry organizations such as city forestry departments and not-for-profit organizations spend most of their effort caring for trees in areas where the native ecosystems have been significantly modified.

Ecological restoration focuses on rehabilitating and maintaining biologically significant natural systems. There are many such systems in the Chicago area, including some that are unique and highly valuable, which have generated significant attention. The effort developed partly in response to the continuing loss of plant and animal diversity in prairies, but subsequently expanded to savanna, woodland, and forest ecosystems. In Chicago, the loss of diversity includes the incremental loss of natural areas to development, erosion of the quality of protected natural areas due to the lack of fires and other natural disturbances, as well as the introduction of exotic species. Traditionally, restoration activities are planned with reference to landscapes as they appeared before European settlement, but also consider current conditions, problems, and resources. Interest in ecological restoration is now extending beyond individual species and sites to the broader regional landscape. This landscape-level approach has accelerated under the Chicago Region Biodiversity Council (i.e., Chicago Wilderness) (Chicago Wilderness 1999b, Ross 1997).

These two movements in Chicago are similar in many ways. Both share a large amount of citizen involvement, including a high level of activism. Not-for-profit groups organize and train volunteers and build strong volunteer organizations that in themselves become important advocates for urban natural resources and their management. Studies show strong commitment by volunteers and similar motivations for the two movements (Westphal 1993, Schroeder 1998). Charismatic leadership among volunteers and in not-for-profit groups has been a driving force in shaping both movements. Efforts of both movements have brought increased public attention to trees and other natural resources in the urban environment.

Urban forestry volunteers participate in site design, site preparation, tree planting, mulching, and follow-up care of young trees such as watering and pruning. Ecological restoration volunteers participate in site mapping, location of significant species of plants and animals, prescribed burning, seed harvesting, and removal of non-native species. These tasks are sometimes organized as social events that may include potluck dinners or picnics in addition to the work activity. While both movements stress on-the-ground action, some volunteers participate in other ways, including writing newsletters, scheduling and coordinating events, and so forth. Increased attention is being given to volunteer training so that they can work more effectively with natural resources, as well as with the people who manage and use them. Training materials are sophisticated, well developed, and updated regularly. Both movements have strong environmental education programs aimed at children and adults.

Both movements capitalize on "active" participation as a means for citizen involvement, but neither has fully embraced or mastered widespread public involvement. There is a belief among both movements that if people can see and participate in management activities they will support these activities. Both movements are working hard to make urban residents and public officials more aware of urban vegetation, its management, and its significance to the urban environment and quality of life.

A comprehensive and adaptive approach to management of vegetation throughout the urban ecosystem would encourage linking of urban forestry and ecological restoration efforts, as well as collaboration among them (Dwyer and Childs 1997, 1998). From the standpoint of citizen involvement with natural resources, combined training and environmental education programs for individuals and groups involved in urban forestry and ecological restoration would provide a wider range of skills and experiences for volunteers, enhancing their experiences and the contributions that they will be able to make to resource management across the urban environment and beyond. The movement in this direction is encouraging. Some of the TreeKeepers effort is being focused on the restoration and management of specific sites. Volunteers from TreeKeepers and the Volunteer Stewardship Network have received training and are working to survey for the Asian longhorned beetle, an exotic invasive pest that was recently discovered in three Chicago-area neighborhoods.

Discussions with homeowners in the areas where trees were lost to the Asian longhorned beetle made it clear that they wanted to be kept well informed about the beetle, control options, and decisionmaking concerning management of the pest and its damage. This response reaffirms the interest of urban citizens in learning about and becoming involved in natural resource management. Such interest is a cornerstone of citizen involvement in collaborative management of urban forests.

Urban Coalitions and Partnerships

Collaborative stewardship requires a wide range of organizations working together to manage natural resources. To illustrate how this can take place, we will discuss two initiatives in the Chicago Area: (1) the Urban Resources Partnership, and (2) Chicago Wilderness. Both of these efforts bring public agencies, not-for-profit groups, communities, and citizens together into new working relationships to do a more effective job of natural resource management in the Chicago area. Each effort seeks improvement in the management of urban natural resources, but has different origins, emphases, and goals.

Both efforts encourage citizen involvement and have included volunteers from the urban forestry and ecological restoration movements. Although the efforts involve some of the same organizations, they remain separate in their mission and goals.

The Urban Resources Partnership

The Urban Resources Partnership (URP) is administered by the U.S. Department of Agriculture and co-sponsored by the Forest Service and the Natural Resource Conservation Service in 13 cities around the United States. Agencies with missions related to the urban environment have joined the partnership. In Chicago these partners include the U.S. Fish and Wildlife Service, National Park Service, U.S. Environmental Protection Agency, U.S. Department of Housing and Urban Development, and Cooperative Extension Service; as well as the State of Illinois (Department of Natural Resources) and City of Chicago (Department of Environment). The program advocates and assists community-based action through local partnerships to enhance, restore, and sustain urban ecosystems. These actions contribute to the improvement of the social, economic, and physical well-being of the people and their natural environment. The partnership provides technical assistance and partial funding to community-driven environmental restoration, enhancement, and educational projects. The program stresses projects that have physical (on the ground) components. URP strives to link community residents and the environment. The URP philosophy hinges on the belief that through education and participation, project participants build lasting ties to the natural environment, their communities, the government agencies that serve them, and most importantly, each other.

Chicago URP projects range from community gardens to large-scale ecosystem restorations. Chicago URP resource goals include: open space enhancement; water quality improvement; urban habitat creation, enhancement, and management; environmental education and stewardship; and the implementation of ecosystem management techniques.

The partnership supports natural resource conservation projects throughout the Chicago Metropolitan Area. Many individual projects involve Federal partners, not-for-profit groups, and community organizations. Projects target underserved inner city areas. Efforts are made to support projects where there is substantial community involvement and to encourage the involvement of urban residents in the actual management efforts. URP does not try to organize community groups, but rather approaches groups that already have community consensus for a project. URP targets urban conservation projects through a unique network of community groups such as boys and girls clubs, block clubs, public housing resident associations, and youth service organizations.

The URP experience in cities around the U.S. demonstrates a wide range of useful approaches for enhancing the management of urban natural resources by spawning partnerships that involve many different actors, organizational structures, and group missions in each city. Variation in the types of groups, resources, and resource issues involved in the different URP cities suggests that the most effective mix of partners, working relationships, and leadership structures in collaborative urban natural resource management may be different for each city.

What has been learned from the Chicago URP experience?

1. There are a wide range of important conservation needs in urban areas, and while local residents and community groups are interested in addressing these needs, they are often unfamiliar with the public agencies and not-for-profit groups that can assist them.
2. Urban residents see conservation efforts as a way to derive a range of important benefits for their community such as improving appearance, increasing recreational possibilities, creating jobs and opportunities for youth involvement, and building the capability to tackle other issues.
3. Community-led projects can be difficult to manage for a natural resources professional. In some cases,

the community may have different priorities for resource management than the professional.

4. Local support and involvement are critical to getting urban conservation projects started, and absolutely essential for sustaining them.
5. In getting urban conservation work done, technical assistance is often as much of a limitation as funding is. The demand for technical assistance for natural resources management exceeds current capacity of natural resource agencies.
6. Natural resource management issues in urban areas may be more complex than rural resource issues, and may require a level of sophistication and expertise beyond what one agency can provide. Agencies problem-solving together may be a solution.
7. There are substantial differences in the way that federal, state, and local agencies, even within the same urban area, approach resource management issues in urban areas. Thus, there is much to share and to learn through collaboration, and that sharing enhances the resulting projects.

Chicago Wilderness

The 100 + members of the Chicago Region Biodiversity Council (or “Chicago Wilderness") work to protect the natural communities of the Chicago region and to restore them to long-term viability to enrich the quality of life of citizens and to contribute to the preservation of global biodiversity. Chicago Wilderness has brought significant attention to the management of more than 200,000 acres of public and private land in northeastern Illinois, southeastern Wisconsin, and northwestern Indiana; and brought new collaboration among diverse groups. The areas that make up Chicago Wilderness are seen as a globally significant concentration of rare natural communities -- woodlands, forests, grasslands, streams, and wetlands.

Chicago Wilderness originated in local efforts to protect, restore, and enhance biodiversity. Those efforts drew support from the existence of significant remnants of pre-settlement vegetation in the Chicago Metropolitan Area and the desire to prevent their loss to development or exotic invasive plants. As this work expanded in scope, scale, and significance and began to take a landscape perspective, Chicago Wilderness was born.

The scope of the work of Chicago Wilderness is captured in the titles of the teams responsible for work that is carried out: science, land management, education and communications, and policy and strategy. There are strong efforts to integrate the work of these teams. The science and land management teams often meet jointly to be certain that there is a science input into land management. Policy and strategy works to implement initiatives developed by the other teams. Education and communications are tightly interwoven into developments in science and land management, and there are designated demonstration areas for restoration activity.

The partnership expanded rapidly and includes members from land management agencies; environmental groups; educational institutions; and federal, state, and local natural resource agencies. Chicago Wilderness provides funding for a wide range of projects that further its mission. A substantial amount of the initial funding has come from Federal agencies, but there has been some funding from state, foundation, and private sources.

Chicago Wilderness took a multi-pronged approach to engaging the public in restoration activities. The partnership attracts public interest by creating museum displays, zoo exhibits, and demonstration areas in forest preserves, organizing volunteer days at forest preserves, parks and nature centers, and by publishing and distributing Chicago Wilderness magazine throughout the metropolitan region. In addition, the partnership has produced a series of educational materials, including: an *Atlas of Biodiversity* (Chicago Wilderness 1999a), and *12 Natural Wonders of the Chicago Wilderness* (Chicago Wilderness 1998). The *Atlas of Biodiversity* has been distributed to every 8th grade teacher and every library within Cook County. Chicago Wilderness has also produced the *Biodiversity Recovery Plan* *for Northeastern Illinois* (Chicago Wilderness 1999b) that outlines the steps necessary to achieve the overall goal of Chicago Wilderness. The plan was adopted by the Northeastern Illinois Planning Commission (NIPC) in December 1999, the first major metropolitan planning agency in the nation to adopt a biodiversity plan for its region. Not only do these documents broadcast the importance of biodiversity to urban residents, they serve as a means of instilling public pride in the uniqueness of the prairie landscape.

What has been learned from the Chicago Wilderness experience?

1. The coalition can accomplish much in terms of public awareness and environmental policy that individual member organizations cannot do alone.
2. Preservation and enhancement of biodiversity can be a useful integrating theme for a group of diverse organizations with missions that focus on land management, research, and education.
3. There are numerous linkages among the Chicago Wilderness partners, with many opportunities for productive partnerships.
4. Public relations are important for the effort, and it can be a challenge given the large number of diverse organizations involved.
5. Coordinating a large coalition with a wide-ranging mission is a challenge that requires a significant amount of time and effort. Coordination across political and institutional boundaries is difficult. Even though most Chicago Wilderness partners agree on the mission, and the mission reflects that of their own institution, each institution has prior commitments of time, resources, and personnel that complicate its participation in Chicago Wilderness.
6. Even with the commitment to public relations and public outreach, Chicago Wilderness is hardly a household name with the metropolitan public.

Summary and Conclusions

Urbanization poses important challenges to resource managers. These challenges can be met by implementing comprehensive and adaptive management of forest resources in urban and urbanizing areas, and by connecting people with forests and their management. Comprehensive and adaptive management involves a wide range of disciplines, government organizations, citizen groups, etc. In this process, a widening spectrum of people become involved in forest resource management, including the establishment of policies and plans, generating support for those efforts, and actually carrying out resource management activities. These efforts are enhanced by coalitions and partnerships of public agencies, not-for-profit groups, community organizations, and others. Examples of successful collaborations include the Urban Resources Partnership and Chicago Wilderness. Direct involvement of citizens in resource management through groups such as TreeKeepers and the Volunteer Stewardship Network is also helping to implement collaborative stewardship and to connect citizens to natural resources and their management. As urban forestry becomes more comprehensive and more people are involved, the ties between it and forestry in rural areas become stronger, and the urban experience is more likely to influence what happens in rural areas. Comprehensive urban forest management can become a demonstration or reference for management of forests in rural areas. Citizen involvement and collaboration among groups is not only improving the management and use of urban forests, but also helping to establish critical links between people and resources that will help enhance resource management across the urban to rural spectrum of lands in the 21st century. Individuals and groups interested in involving urban residents in resource management decisionmaking might find it productive to work in conjunction with urban forestry programs and associated collaborative and citizen involvement efforts in urban areas.

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The Urbanisation of Forestry: Towards Better Incorporation of Urban Values Into a Once Rural Profession or: The Good City, the Bad City, and the Forest

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Abstract

Urban values have become increasingly dominant in today's society. The share of the world's population living in urban areas has now bypassed that of those living in rural settings. Moreover, the socio-economic, cultural and ecological footprint of urban areas extends far beyond their physical boundaries. The world's rural and nature areas have become 'backyards' for the world's cities, primarily aimed at delivering goods and services to them. Forests and forestry are among those areas affected by the process of urbanisation. Forestry has typically been characterised as a rural profession. However, forestry today, to an increasing extend, has to deal with the dynamics of urban society. This paper features city and forest as both the Romeo and Juliet, and Cain and Abel. It describes how forests can be used in the continuous effort to create liveable cities, where the bad sides of urban life are minimised, while the positive aspects are optimised. As a recent study on urban woodland policy-making, planning and management in major European cities has shown, forests do in fact have potential to contribute to better cities through a wide range of social, economic and environmental values. Most importantly, they are crucial tools for keeping urbanites in contact with nature and natural processes. Some of the values of urban woodlands within an urban context will be elaborated, following an elaboration of the dichotomy of the city as being both 'good' and 'bad'.

Keywords: Forests, Cities, Urbanisation, Social values, Urban forestry

The Urban Boom

Most of us are urban people, even if we still have some green blood of the countryside in our veins. Internet, McDonald's, supermarket, cinema, traffic jam: urban phenomena that are part of our daily lives. But mostly we have to go only one or two generations back to find a farmer in our immediate family. Much has changed within the short period of one century. The Industrial Revolution may have been the incentive, but it is the 20^{th} century has really made the difference. According to United Nations figures, only 14 % of the world's human inhabitants lived in cities around 1900. In late as 1960, 2/3 of the people still lived in rural areas. At the start of this new millennium, the world hosts more urban than rural dwellers for the first time in history. By 2025, the UN estimate, only 1/3 of the people will still reside in rural areas. This development, jointly with the population explosion from 1.7 to over 6 billion within the past 100 years, had led to a boom in the number of urbanites. In 1950, there were only 2 megacities with over 8 million inhabitants. In 2015, there will be 33, and an additional 500 cities with over 1 million people. (Ponting 1991, EEA 1995, National Geographic 1998)

Even more rapid has been the physical growth of urban areas. Jack Ward Thomas (1999), former chief of the US Forest Service, has elaborated on the phenomenon of urban sprawl in the USA. He mentioned, among others, that while the city of Atlanta doubled its population during the past decades, its urban area increased by 400 %. Cities have gradually been 'eating away' at the countryside, not only through direct building activities, but also via the extension of railroads, roads and communication infrastructures. Through the latter, the dominance of urban values and norms has increased. Even in the most rural areas of Europe, children dress up in LA-style street gear, wear Manchester United football shirts, and people watch the Bold and the Beautiful and ER. In the process, we humans are steadily losing our direct contact with the earth. The dirt under our fingernails is gone.

Europe, of course, was the first continent to become truly urbanised. At this moment, over 2/3 of the Europeans can be classified as urban. Even though some large cities have actually lost inhabitants, urban agglomerations are steadily expandeding. Countries such as the Germany, Netherlands and the United Kingdom are approaching the 90 % urbanisation rate (e.g. EEA 1995, World Resources Institute 1996). My own life, for example, has also been urbanised. I started off in two small villages with just over 1000 people, before I moved to Wageningen, a Dutch university town with 35,000 people. Via Joensuu, Finland (55,000) I have now reached very urban Frederiksberg, a town of almost 100,000 absorbed within Greater Copenhagen with its 1.2 million people. The home computer entered my life when I was 13, the Internet when I was 20. Still, my great grandparents were farmers and fishermen.

The City Calls

Why do so many of us prefer to live in cities? People are social animals, like ants, but why do we seemingly prefer ant heaps of concrete, steel and tarmac over the rolling hills of the countryside? In his book 'The Gaia Atlas of Cities', Herbert Girardet (1992) mentioned the Industrial Revolution as major catalyst of urbanisation. Economic development became increasingly concentrated in cities and pulled people from the countryside. This process is still ongoing, particularly in developing countries. Cities have been windows of opportunity, offering prospects to dramatically change people's life. As Frank Sinatra sang about New York: "if you can make it there, you can make it anywhere"…

Spiro Kostof, in his book 'The City Shaped' (1991, p. 37-41), mentioned that cities are places "where a certain energised crowding of people takes place". Simply by putting a lot of people together on a small surface, a high level of activity and creativity is generated. People are pushed, one could say, towards and beyond the limits of their capacities. City life requires continuous learning, communicating, understanding, and adapting. Thus it is not surprising that Kostof said that in order to understand a city, one has to understand its cultural dimension.

Exactly what constitutes a city is, one has to say, a very difficult question to answer. In Iceland, settlements of over 50 people are already classified as urban (Benedikz and Skarphéðinsdóttir 1999). This is not really in line with the image most of us have of cities. Scholars have tried to grasp the concept of a city. The well-known urban designer Kevin Lynch (cited by Kostof 1991, p. 40) stated: "City forms, their actual function, and the ideas and values that people attach to them make up a single phenomenon". Kostof (1991, p. 37-41) provided a range of characteristics. Cities, he said, are places made up of buildings and people. But cities are also distinguished by some kind of monumental definition, that is, where the fabric is more than a blanket of residences. Cities have some physical circumscription, whether material or symbolic, to separate those who belong in the urban order from those who don't. In the old days, these were the city walls. But cities are no independent entities. They are "intimately engaged with their countryside, a territory that feeds them and which they protect and provide services for". Kostof concluded his work on city design by expressing his admiration for the city as human phenomenon: "the city is one of the most remarkable, one of the most enduring of human artefacts and human institutions."

A Tale of Two Cities

The development of the city, however, has always been put into the perspective of its good and bad sides. Or, as Charles Dickens wrote in his Tale of Two Cities (1859, 1992 edition): "It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the epoch of belief, it was the epoch of incredulity, it was the season of Light, it was the season of Darkness…"

The Bad City is, as the American philosopher and writer Henry David Thoreau stated, the place where "millions of people are feeling lonely together" (cited by Ponting 1991, p. 312). American president Thomas Jefferson called the city a "sore on the body politic" (cited by Kostof 1991, p. 39). Jefferson favoured development via agriculture, so his view was perhaps rather biased. A more objective view has been expressed by the sociologist Redfield (1956, cited by Mak 1995), who described how cities obtain more power and wealth in their development, but have to pay a high price for this in terms of alienation, absence of norms and personal isolation. Ultimately, this would lead to the collapse of many cities. Human history, indeed, is full of cities that where once great but then declined, and in some cases - like Rome - became great again.

Cities are often overcrowded and evoke feeling of stress. This feeling is enhanced by the continuous information overload, the noise, fast moving traffic, the rapid pace of city life and the difficulty to escape from it. It is never completely dark in a city and senses are over-activated. Social conflicts emerge, for example due to increasing income inequality and immigration. Urbanisation has led to the break with traditional social ties towards individualisation. The German sociologist Bahrdt (in Zijderveld 1983) mentioned the transition from a Gemeinschaft build upon traditional social ties (the family, the neighbourhood), to a Gesellschaft where impersonal arrangement and institutions have to be created for maintaining law and order.

Cities are often seen as irresponsibly draining scarce natural resources. The price paid for development is high, for example in terms of environmental pollution and degradation. Girardet (1992, p. 67) cited Lewis Mumford, who wrote: “The more complete the urbanisation, the more definite is the release from natural limitations; the more highly the city seems developed as an independent entity, the more fatal are the consequences for the territory it dominates.”

Urbanisation has drastically changed the relationship between people and nature. People have become supermarket hunter-gatherers, as Girardet called them. They are primarily spending time in sealed, climate-regulated buildings. Encounters with nature are restricted to the *Ficus benjamini* in the hallway and the Grand Canyon screen saver on their computer. The European Environment Agency, in its 1998 ‘State of the European environment’ report, signals a large number of environmental threats in Europe’s cities. Car traffic is further expanding across the continent, primarily due to a steep rise in leisure traffic. In spite of better air quality in EU cities, problems still exist with winter smog, ozone and other pollutants, particularly (also) in Eastern Europe. Noise levels are too high and clean water resources are under pressure. As remarked, urban problems are not confined to the cities themselves. Growing areas of land are needed to provide city populations with all the resources they need and to absorb the emissions and wastes they produce. The urban footprint has long reached Big Foot dimensions.

It is not fair, however, to simply classify the city as a source of evil. Cities have taken a central place in the development of humankind. They have been centres of innovation, of culture - the winds of intellectual advance blow strong (American Behavioral Scientist 1978) - and the arts, economics and politics. The citizens were those who first challenged feudal relations and called for democracy. Even today, this call especially is uttered on city squares, the true theatres of politics. Wenceslaw Square in Prague, Tiananmen Square in Bejing, Plaza del Mayo in Buenos Aires; indeed, as the Dutch cultural-sociologist Zijderveld (1983) has claimed, democracy is in the city’s heart.

Cities are centres of learning, transmitting accumulated knowledge on which future achievements can be built (Girardet 1992). In the bible, in Genesis 11, 3-5, it is written: “Come let us make bricks and bake them hard. Come, let us build ourselves a city and a tower with its top in the heavens, and make a name for ourselves; or we shall be dispersed all over the world.” (see Girardet 1992, p. 39). Cities also play a critical role of acculturating refugees from many countrysides.

The Forested City

This ‘Tale of Two Cities’ may support the notion that, for developing liveable cities, the good sides of the city have to be maintained and enhanced, while negative aspects are minimised. Liveable cities need liveable environments, where pollution levels are not too high and where there are enough opportunities to occasionally escape from hectic city life, from overcrowding. Where there are enough places, particularly in people’s everyday living environments, where they can get in contact with nature, see the change of the seasons, get dirty fingers - and not just from eating junk food.

It is my strong believe, based upon a four-year study of urban forestry in Europe (Konijnendijk 1999), that the forest can be a major partner in this quest for liveable cities. Forests and cities, they seem so different and even contradictory. But history has shown that forests and cities can in fact make a pact, a symbiosis to create very special places. This is not to say that cities and forests have not been at war. When cities developed, forests were often among their first victims, when land was needed for feeding urban mouths. Later, forest land was - and in some cases still is - directly used for urban expansion. Mostly there was not much protest against this development. The relationship between forests and people has been very much two-sided. The Dark and Dangerous Forest has often had the upper hand over the Cathedral and Refuge (e.g. Schama 1995). Even today, forests and woods are often associated with unwanted activities and danger, in the form of murder, sexual abuse, robbery, but also rabies and Lyme's disease. As Simson (1998) mentioned: whenever the English press reports on a murder, they make clear that it happened in, near or on the way to a wood, or perhaps on a place where there once was a woodland.

In spite of the negative feelings woodlands sometimes evoke, history shows that cities and forests can go together very well. What would Paris be, for example, without its Bois de Boulognes or Bois de Vincennes? Or Vienna without its Wienerwald and Berlin without its Grunewald? The benefits of having forests nearby were recognised by city governments centuries ago, who tried as a result to expand their forest ownership. Woodlands could be used by the local population for gathering food and fodder, as well as construction and fuelwood.

Later, forests became appreciated as recreation environments. First of all by the noble and the rich, and then by all social strata. Woodland parks became stages for plays of social order. Different social classes had their own way and time of using the forests, thus reconfirming their place in society (Konijnendijk 1997). When the railroad network reached the Fontainebleau, 60 kilometres from Paris, the forest was turned into a 'promenade parisienne' and mass recreation commenced (Kalaora 1981). The annual Dunlop Fair in the Epping Forest near London attracted crowds of over 100,000 Londoners as early as the mid-1850s (Green 1996).

During the 19th century, another role of forests and green spaces became apparent. Scientists and planners started to promote the image of the 'organic city'. Cities, like plants and animals, were subject to sickness and decay. The Industrial Revolution was regarded as the villain, threatening the life of the city and its inhabitants (Kostof 1991, Ponting 1991). Parks and other green areas were the lungs of the city. Ample green spaces were needed for maintaining a healthy working class. Industrialists and city governments favoured labourers spending their free Sundays in the open air with their family, instead of embarking on bouts of socially harmful behaviour.

Both the recreation and 'sanitary' use of urban green and woodlands became more important over time. Urban dwellers also founded the nature conservation movement and urban woodlands such as Fontainebleau and Zonienwoud near Brussels, Belgium were among the first of such areas (Konijnendijk 1999).

The Urban Woodland under Pressure

Nature conservation, recreation environments nearby, providers of cleaner air and water: urban woodlands were seen as providers of myriad goods and services to urban society. City governments had also started to realise that woodlands could assist with creating attractive cities. Attractive for rich taxpayers and for businesses, that is. Woodlands and parks were bought specifically for this purpose. Some cities wanted to rapidly cash in on the presence of woodlands, and they converted them to areas of upper-class housing.

Threats to urban woodlands, for example from urban development pressure, are still manifold. The intensive recreational use of the limited forest resource is another major concern for ecosystem conservation. Many of Europe's urban woodlands have annual rates of 2,000 visits per hectare per year or more, rising to over 5,000 in Amsterdamse Bos and Bois de Vincennes (Paris) (Konijnendijk 1999), i.e. 1 visitor per 2 m^2 of forest each year.

Threats also occur through air pollution, abuse (a nearby woodland comes in handy when you have to get rid of some rubbish), and the risk of conversion to more financially profitable land use. In more unstable times, and times of war in particular, urban woodlands are an easy victim. In the 16th century, the Dutch Count William of Orange wanted to cut his Haagse Bos, an urban woodland, so that he could pay his soldiers fighting against the Spanish. The people of The Hague went as far as melting the church bells to generate enough silver in compensation, so that the forest was saved (Buis 1985). Town forest successfully competing with religion, perhaps incredible but true. Wars continue to threaten urban forests, even in Europe. The forests around Sarajevo were stripped of fuelwood during the Bosnian War. Before the war, they were popular recreation environments for the local people. As soon as the war was over, young people took to the forests again, in spite of the risk of mines. Some of these people were killed (Pettenella, pers. comm.). A dramatic and deadly close relationship between urbanites and woodlands…

The word 'urban forest', of course, holds intrinsic tension. Urban pressures, be it not typically in the form of a siege, are an everyday reality. As reasoned in my dissertation, a clear need exists for a sustainable urban forest resource, large and healthy enough to meet the manifold current and future demands of Europe's urban populations. This can only be realised by means of a strategic approach, bolstered by a widely supported and enforced framework of concepts, policies, plans, laws and regulations. In this way, existing urban woodland resources can be conserved and managed to optimally fulfil their roles. Moreover, new woodlands can be created to relieve the pressure on existing woodlands and to meet new social demands. There are still many forest-poor cities across Europe, and especially in the Western and Southern countries. For example, Dutch, Belgian, British, Danish and Italian cities seldom make it to the 5 % woodland cover mark. On the other hand, the European municipal forest cover average is pushed to over 15 % by forest-rich cities in Scandinavia, Eastern Europe and parts of Central Europe. It is a big contrast: less than 1 % forests within the municipal area of Amsterdam versus 42 % in Freiburg, Germany (Konijnendijk 1999).

Towards an Urban Forestry Approach

Strategic planning and management of urban woodlands, old and new, can only find sufficient public and political support when woodland benefits are unambiguous. No false expectations should be raised. The Bad City will not become Good just by pouring a sauce of urban woodlands over it. On the other hand, not every Good City is characterised by a high share of urban woodlands. But, as has been discussed here, urban woods do deliver many goods - going for an evening stroll away from the city noise, bringing the rhythms of nature into the city, perhaps improving mental and physical health, and reducing air pollution. Even raising real estate prices, as demonstrated in a doctoral study carried out by Tyrväinen (1999).

It is right to focus on benefits, if done in an honest way by not ignoring the attendant difficulties and problems. Urban woodlands do have negative sides to them, as we have seen. But if the true values become recognised within their proper context, a political case can be made for the need to conserve and manage forests, and for the expansion of urban woodland cover.

As a next step, people are needed who are ready for the tremendous task of uniting city and forest. Luckily we can build on a vast human resource base of planners, designers, managers, researchers, educators, and volunteers. In Europe, we are lucky to have a strong tradition of town forestry, at least in many cities. It would be silly to ignore the existing expertise and to reinvent the wheel. Private financing to support public funds? Generating public support for forest conservation? Many lessons can be learnt, just by studying urban forestry history.

But times have changed, of course. Urban pressures and demands are higher than ever before. Traditional expertise and knowledge are no longer sufficient and innovations are needed. I have argued, for example, that traditional forestry is not ready for the job. We foresters are no experts, in most cases, in communication, conflict management, public participation and education. All of these are crucial skills in urban forestry, and suggest a multi-disciplinary approach to the discipline, such an approach being defined as encompassing "*the art, science and technology of managing trees and forest resources in and around urban community ecosystems for the physiological, sociological, economic and aesthetic benefits trees provide*" (Helms 1998). Thus urban forestry does not only incorporate the planning and management of urban woodlands, but is an integrated approach towards all urban tree resources. Many of the innovations in forestry, such as multipurpose management, public participation, and forest certification have been built on experiences from 'tests' in woodlands closest to urban centres. German founding fathers of forestry science such as Pfeil and Hartig had urban forests as their experimental areas. Tree species from abroad were often first introduced to urban forests and woodlands parks. Today, forestry faculties and departments often use the forests in or near the cities where they are based as testing grounds, for research as well as education (Konijnendijk 1999).

Who should take the lead in future urban woodland planning and management? Who should ideally own and manage the forests? Most important, as history has shown, are committed and knowledgeable owners and managers, with public support and sufficient power and means. This often can be a city. Over 2/3 of all woodlands within municipal boundaries are in fact owned by cities (Konijnendijk 1999). But in other cases the best owners may be private owners. Urban forestry may be 'social forestry' in optima forma, but private urban woodland ownership is not a dirty phrase. Thanks to private owners and their efforts, be it based upon egocentric motives, some urban woodland jewels have survived the ages.

Whoever own**s**, plan**s** for or manage**s** urban woodlands, their actions have to be based upon a sound knowledge base. Urban forest managers across Europe complain about the lack of research specifically dealing with woodlands in urban areas. It has become recognised, for example within the European research network COST Action E12 'Urban Forests and Trees' and the IUFRO-supported European Forum on Urban Forestry, that traditional, sectoral research is not enough in high-pressure, urban environments (e.g. Krott and Nilsson 1998, Forrest al. 1999). Urban forestry research has to draw upon and integrate perspectives and methods from various disciplines, including forestry, horticulture, planning sciences, landscape ecology and the social sciences. This is promoted within the urban forestry approach. Apart from looking beyond disciplinary boundaries, other walls have to be brought down, for example between different types of green areas. Urban woodlands, parks and street trees have often been dealt with separately. Urban forestry, on the other hand, looks at the green structure as a whole. It also favours a close link between green and overall town planning. More recently, an integrated approach to the urban-rural interface has become favoured as well. Most city walls have long gone, and the traditional differentiation between city and countryside is outdated. The city is everywhere. Perhaps it is about time that the countryside, particularly in the form of forests, was everywhere as well.

Urban forest, the forest at people's doorstep. Woods can be a mighty means for keeping urbanites in touch with natural values, processes and realities. When school children in Berlin start to think that cows are purple (thanks to a popular milk chocolate commercial), nature is far away. The forest is needed as a school. Not only for children, but increasingly also for their parents. It should become a logical, integral part of the city, just like the theatre, the railway station, or the local football club. Like the last, forests may help cities that are loosing their distinct identities. The forest should be seen as a social stage, as nature nearby, as green lung, as attractive environment for economic and other activities.

In spite of his rather negative look upon today's cities, Girardet (1992, p. 181) concludes by acknowledging the immense potential of the Good City: "Cities should be places where we can all feel as some of our ancestors did: that we are making cities to be proud of and where future generations will be proud of to take our place." Well-planned, managed and protected woodlands can significantly contribute to recreating these Good Cities. By identifying the specific, often European-wide characteristics, challenges and opportunities of urban forestry, and by calling for a structured and integrated approach to urban woodlands, research may contribute to the further establishment of urban forestry as a multidisciplinary field. Moreover, by operating on the cutting edge of the urbanisation of forests and forestry, it can act as a testing ground for forestry and other disciplines for better meeting the changing demands of society.

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Urban Social Forestry Programme (USFP) Development and Management: Greening Our City through Community Participation

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Abstract

The underlying concept of urban social forestry (USF) is active public participation in urban forest resources management. Community participation can enhance the quality of community life through a strong partnership among government officials, non-governmental/voluntary organizations, foresters and local people. Public involvement is strongly encouraged, with community members viewed as the most reliable motivation force for implementing USF programme. As a developing concept of public participation in urban ecosystem management, this program needs exploration of its principles, setting, development of strategy, and application. Sensitization of the community people toward tree resources is important and their attitude toward the USF programme can be measured. Public agencies, neighborhood groups, academic institutions, business establishments, PVOs/NGOs are brought to make a coalition of an effective organization for USF implementation. The strategy of developing an USF programme includes organizing community assembly/group meetings to determine local priorities, identifying viable options to address its prospects and aspiration, developing action plans and schedules, and mobilizing members, non-members and local resources. People feel encouraged with the empowerment of working side by side with government/municipal agency. Community understanding and realization about the importance of tree resources in urban area and their active participation in tree resources management can strengthen and materialize USF programme.

Keywords: Urban social forestry, Community participation, Neighborhood groups, Sensitization, Resource mobilization

Introduction

Urban afforestation as a means of environmental and aesthetic improvement has been a long practice by the foresters/arboriculturists in the city administration. Despite a growing awareness of the importance of trees in the physical welfare of urban communities, limited consideration has been given to their social and psychological functions (Johnston 1985). Involving community in urban forest development and management is a new concept in modern day practice. Social forestry is of recent interest in ecosystem management and urban forest management. It can perform multiple objectives of natural resources management and extension. Public education and awareness creation about nature and natural resources, sense of stewardship or ownership development among the citizens, and above all, satisfaction to transfer a habitable environment to next generation are some of the prime outcomes of community participation in urban forest management. Study by Sommer et al. (1994) revealed that city residents who planted their front/backyards by them or paid for planting were more satisfied with the outcomes than residents whose land were planted by city/outside agency or without an extra charge. Street planting sessions brought the neighbors close and made better acquainted (Sommer et al. 1994), and enhanced neighborhood solidarity. But, in reality, the tenants' awareness and appreciation of trees remains limited and any feelings of identification and responsibility for their publicly-owned trees are actually discouraged (Johnston 1985). Urban forestry can enhance community stability, pride and spirit, stimulate community stewardship for urban vegetation, natural resource understanding and conservation ethic (Deneke 1983).

The prospects and importance of community participation in environmental conservation and pollution control are recognized and advocated by the world leader foresters and academicians. In USA, Policy and legislative support for community participation was promulgated explicitly in 1990 Farm Bill that extended the authority of the Forest Service to work with states in developing and implementing urban and community forestry programme. National funding for urban forestry has increased each year since 1991, reflecting a commitment towards the improvement of the quality of community life, based on a strong partnership between federal, state and local government, volunteer organizations, urban foresters and local people (Schoeneman and Ries 1994, cited in Ryan 1997). Public involvement is strongly encouraged, with community members viewed as the most reliable motivation force for implementing successful urban forestry programme (Schoeneman and Doyle 1992, cited in Ryan 1997). Public participation in natural resources management can be a means of reducing social conflicts in urban area and strengthening neighborhood solidarity. Social forestry provides a conceptual and practical framework for urban forest resources management through people’s participation. During last two decades social/community forestry has been recognized as a strategy for forest development and conservation with people’s economic upliftment. In SF, people’s participation is a prerequisite for fulfilling people’s needs and aspiration. Similarly, urban social forestry (USF) means to involve urban resident actively in urban forest resources management beginning from community consultation an needs assessment to project design and implementation. USF can bring the urban residents onto one platform for social movement of tree plantation in urban area.

This document is about a proposal/concept paper how to initiate, sensitize, organize and actively involve urban community people into a body of strong support and action for development and management of USF programme. This article will also deal with the development of a model of USF that includes formulation of policy and legislation; strategy for community involvement; principles and guidelines of urban forests management through peoples’ participation; care and share, partnership, incentives and rewards; role of neighborhood groups, academic institutions, business establishment, private voluntary organizations (PVOs)/non-governmental organizations (NGOs); implementation and maintenance; participatory research and extension; and strategy to overall programme development and management. The strength of this proposition is that the concepts of ecosystem management and urban community forest management have attracted the foresters, arboriculturists, and legislators and administrators in various agencies of forestry resources management and private forestry enterprises/industries, and general people alike.

An Overview and Needs of Community Involvement in Urban Forest Development and Management

Due to rapid urbanization in world cities, the developer and owners have been destroying tree resources for construction of roads, houses, shopping malls, and institutions buildings. The residents of a modern city have become mechanical, and are unaware about urban tree resources development and conservation. The landlord, tenants, and the pedestrians are also kind of insensitive toward urban trees. For the development and management of urban forests, it is imperative to develop a concerted efforts of all the stakeholders and users of urban trees and green spaces.

Traditional practice of urban tree resources management is lying with the city arboriculture department equipped with limited manpower and fund. Their job is planting, protection and care, tending operation, and removal of diseased and uprooted trees. It is a common practice of many city administrations in developing countries that they plant trees and do not much care about survival and growth of the trees. The trees are destroyed or damaged by the pedestrians with no reasons, or the young seedlings may be stolen, or the gavions may be broken. Another important urban stress factor is vandalism. Vandalism is predominantly a social problem. Successful community landscaping and gardening in densely populated inner-city neighborhoods have shown that one deterrent to vandalism is to the development of a spirit of proprietorship in residents (Flint 1985, cited in Nilsson and Randrup 1997). Percentage of highest tree mortality is strongly correlated with unemployment and lower social status (Nowak et al. 1990). Social conflicts on urban forests (Konijnendijk 1997) strongly suggest involvement of local people in policy-making, planning and management of a successful urban forest (Nilsson and Randrup 1997). Dusan Mlinsek, the past president of IUFRO, stresses the need for a holistic approach in forestry, but also recognizes that the social aspects of forestry need particular attention if a holistic approach is to be achieved (cited in Marcin 1995). Management of the urban forest is the responsibility of public and private owners (Grey and Deneke 1978). Its success clearly lies with various departments of city administration and urban residents. Urban forest management decision should be based on a new ethic that responds to the desires of people, their involvement and politics.

In USA, community involvement in urban forest resources management were initiated in the city of Baltimore (MD), Philadelphia (Pennsylvania), Navajo Indians community (Arizona), New haven (CT), Raleigh (NC), Cincinnati (Ohio), and other cities in several states, and observed preliminary success. Community participation is gaining rapid momentum in city arboriculture, forest management, park service, and outdoor recreation and similar departments. Federal and state forest services and environmental agencies are involving citizens' concern in ecosystem management for better community benefits and environmental awareness creation. In recent years almost every state has developed a separate management unit under state forest service named Community forestry unit with an objective of involving community people in forest management.

Principles and Practice of Social Forestry: Fitting it into Urban Social Forestry Programme

Social forestry is a collaborative forestry development programme of the government and citizenry aims at alleviating rural economic distress and mobilizing the energies and efforts of the people to make them self-reliant. The aims and targets of social forestry are economic uplift, environmental protection and awareness creation toward environment. Social forestry aims to get people involve in forestry activities for their common and individual welfare (Ahmed 1999). It has viewed as social sciences tool with integration of forestry techniques in understanding and resolving the problems of human ecosystem. Social forestry projects are meant to bring social change, to ameliorate distortion in the economy and to ensure equitable distribution of income and decision making power of the community people through their active participation. Explicitly or implicitly social forestry programmes are oriented toward cultural changes in the behavior of large number of people toward tree planting and protection (Cernea 1991; Burch 1988). It concentrates on harmonizing the relations among tree, forest, and human society, and on building a dynamic balance among nature, economy, society and politics (Weichang and Pikun 1998).

People's participation in SF means that the target beneficiaries take part in all stages of the project development process; i.e., they participate actively in action research connected to the project, in decision making, planning, in the process of implementation, in sharing benefits of the project, and in monitoring and evaluation. Similarly, people's involvement in USF management can be a social movement for tree planting and conservation in urban areas. Enjoyment of participation and empowerment of urban community people can bring success in USF development. As social forestry is new and developing concept of modern forestry practice, it's applicability in various situation should be examined. It thrusts on motivating active participation, self-decision and empowering people into forestry activities. Social forestry practice can effectively be adopted in urban forest resources management.

Development of Urban Social Forestry Programme

Principles of Urban Social Forestry

Urban forestry is defined as a specialized branch of forestry that has as its objectives the cultivation and management of trees for their present and potential contribution to the physiological, sociological and economic well being of urban society (SAF 1974). Urban forestry embraces a multi-managerial system that includes municipal watersheds, wildlife habitats, outdoor recreation opportunities, landscape design, recycling of municipal wastes, tree care in general and the production of wood fiber as a raw material (Kuchelmeister and Braatz 1993). Urban forestry is a merging of arboriculture, ornamental horticulture and forest management. It is closely related to landscape architecture and park management and must be done in concert with professionals in these fields as well as with city planners.

The "green space" an/or "open space" concepts of city management for environment and quality of life for the city dwellers is very important. Urban forest is the "city's Lung" because of their role in oxygen balance, and removing carbon dioxide. The urban people living in dead environment of steel and bricks always try to come closer to the nature by visiting parks or green space to close to their home. Trees have long been used to beautify and ameliorate the urban environment but in view of the prediction that half of the planet's population are expected to be living in urban areas by the year 2000, the need for urban forests development is increasingly perceived. The primary function of urban parks and green areas is to ensure satisfactory surroundings for recreational and social activities (Nilsson and Randurp 1997). It is universally recognized that the invaluable role urban forests play are dispersing the wind, intercepting glare and noise, filtering air pollutants, and aerating soil and conserving energy. It has invaluable contribution of providing aesthetic outdoor recreation, psychic appeal, and cool resting-place and wildlife habitat and municipal watersheds. It is also noteworthy that it provides firewood, lumber, and chips from tending operations.

Throughout the history, the urban forests were developed and managed exclusively on the basis of its aesthetic and spiritual than on utilitarian benefits. Only recently has their full value to urban dwellers been considered. Now a closer look is given to the environmental services and economic benefits they provide. Urban forestry is a tool, which consider the role of trees in and around densely populated areas as well as the opportunities and challenges related to their planting, conservation and use.

Integration of various aspects of social science tools and methods in urban forest management practice for sustainable development of the community and the forests is imperative. Policy analysis in community participation in urban forest management and environmental education, and strategy for participatory development is important. The concept of USF lies with the integration of community people in urban forest management and development. The underlying concept of urban social forestry is public participation and decision making in urban forest resources management. As a developing concept of public participation in urban forestry management, this programme needs further exploration of its concepts and principles, application, and setting and development of strategy. According to United Nation's Economic and Social Council (ECOSOC), participation requires "the voluntary and democratic involvement of people in (I) contribution to development effort, (ii) sharing equitably in the benefits derived therefrom, and (iii) decision-making with respect to setting goals, formulation of policies, and planning and implementing economic and social development programmes (cited in Banerjee 1992). Promotion of USF needs much stimulation and encouragement among the public. It needs community resources mobilization and organization into a successful USF programme.

Goals and Objectives of the Urban Social Forestry Programme

Since an increasing part of the population lives in urban areas and receives its daily perception of nature therein, nature in urban areas is important to the environmental awareness and an understanding of nature (Nilsson and

Randrup 1997). People's awareness in environmental pollution control is important and it can be addressed through extension of education to general mass of a country about environmental ingredients that keep ecological balance and harmony in local climate as well as global climate system. Many cities in the world are facing environmental disastrous situation and is getting worse if it is allowed to grow unchecked. Modern cities need strategic planning to combat environmental pollution. It is very important to think about citizens' concern and involve them in combating environmental disasters in many cities in the world.

There should be manifolds objectives on social, cultural, economic and environmental considerations. Significant efforts should be undertaken to increase public awareness of benefits, opportunities, and problems associated with urban forests. Encourage maintaining and protection of tree resources, sensitize community identification of their own issues and problems, and design and implement management plan. The objectives of this programme are to provide training, education and communication about new knowledge of urban forest management, and to establish a coalition of individual and organization of community people. Education of employees and the public about the needs and benefits of urban trees, and about knowledge of urban forest management are some of the precondition of successful USF. Empowering community people with the feelings of proprietorship on public resources and contribution in tree resources management should be recognized.

Policy Formulation for Urban Social Forestry Development

Public awareness and citizens' concern about environmental/natural resources conservation and development plays a significant role in national environmental policy decision. The policy decisions always affect certain groups or individuals in the community either positively or negatively. Hence, it is imperative to seek citizens' views and opinions on any major decision that affect public life. A firm political commitment by the government to USF development and continuing involvement of the various services concerned is essential if any major break-through is to be achieved. Unwanted interruption in project activities by local group of touts and other vested interest groups creates serious problems in project management. Concerted efforts of owners, tenants, local institutions, and NGOs/PVOs should be formulated and adopted. Some of the important policies may be as follows:

- People should be actively involved in USF management.
- Land owners, tenants should maintain their land and premises.
- Acts and legislation of development, protection an management should be clearly spelled out.
- Incentives, skill development training, compensation, and awards should be provided.
- All available public/communal and private land should be brought under this programme.

Strategy for Sensitization, Mobilization and Community Organization

The most difficult task of any community forestry programme is to generate sufficient interest to motivate people to take the first crucial steps in realizing the benefits for themselves (Johnston 1985). Sensitization of the community people toward tree resources is important and their attitude toward the USF programme should be measured. Sensitization is a process of educating people by feeding them with adequate information and knowledge. Its effect lies in the fact that after sensitization, a person can take decisions based on realistic, dependable and complete information. Through sensitization process the acceptance of the programme by the community people, their reluctance or skepticism, indifference, and the programme initiator can realize objection about the programme. Community resource mobilization can only be possible through community organizations which the people themselves set-up and manage. Inadequate attention to dealing with social diversity, especially highly stratified social structure reduces formation of strong organization. The heterogeneity and linkage with external societies matter in community group formation. In many cases, peoples' perception and priorities of tree planting and management were ignored and community need assessment was not done before the project initiation. Motivation and extension efforts by the forestry department were minimum which bring failure in many SF projects. Role of extension, research and education linkages in maximizing social forestry project benefits are also issues counted for success. Communities' conceptions of their needs should be considered as high priority. Group process, cooperatives, group discussion, collective action, joint monitoring and evaluation are strategies for community mobilization and organization. Citizen-volunteer groups, capacity building programmes, and community level planning and action should be undertaken. Initiating sensitization activity, contact with community individuals, leaders, formal and informal groups, holding meetings with various groups, select target community are important for designing a USF programme. Programmes compatible with local needs as well as assured and immediate economic benefits can help mobilize people to participate (Swarup and Chand 1987).

Development of Partnerships

Exclusive management by "single entities" whether government, private, NGO or local community, has fairly frequently been inadequate, except in some limited cases (Anderson et al. 1999). Ecosocial linkages between the forest and the society are important as the forest stands at the middle of the society. Urban Forest management should consider public interest in decision making about USF development and utilization. Public institutions/organizations, neighborhood groups, academic institutions, business establishments, PVOs/NGOs are brought to make a coalition into formation of an effective organization for USF implementation and management.

Ensuring People's Participation

Recognition of a partnership between development programme and people must be ensured through people's participation. Public participation provides a forum whereby the scientific information and values of the publics and the agency can be integrated so that the final decision is viewed as both desirable and feasible by the broadest portion of the society (Daniels and Walker 1999). Community participation depends on social arrangements, political and power relation, on economic and non-economic benefits. Experience indicates that immediate and significant benefits to participant influenced active and meaningful participation of community people. What is stimulation of interest for participation? Specific actions? Recognition/appreciation of peoples' contributions, incentives, awards, empowerment can ensure peoples' active participation in USF programme.

The participation process should aim at mobilizing latent local resources effectively. It must aim at avoiding any kind of unilateral decisions by sponsoring agency, its staff members, and management and/or by it's technical experts – who usually neglect consultation with community people. It organizes community assembly/group meetings to determine local priorities, identify viable options to address its problems and prospects, develop an action plan and schedule, and mobilize members, non-members and local resources.

Training and Education Programme for the Community People

Training deals with development of knowledge, skills, techniques, motivation, attitudes and experience which enables an individual to contribute most effectively to the concerted effort of the team or group to which he belongs (Roy and Chatterjee 1994). Implementing agency should intensify information and education to create awareness and disseminate of knowledge about urban forestry. The research institutes, training academies, and universities should organize training programmes/workshops for the general people, extension workers, managerial staff, and policy makers. Training on group sensitization techniques, participatory rural appraisal (PRA), skill/technology development, etc. should be organized. The people should know working as a team, and develop organizational abilities.

Community Level Planning and Action

Initiating, selecting, planning, implementing, monitoring and evaluation of USF, urban community should share same interests and aspirations. Community people and neighborhood groups should be well informed and consulted before designing and implementation of USF programme. Representatives from local bodies, social associations, professional groups should be welcome in decision meeting. Community participants should prioritize the agenda to accomplish during the project period.

Care and Share, Incentives and Rewards

The partner organizations/groups will participate in selection of new planting area, landscape designing, tree species selection, planting and after care and maintenance with the professional assistance from the city arboricultue/forestry department. Their active involvement will uplift awareness about urban environmental conservation among the urban community people. Acting together strengthens community's ability to gather, organize and evaluate any programme with sharing ideas of work together and test the reality for future plans. People feel encouraged with the empowerment of working side by side with government/municipal agency.

Introducing various incentives and rewards should encourage people's initiative, enthusiasm, and active participation. Several incentives like cash/kind subsidy, presentation of gifts/souvenirs, T-shirt with blocks with words of appreciation, prizes or awards on various occasions. Tree planting or tree care competitions can be organized and certificates can be distributed among the winners.

Implementation and Maintenance

Trees that naturally grow in a region are kept intact, and trees of such species are often planted because of their natural suitability to the local environment and soil conditions. Responsibilities of tree planting schedule, site selection, landscape designing, species selection should be done by the specialized groups. Mass tree planting, protection should be handed over to the community people. Specialized works like pruning, pollarding and treatment of diseases should be done by the specialists. Various working groups should be organized for specified tasks.

Sustainability of the Urban Social Forestry Programme

Sustainability should mean that local community should not degrade its natural resources base at least in irretrievably, but rather maintains or even improves it. Sustainability means increasing the potential of community members to influence and control their future on a long-term basis, a goal that can be achieved by strengthening capacity, supporting equity and fostering empowerment. A project is socially sustainable if it is sufficiently adapted to local conditions that people can see the advances of making changes and modifying their practices to attain new benefits. In many social forestry projects benefits were not sustained once the external assistance ended. The city administration should monitor the programme on a continuous basis and inform the community groups in regular meetings. There should be interaction among the community, implementing agency, environmental advocacy groups and concern citizens on continuous basis.

Conclusion

Urban social forestry aims at the welfare that includes social, psychological, economic and ecological aspects of the city residents and the surrounding environment. It is the contention of this article that USF activities can establish bondage between human community and tree resources in a city for ecosocial development. The proposition of this article is that of a concerted effort of the citizenry including government agencies, resident people and voluntary groups/organizations for the promotion and management of urban forests. Community understanding and realization about the importance of tree resources in urban area and their active participation in tree resources management can invigorate and materialize USF programme.

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How Do People Love Their Forests? Let Me Count the Ways

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Abstract

This paper presents empirical estimates of the many non-market economic values forests provide to people in United States and Australia. These values include a wide range of recreation values and passive use or existence values of forest protection from logging, insect damage and fire. The paper provides estimates of the absolute and relative magnitude of the recreation and existence values for old growth forest and wilderness protection in the United States and Australia. These studies demonstrate that passive use values such as existence and bequest are normally larger than recreation benefits.

Keywords: Recreation, Existence, Forest protection, Endangered species, Fire

Types of Benefits Provided by Forests

Direct Use and On-site Values

It is well known that forests provide marketed commodities such as lumber, and paper as well as on-site or forest-based recreation in the form of camping and hiking. Forests also provide habitat for game animals and sport fish, which are often enjoyed on-site as well.

Downstream Benefits

Forests are also watersheds that provide downstream benefits to instream and offstream water users. For example, the forest cover provides for more even releases of high quality water. This high quality water increases downstream enjoyment of water based recreation as well as reducing water treatment costs of downstream cities. Thus in evaluating the benefits of maintaining forest cover it is relatively well established that downstream physical effects must be accounted for (Loomis 1993).

Off-site Public Good Benefits: Existence or Passive Use Values

Additional downstream effects on society include the values to the non-visiting general public just to know particular forest ecosystems and their rare wildlife species exist and are protected. This benefit is called existence value and as the empirical examples below indicate it is likely to be one of the more dominant benefits of maintaining forest ecosystems. The second downstream benefit is the value the current generation obtains from knowing that protection today will provide forests to future generations. These benefits may arise primarily from the virgin forests themselves or from the structure of habitat these forests provide to unique species found nowhere else.

Existence and bequest values are sometimes referred to as non-use values, although this somewhat misleading term has been replaced by the term passive use values. I prefer the term off-site preservation values, but either passive use or off-site preservation values captures the public good notion of these values. That is, existence or passive use values of a specific forest ecosystem has all of the required characteristics of a pure public good: (1) such benefits are non-rival in that any number of people can simultaneously enjoy the satisfaction from knowing a particular forest exists; (2) non-excludable in the sense that no one can be prevented from enjoying the knowledge that a particular forest ecosystem is preserved, say as a Wilderness or National Park.

Commensurate Valuation of Market and Non-market Values of Forest Resources

Price is a readily acknowledged measure of the value in exchange for one more unit of the good. However, price is just one point on the demand curve for a good. The value in use for the first few units consumed, can be read from the demand curve, and often exceeds the market price. This difference between the maximum amount that consumers would pay for each unit and what the price they actually pay for all the units they consume, is their consumer surplus or willingness to pay in excess of price. This is a personal profit, analogous to what firms earn in excess of their costs. Market goods such as lumber which are traded in national and international markets, tend to have a relatively uniform price or value in exchange. Non-market goods do not have explicit prices, but may have implicit prices due to travel cost to the recreation site. The spatial market for recreation results in visitors living at different distances from the forest facing different travel costs or "implicit prices" for forest recreation. This presents the opportunity to estimate the entire demand curve and to directly calculate the consumer surplus of forest recreation. The consumer surplus represents the maximum amount visitors would pay for recreating at this site compared to the next best alternative. This consumer surplus can be compared to the businesses net income or producer surplus from logging the forest.

Measurement of Recreation Value

The most common approach to estimate the demand for forest recreation is the Travel Cost Method (TCM). This method uses travel costs as a measure of price and number of trips as a measure of quantity to statistically trace out a demand curve. From the demand curve, the consumer surplus or net WTP can be calculated. By pooling data across different forest recreation areas with different forest characteristics, the net WTP for those different forest characteristics can be estimated. Examples will be provided below.

The other main approach for estimating the economic value of forest recreation is the Contingent Valuation Method (CVM). This method uses a survey of visitors with regard to their maximum willingness to pay for recreating in the forest. CVM involves: (1) conducting a survey (either mail, telephone or in-person) of visitors; (2) describing the forest recreation resource the respondent is asked to value and if desired, the increase in quality of the recreation resource that would be provided if the respondent agrees to pay; (3) the means by which the visitor would pay, i.e., in higher entrance fee, travel costs, etc.; (4) whether the individual is asked to reveal their WTP by stating the maximum they would pay in response to an open-ended question, selecting a dollar value from a range of values (e.g., payment card) or responding yes or no to one particular dollar amount the respondent is given (e.g., dichotomous choice). Mitchell and Carson (1989) provide a complete discussion of the issues associated with 1-4 and numerous other issues in design and implementation of CVM.

Measurement of Passive Use Values Using Stated Preference Methods

At present the Contingent Valuation Method (CVM) and conjoint analysis are the only methods generally recognized as being able to capture the general public's total willingness to pay (WTP) for forest preservation. I emphasize total to indicate that often CVM surveys ask the public one valuation question requesting their WTP to protect the forest for all reasons including recreation use, the option for future use, existence and bequest values. The sum of these components is called Total Economic Value. In studies described below, some authors have used a follow-up series of questions to have the respondent prorate their total value into separate recreation, option, existence and bequest components. CVM and conjoint when applied to estimate either total economic value (TEV) or simply passive use values is similar to recreation with a few exceptions. First, the general public rather than visitors are usually surveyed. Second, the way the household would pay is broader such as higher taxes, product prices, utility bill, etc.

The central criticism of CVM and conjoint when applied to measuring non-use values is whether individuals would actually pay the dollar amount they state in the survey. This validity issue is difficult to test in the case of passive use values since there is, by definition of it being a public good, no market analog that responses can be compared to. Field experiments to directly test the validity of CVM estimates by performing cash comparisons have provided valuable insights (Champ et al. 1997) but are imperfect tests due to free riding and difficulty in excluding non-payers. In absence of perfect validity tests numerous researchers have turned to tests of reliability, a necessary condition for validity. Loomis (1989) has demonstrated the reliability of CVM when measuring total economic value.

Inclusion of passive use values in U.S. federal government analyses is becoming more frequent. In 1986 when the U.S. Department of Interior proposed its first procedures for valuing natural resource damages, it included passive use values (Department of Interior 1986). While the Department of Interior originally took a rather narrow view of when these values could be incorporated, the U.S. District Court of Appeals directed Interior to broaden its inclusion of passive use values to include all natural resources, even those with on-site use. That is, recreation use and passive use often be complementary, not mutually exclusive.

The U.S. National Oceanic and Atmospheric Administration (NOAA) to appoint a "blue ribbon panel" to hear the evidence whether a survey method called contingent valuation method could be used to reliably estimate passive use values. The panel was co-chaired by two Nobel laureate economists and included an environmental policy economist and a survey research specialist. The panel concluded that when carefully performed following guidelines they suggested, that contingent valuation was capable of reliably estimating passive use values (Arrow et al. 1993). Thus while neither the theory or measurement of passive use values is without controversy, the principle of including existence values in natural resource assessments is accepted by most mainstream economists.

Empirical Examples of Values of Forest Protection

Recreation

Table 1 presents the values of fishing, hunting, firewood gathering and Christmas tree cutting calculated from TCM and CVM studies in the literature. Big game hunting is one of the higher forest recreation values in Table 1. This table also presents the value of direct forest recreation such as hiking, camping and wilderness recreation. As can be seen, forests provide high values of forest based recreation. While these values per day seem modest, when multiplied by even conservative estimates of visitor use, the magnitudes are quite large. For example, at $39 per day, the economic value of recreation in officially designated Wilderness is $574 million per year. In 1996 there was about 153.78 million big game hunter days, which given the value per day of $38.63 per day yields nearly $6 billion in annual big game hunting benefits, most of which is likely attributable to forests.

Passive Use Values

The existing empirical estimates can be grouped into three categories. First are the estimates of the existence values of wilderness preservation. This represents both the earliest attempts to measure these passive use values of forests as well as an area of continuing application. The second main area represents valuation of old growth forests and dependent wildlife. Finally, the existence values of maintaining forest quality defined as healthy, living trees. We will summarize the results of the studies in each category.

Wilderness Passive Use Values

The U.S. Wilderness Act of 1964 emphasizes many societal benefits to wilderness preservation that go well beyond simply recreational use. Walsh, Loomis and Gillman (1984) represent the first attempt to apply CVM to measure the option, existence, bequest as well as recreation value of Wilderness. They conducted a mail survey of Colorado residents in 1980. In the survey booklet they asked households their annual WTP into a fund for continued preservation of the current (at the time of the study) .48 million ha of Wilderness in Colorado, and then WTP for 2 million ha and finally designating all roadless areas in Colorado (4 million ha) as Wilderness. Following these questions they asked what percent was for recreation use this year, maintaining the option to visit in the future, knowing that wilderness areas exist as a natural habitat for plants, fish and wildlife, and finally, knowing that future generations would have Wilderness Areas. The results are summarized in Table 2.

Table 1. Economic Value per Day of Forest Recreation in the U.S.

Activity	No. of Studies	Dollars per Day (in 1996 dollars)
Camping	36	$35.31
Picnicking	10	$36.92
Sightseeing	55	$25.06
Off-road driving	3	$21.78
Float boating	14	$31.26
Hiking/Backpacking	20	$26.84
Downhill Skiing	4	$21.25
Cross Country Skiing	12	$26.81
Snowmobiling	2	$69.97
Big game hunting	162	$38.63
Small game hunting	18	$26.43
Fishing	109	$32.83
Wildlife Viewing	109	$31.14
Wilderness recreation	20	$39.61
Christmas Tree Harvesting	1	$15.88
Firewood Cutting	1	$27.07

Two other findings are worth pointing out. First, WTP per household and in the aggregate increases with the number of acres protected, but at a decreasing rate as expected from diminishing marginal rate of substitution. Second, option, existence and bequest values represent about half the total economic value of Wilderness. Walsh, et al., also concluded that WTP exceeded the opportunity costs of designating 3.5 of the 4 million ha as Wilderness. The present value per ha of Wilderness ranged from a high of $3,077 per ha for .48 million ha to $543 per ha when 2-4 million ha was preserved.

The second study of the benefits of wilderness preservation was performed by Pope and Jones (1990) in Utah. They conducted telephone interviews of Utah households regarding designation of alternative quantities of land as Wilderness.

The only eastern U.S. wilderness preservation study was conducted by Gilbert, Glass and More (1992) to value the Lye Brook Wilderness area and other Wilderness Areas in the New England region of the U.S. One version of the questionnaire asked respondents to value continued protection and management of the Lye Brook Wilderness area; the other to value protection of all Wilderness areas east of the Mississippi River. The two separate samples composed of those individuals who had visited an eastern Wilderness area were apparently able to use this familiarity to distinguish between valuation of one area and all eastern Wilderness Areas. Table 2 also shows the breakdown of total value for all eastern Wilderness into the components, and yields a pattern similar to that of Walsh et al. i.e., a majority of the value of Wilderness being related to option, existence, bequest and the authors' new category, related to altruism, protecting it for use by others.

Table 2. Percentage Distribution of Total Economic Value per Household of Wilderness and Forest Protection

	Own Recreation	Option Value	Existence Value	Bequest Value	Altruistic Value
Colorado Wilderness (Walsh et al., 1984)	43%	16%	20%	21%	not asked
All Eastern Wilderness (Gilbert et al. 1992)	16%	17%	21%	29%	17%
S.E. Australia (Lockwood et al. 1994)	11%	19%	37%	33%	not asked
Total Economic Values of Protecting Forest Quality					
Colorado Forests (Walsh et al. 1990)	28%	21%	21%	30%	not asked
So. Appalachians (Haefele et al. 1992)	14%	not asked	30%	56%	not asked

As contingent valuation has spread internationally it has been used to estimate the value of placing public forest lands off limits to logging in national parks. One such study was performed by Lockwood, Loomis and DeLacy (1993) for preservation of wet and dry eucalyptus forests on the Errinundra Plateau in Victoria and New South Wales, Australia. A mail survey of households in the two states was sent out asking households their WTP to preserve roughly 100,000 hectares of old growth forests. Dichotomous choice CVM was used and the median WTP was $52 per household. As shown in Table 2, the distribution of total economic value is dominated by existence and bequest values, again illustrating the importance of including these values in economic analyses of forest allocation decisions.

A companion study by the same authors (Lockwood et al. 1994) addressed whether there was a significant passive use value for logging of these forests. The median WTP was zero, although 19% did indicate a positive WTP for logging. When asked to state the reasons, 70% was related to the economic activity generated or timber jobs. Since protection of old growth forests in the Errinundra Plateau will result in increased harvesting of timber elsewhere in Australia to meet demand, overall economic activity will likely not change and logging jobs will increase elsewhere in Australia by the amount they fall in the Errinundra Plateau. This is consistent with the conventional treatment of the level of economic activity (which is primarily determined by macroeconomic policies and trends) and treatment of regional economic activity in benefit-cost analysis (Loomis 1993). Only 30% of the WTP of those 19% offering a positive WTP was related to the benefits derived from knowing the forests are logged. This amounts to $6 per year, for the 19% that would pay. If this is replicated in other studies, this concern about a non-market WTP for development can safely be ignored as empirically small effect of a minority of respondents.

Passive Use Values of Protecting Forest Quality

Forests outside of wilderness areas have many characteristics that are of value to the general public. Having healthy, green, living trees is preferred to dying trees, whether they are dying from acid rain or insects. Up to some limit, having more trees per acre is preferred to fewer trees. The health of trees is one influence on the long run number of trees per acre. There have been several studies of the recreation benefits arising from avoiding dead and dying trees from beetle kill as well as how recreation benefits change with the number of trees per acre (Walsh et al. 1989). The next three studies measure the passive use values from keeping forests healthy. Walsh et al. (1990) used color photos of forest scenes in Colorado with varying number of trees per acre over 6 inches dbh. The photos supplemented verbal descriptions of the pine beetle and spruce budworm infestations that were the cause of the differences in number of trees per acre. In person interviews were conducted with Northern Colorado residents. Respondents' total economic value was elicited and then they were asked to prorate this value to recreation use, option, existence and bequest values. Table 2 presents the results in the range of 320-420 trees per ha. Once again, option, existence and bequest values make up a bulk of the total economic value.

Haefele, Kramer and Holmes (1992) used a mail survey of North Carolina residents regarding their WTP to reduce losses of red and frasier fir trees from insects and air pollution. Residents were shown photos and provided pie charts of alternative forest conditions. They were then asked annual WTP to provide protection for all spruce fir forests in the Southern Appalachian mountains. In addition, Haefele et al. asked respondents to partition their bids into recreation, existence and bequest values. As shown in Table 2 well over 80% of the total benefits are related to existence and bequest values.

Conjoint analysis is a marketing research technique that allows direct valuation of product or resource characteristics. Haefele (1999) used conjoint to estimate the economic value of reducing affected forest characteristics such as acres infested with insects (e.g., gypsy moth, spruce budworm). Haefele found that people would pay about $1.20 per ha per year to reduce infestations by forest insects such as gypsy moth and spruce budworm.

Benefits of Preserving Old Growth Forests and Dependent Wildlife

Recently several papers have presented the total economic value of preserving old growth forests as habitat for endangered species such as the threatened northern spotted owl (Hagen et al. 1992, Loomis and Gonzalez-Caban 1994). The northern spotted owl was chosen as a species that would serve as an indicator for old growth forests by the USDA Forest Service. In some sense, WTP for northern spotted owls is viewed by the public as WTP for preservation of old growth forests as well. Hagen, et al. (1992) used a mail survey of a random sample of U.S. households. The authors presented a map showing the approximately 2.83 million acre Habitat Conservation Areas recommended by the scientific committee. Adoption of these old growth protected areas was suggested as a means of preventing the extinction of the northern spotted owl. The CVM used the voter referendum approach with higher taxes and wood product prices as the means of payment. The results indicate an average household WTP of $189. Performing a sensitivity analysis of the benefits and the costs of spotted owl protection yields benefit-cost ratios ranging from 3.5 to 1 and as high as 42 to 1.

As the northern spotted owl debate has shifted from designation of critical habitat areas to their management, reducing the risk of fire in old growth forests has emerged as one of the key issues. Loomis and Gonzalez-Caban (1994) estimated the WTP of Oregon residents to reduce the number of acres of Critical Habitat Areas in Oregon that would burn each year. Using a voter referendum format CVM, the estimated annual value, adjusted for demographics of the Oregon population, is $77 per household for an reduction of 1417 ha burned. Expanding the sample just to Oregon's population results in a value per ha of old growth forests saved from burning of $59,280.

More recently, Loomis and Gonzalez-Caban (1997) estimated the value to both California and eastern U.S. residents of protecting habitat of the California spotted owl from fire. While the amount eastern residents would pay is less per household ($45.70, 90% confidence interval of $41-50) than California residents ($78.69, $72-88), the amount eastern residents would pay is significantly different from zero. This illustrates that the public good market for forest protection for rare species is often nationwide.

Conclusion and Recommendations

In general these studies show substantial existence and bequest values for protecting old growth forests from (1) logging by including in Wilderness areas or National Parks; (2) from damage related to air pollution and insects; (3) from fire. Public forest management agencies should recognize that much of the public comment they receive regarding current timber management practices are probably related to existence and bequest values. As such they should formally include these values in their economic analyses. This is particularly true as these agencies begin to use ecosystem management as a tool for maintaining biodiversity. Ecosystem management often uses tools such as Geographic Information System to track and manage different landscapes. Forests in various successional stages are part of different landscapes. Therefore, total economic values per acre for forests in different successional stages and stocking density should be incorporated into future USDA Forest Service's Resources Planning Act values.

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Regional Differences in the Demand for and Supply of Nature-Based Recreation within the Netherlands

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Abstract

A model was developed to estimate the local demand for nature-based recreation, taking into account the composition of local populations. This composition was assessed in terms of a segmentation designed to maximise differences in demands between segments. The model has been applied on a nation-wide scale to generate a detailed spatial map. At the same time GIS-technology was used to create a database with characteristics of the local supply for each residential area within the Netherlands. Finally a nation-wide survey has been conducted, in which data were gathered on the individual's perception and evaluation of this local supply, and his recreational behaviour. The relationships between physical characteristics of the local supply of forests on the one hand, and subjective judgements as well as recreational behaviour on the other hand, were analysed. The main conclusions are that spatial differentiation in demand (based on the composition of the local population) tends to be rather small. With regard to the local supply, subjective judgements regarding forests are clearly related to physical characteristics of this supply. As for behaviour, it seems that in the Dutch case personal circumstances mainly influence participation level and intensity, whereas the local supply situation mainly influences the distance travelled in order to participate in activities or to visit certain types of natural environment. In other words, a bad local supply situation does not lead as much to a reduced participation, as to an increase in leisure mobility.

Keywords: Recreation, Demand, Supply, GIS, Regional differences

Introduction

Participation in nature-based recreation activities is generally believed to have beneficial effects on the individual's physical and mental health (see Ten Wolde, 1999). For this reason the Dutch government has facilitated participation in this type of activity for several decades. On the other hand, however, recreation in natural areas was often perceived as being incompatible with the goals of the government's nature management policy, such as conservation, sustainability and bio-diversity. But recently a change in this latter policy has taken place. In order to strengthen the social support for the government's policy on nature management, it is now believed to be important to have citizens experience nature, to let it be part of their life. This has made the facilitation of nature-based recreation more prominent. In the Netherlands, as well as in other West-European countries (e.g. Denmark), nature-based recreation most often takes place close to home. For example, according to Statistics Netherlands (1997) of all the day-trips of two hours or longer with walking or cycling as the dominant activity almost 60% takes place within 15 kilometres from home. Furthermore, it is a fair assumption that the number of times one walks or cycles for less than two hours is a multitude of the number of times one spends two hours or more on this activity. It is also reasonable to argue that the shorter the time that is spent on the activity, the smaller the distance travelled from home will be, at least on average. This makes the environment close to home even more important.

The short distances travelled away from home may imply that the local supply for this type of activity is usually good, or at least satisfactory. On the other hand, it may also be that the price that people are willing to pay for it, in terms of travel time or costs, is quite low. In the case of high distance sensitivity, a bad local supply situation will lead to lower participation levels and intensities of participation. To facilitate participation, it then becomes important to match local supply with local demand. The size of the demand not only depends on the sheer number of inhabitants of a residential area, but also on the composition of the population. If a rather high level of spatial detail is required, the costs of a survey among a representative sample of the population of each residential area of interest are likely to become prohibitively high. That is why a model was developed to estimate this local demand (see De Vries and De Bruin, 1998; De Vries, in preparation). In the next paragraph this model will be briefly introduced. In addition to modelling the demand, the local supply of areas suited for nature-based recreation was assessed, based on existing GIS-databases. We will also briefly describe this assessment. Finally, a nation-wide survey was conducted, in which over 3000 respondents were questioned regarding their local supply situation and their recreational behaviour. This survey will also be outlined. The main focus of this paper is the analyses based on these three different sources of information and what they tell us about regional differences in demand, supply and behaviour.

The Demand Model

The demand model focuses on the composition-effects of the population on the size and type of demand. The model was developed in three parts. The first part consists of a segmentation of the Dutch population. Each segment had to be as homogeneous in their demands regarding nature-based recreation as possible. Heuristic use of the Rational Choice approach led to a focus on constraints (see De Vries and De Bruin, 1998). This approach also led to a focus on generic constraints, as opposed to activity-specific constraints. Furthermore, because the demand model should not incorporate effects of differences in local supply situations, we concentrated on *personal* constraints: constraints that may differ between a person and his next-door neighbour. The final segmentation we arrived at classifies the Dutch population of 15 years of age or older into five groups. These five groups were labelled as follows (in order of ascending average age): the Busy, the Reluctant, the Family-oriented, the Satisfied, and the Weary.[1] Children below the age of 15 constitute an implicit sixth segment. The five segments are defined in terms of social-structural characteristics. They mainly differ on three dimensions: age, family stage, social-economic position (see Figure 1).

The second part of the model was the estimation of the composition of a local population in terms of the aforementioned segments. This estimation is based on data that is available for each of the over 10,000 neighbourhoods within the Netherlands. Two databases served as input, one of the Dutch census bureau, Statistics Netherlands, and one of a commercial direct marketing agency, Geo Marktprofiel. By means of linear programming and chi-square based automated interaction detection these input data were used to predict the segment composition of a neighbourhood. Attempts to assess the reliability of these predictions were made by using data from reasonably sized samples for several neighbourhoods (De Vries, in preparation). Of each respondent in the sample the segment membership was known, allowing sample estimates at a neighbourhood level. Several discrepancies between sample and model estimates were observed. Further analysis showed that these discrepancies were likely to be due to the sample not being completely representative for the neighbourhood population. So, relative to the sample estimates the reliability of the model estimates was rather high.

Because the model makes maximum use of census information, it is less sensitive to selective non-response than sample surveys. That is, in as far as the segment composition is concerned. The outcomes of the nation-wide application of this part of the demand model are presented in the results section of this paper.

[1] The labels are based on the dominant constraints as perceived by the individuals themselves. For example, the Busy mainly experienced a lack of (leisure) time. Two segments were not dominated by a single constraint. The Satisfies experienced few or no constraints, whereas the Reluctant saw many constraints, and even included the unpredictable weather.

Figure 1. The five recreation segments in order of ascending age.

The youngest segment is that of the *Busy*. These persons usually live in 1- or 2-person households without children. The socio-economic position, in terms of education and household income, is relatively high.

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This last aspect constitutes the most significant difference with the next segment, that of the *Family-oriented*. This segment is a little bit older on average, but socio-economically speaking much better off. The children within these households are younger than in the households of the Reluctant

The fourth segment is that of the *Satisfied*. This segment is dominated by people living in empty nest households. Of course the average age is higher than among the Family-oriented. Usually the couples involved have an above average socio-economic position.

The fifth and last segment is that of the *Weary*. Within this segment a high age is common. Many Weary live in 1-person households. The average socio-economic position is the lowest of all segments.

The third part of the demand model is the assessment of the demand characteristic at hand for each of the segments. The differences between the segments on such a characteristic, in combination with the differences between neighbourhoods in segment composition, determine the level of spatial differentiation in demand at the neighbourhood level. From an application-oriented perspective, the most useful demand characteristics are those than can be related to or translated into supply characteristics. Otherwise no confrontation between demand and supply is possible. At the same time the demand characteristic should not already take into account the local supply conditions. This would render a confrontation of demand and supply useless. The demand characteristics that we use, are behavioural in nature. It can be the participation in an activity, or the visiting of a certain type of area. Because at the individual level such a characteristic will be influenced by the local supply situation, it is important to calculate mean participation or visiting levels, averaged over a large number of different local supply conditions. We may note that the purpose of the demand model is not to predict actual behaviour. Conceptually we consider demand to be a latent variable, that, in interaction with supply conditions, determines actual behaviour. The demand characteristics can be based on a survey, in which special care is taken with regard to sampling local supply conditions.

Assessment of Local Supply Situations

Local supply assessments can be based on an inventory of physical characteristics of this supply, on expert perceptions and/or judgements of it, or on perceptions of local residents. Given the desired level of spatial detail (over 10,000 neighbourhoods), the expert option is not very feasible. A great number of local experts would be required. Moreover, it will be difficult to ensure that all these experts use the same criteria to evaluate the supply situation, and assign the same weights to these criteria. Using local residents to assess the supply situation also has a major drawback. Their perceptions may be influenced by their demands and by local standards. Therefore we have opted for the first approach: a straightforward inventory of physical characteristics. Based on recent literature, we selected types of physical characteristics that were likely to be relevant. For example, besides the type of land use also quietness and silence proved to be important aspects (see e.g. Reneman et al. 1999). Nowadays in the Netherlands a lot of information on land coverage, land use, infrastructure, and other characteristics of the landscape is available in GIS-databases. One of the main GIS-databases that we used, was the most recent version of the National Land Cover Classification of the Netherlands (LGN3). This database contains information on the dominant type of land use out of 24 categories for each grid cell of 25x25 metre (see Wit et al. 1999). This information was used to derive supply characteristics in the following way. The same neighbourhoods were used as in the demand model. The living environment of a neighbourhood was pragmatically defined as a circle with a radius of 12 kilometre around the centre of the neighbourhood. This choice was based on the radius of action of an average recreational cyclist taking a trip of two hours (speed of 16 kilometre per hour or less; correction factor for straight line rather than by road: 75%). The number of grids with a specific type of land use within the living environment was determined for each neighbourhood and converted into a percentage of the surface of the circle. This resulted in the percentage of deciduous forest within the living environment of the neighbourhood, the percentage of sea, of arable land and so forth. A foreign country correction was applied for those neighbourhoods with a part of their living environment situation in this country (Belgium or Germany). It was assumed that the land use in this foreign country had the same composition as on the Dutch side of the border.

Other GIS-databases were used to determine additional characteristics, e.g. the level of noise from traffic (road, railway, air) and industries, the density of bicycle path and roads suited for cycling and that for walking. Because the literature suggested that quietness (absence of other people) was a highly relevant aspect of the recreational quality of the environment, a special effort was made to find an indicator for this aspect. By way of a GIS-analysis the available amount of 'real' nature per capita within the radius of 12 kilometres was determined (‘real’nature: forest, heath, beaches & dunes and other natural areas). This indicator takes the number of people living in other neighbourhoods that are also within a distance of 12 kilometres of a particular natural area into account. In other words: each square metre of nature is assigned to only one inhabitant at maximum. The lower the number of square metres per capita, the more likely it is that one will encounter other people when visiting a natural area within the living environment. Because opportunities nearby might have special relevance, all characteristics were also determined for a circle with a radius of 3 kilometres.

The Nation-Wide Survey on Recreational Behaviour and Judgements of Local Supply Conditions

To determine the demand characteristics for each segment, use was made of a survey conducted by Reneman and others (1999). In this nation-wide survey, the Netherlands was divided in nine regions, each thought to be more or less homogeneous with regard to the dominant type of natural supply and landscape. Within each region further stratification took place. Three levels of urbanicity were distinguished. For each combination of region and urbanicity about 100 persons or more were interviewed. The total sample contained over 3000 respondents. This survey suited our purpose quite well, in that a wide variety of local supply conditions were sampled. The survey itself consisted of two parts. First a short telephonic interview was conducted. If the respondent agreed, a quite lengthy questionnaire was mailed. Probably partly due to the length of this questionnaire, the overall response rate was quite low: less than 20%. Lower educated people were underrepresented within the sample. For more information on the survey, see Reneman et al. 1999.

Within the survey the characteristics of the respondent that are needed to determine to which segment s/he belongs were assessed. This allowed us to determine the behaviour of a segment, averaged over a wide variety of (Dutch) local supply conditions. Furthermore also questions were asked on recreational behaviour. The participation data concern recreational activities undertaken in a green or natural environment. Respondents were also asked how they perceived and evaluated their own living environment, defined as the area within 16 kilometres of their home (by road). These questions were not intended to derive additional demand characteristics, but to see whether these perceptions and evaluations could be predicted by physical characteristics of this living environment, as assessed on the basis of available GIS-data. The evaluations can be considered a confrontation of local supply with local demand, using the citizen’s own norm. To the degree that this exercise is completed successfully, the resulting regression equation can be used to construct a nation-wide map of predicted judgements: the GIS-data used to characterise the living environment of the respondents are available for all neighbourhoods within the Netherlands. Of course the same type of analysis can also be conducted for the behavioural data.

Results

Demand: the Composition of the Population of Neighbourhoods

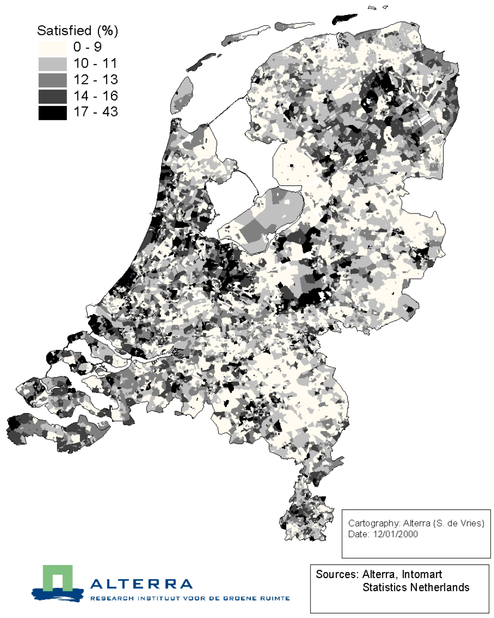
Within the demand model there are two sources of regional differentiation. The first source is the composition of the neighbourhood according to segment. If all neighbourhoods have the same composition, the model will tell us that there is no spatial differentiation, regardless the extent to which the segments differ in their demands. This latter factor, of course, is the second determinant of the degree of regional differentiation. If the segments have similar demands, spatial differentiation will be small, regardless the differences in the composition of neighbourhoods. We will first discuss the composition of neighbourhoods. This composition was determined by applying the second part of the demand model. Table 1 shows some characteristics of the distribution of segment percentages over neighbourhoods. In terms of standard deviations, the Reluctant show the lowest degree of spatial differentiation and the Busy the highest. In addition to these statistics, nation-wide maps were made for each segment, to see whether neighbourhoods within the same region were more likely to be have a similar composition or not. The Satisfied appeared to have the highest level of regional clustering (Figure 2). They are overrepresented along parts of the Northsea coast, in the regions “Gooi” and “Utrechtse Heuvelrug”, at the borders of the most famous national park “De Hoge Veluwe”, and in parts of Drenthe, a province in the north-east of the Netherlands. All these areas are well known for their natural scenery. The Busy, on the other hand, were overrepresented in city centres, especially if the city was a centre for higher vocational education or had a university. Although we did not have a clear criterion, we considered the differences between the neighbourhoods to be substantial enough to continue the development and application of the model.

Demand: Differences between Segments

The second source of regional differentiation is the difference between segments in scores on the demand characteristic at hand. Several types of demand characteristics may be distinguished. Behavioural demand characteristics are the participation in an activity, or the number of times a specific type of location is visited. Other types of demand characteristics can be stated preferences for certain activities, types of location, experiences, or combinations of the above. In order for the characteristic to be a *demand* characteristic, local supply conditions should have no effect on the score of a segment on the characteristic. In the case of behavioural characteristics this may be achieved by averaging out the effect of local supply conditions. We will now present the results for several characteristics, based on the aforementioned nation-wide survey, starting with participation in leisure activities conducted in a green environment.

Since the demand assessment is undertaken with the intention to confront this demand with the local supply of opportunities, it is desirable to express the demand in such a way that this confrontation becomes feasible. This makes the number of times an activity is undertaken on a per capita basis a useful characteristic. This amounts to the average participation frequency for the activity, with the *inclusion* of the non-participants.[1] Four out of thirteen activities undertaken in a green environment showed significant differences between the five segments ($p < 0.001$).

Figure 2:
percentage of Satisfied by neighbourhood



These were bicycling, sports activities, collecting/picking things from nature and experiencing nature (see table 2). The Reluctant stand out when it comes to (recreational) cycling. Their frequency is almost twice as high as that of the Busy. The Busy, on the other hand, have the highest frequency for sports activities. This frequency is five times as high as that of the Weary. Collecting or picking things from nature is especially popular among the Family-oriented, the segment in which young children within in the household are most common. Experiencing nature seems to be more popular among the two elderly segments, the Satisfied and the Weary.

Although only four activities revealed significant differences, in those cases the differences between the segments may be considered substantial. It may be noted that significant differences for participation levels

[1] The distribution of this participation frequency will usually not be normal. This has consequences for the statistical tests that are used. To compensate for the non-normality, a higher than usual significance level was required: $p < 0.001$.

were observed for eleven of the thirteen activities ($p < 0.001$). However, in many cases high participation levels go hand in hand with low participation intensities. For example, in general the Weary partake in the lowest number of activities, but if they participate the frequency with which they do so tends to be rather high. For the Busy this tends to be the other way around (see De Vries and De Bruin 1998).

The other type of demand characteristics on which we will present results here, are desired experiences in a green environment. The respondents had to (partially) rank order twenty-five potentially desirable experiences according to their attractiveness. Mean rank order scores showed significant differences between segments for fifteen of these experiences ($p < 0.001$). The largest differences were observed for:

- forgetting the day-to-day worries
- rejoicing at the beauty of nature
- enjoying nature
- relaxing

Together the results for these four experiences paint a clear picture (see table 3). The three younger segments consider forgetting the daily worries and relaxing more attractive experiences than the two older segments. When it comes to enjoying nature and experiencing its beauty, the pattern is reversed.

Table 1.Characteristics of segment percentages by neighbourhood (including children under the age of 15 as sixth segment)

	Child (< 15)	Busy	Reluctant	Family-oriented	Satisfied	Weary
Mean	19	22	12	21	12	15
St. deviation	4.8	5.3	2.4	5.0	4.1	5.1
Minimum	2	5	2	2	0	0
Maximum	44	75	23	41	43	62

Table 2. Participation frequencies (number of times in 1998) for four leisure activities conducted in a green environment, including non-participants ($p < 0,001$)

	Busy	Reluctant	Family-oriented	Satisfied	Weary
Cycling	47	83	50	54	55
Sports activities	25	18	18	11	5
Collecting things from nature	2.9	3.3	5.7	2.7	2.6
Experiencing nature	26	30	33	47	40

Table 3.Mean attractiveness scores for four selected experiences in a green environment ($p < 0.001$)

	Busy	Reluctant	Family-oriented	Satisfied	Weary
Forget worries	13	13	13	8	7
Relax	15	16	15	12	12
Enjoy nature	9	10	10	13	13
Rejoice at beauty	6	6	7	10	11

So, relatively speaking for the younger segments push factors are more important for visiting nature, whereas for the older segments the pull of nature is more important.

Also for other types of demand characteristics differences are found between the segments (see De Vries, in preparation). The overall conclusion is that the segmentation offers a convenient way to summarise interindividual differences on a broad range of recreational demands. Sometimes the age dimension is the most important, sometimes the family-stage or the socio-economic position. Depending on the demand characteristic that is used, the differences between segments may be large enough to, in combination with the differences in population composition, lead to regional differentiation in demands.

Demand: Differences between Neighbourhoods

The final step in assessing spatial differentiation in recreational demands is to combine the composition of each neighbourhood with the demand characteristic for each segment. This is done in the following way. For each segment the absolute number of members within the neighbourhood is multiplied with the average score of the segment on the demand characteristic at hand. For an activity, such as experiencing nature, this results in the total number of trips generated by the segment members within the neighbourhood. In the next step the total number of trips generated by the neighbourhood is calculated by adding the totals for each segment. Finally, this figure is divided by the total number of inhabitants of the neighbourhood, which gives a demand characteristic at the level of the neighbourhood that is standardised for the size of the population of the neighbourhood. Comparison of this characteristic between neighbourhoods indicates the amount of spatial differentiation due to the composition of the neighbourhoods.

To have a criterion to judge whether or not the amount of spatial variation was relevant, the deviation of a neighbourhood's score of the national average for neighbourhoods was calculated. This deviation was subsequently expressed as a percentage of this average score. In this way the effects of the composition of the neighbourhood can be compared with the effect of a change in the size of the population of the neighbourhood. After all, for a (quantitative) confrontation of the demand with the local supply, the demand in needed in absolute terms. This absolute demand consists of the multiplication of the demand characteristic for the average inhabitant of the neighbourhood with the number of inhabitants. A change with a certain fraction in the demand characteristic will have the same effect on this total demand as a change with the same fraction in the size of the population. This calculation was made for several demand characteristics based on participation in activities. For all these demand characteristics the level of spatial variation between neighbourhoods was rather small. For example, for experiencing nature there are only a few neighbourhoods with a frequency that deviates from the national average by more than plus or minus 5%, and almost no neighbourhoods with deviations larger than plus or minus 10%. Since experiencing nature was one of the activities with relatively large differences between the segments, our preliminary conclusion is that compositional effects on the spatial differentiation in recreational demand are rather small.

Local Supply Conditions and How They are Judged

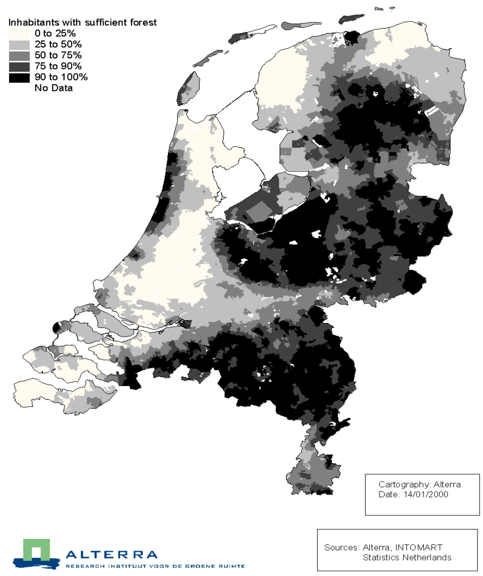
Another part of the study focused on differences in local supply conditions, or better, on the effects of these differences on how the own living environment was judged. The living environment was defined as the area within 16 kilometres from home (by road). In this paper we will concentrate on judgements regarding forests. Respondents were asked to indicate whether forested areas were present within their living environment, and if so, if the amount of forest was too limited, sufficient, or even more than sufficient. We reclassified these answers into two categories: absent & too limited versus (more than) sufficient. Subsequently a logistic regression analysis was performed on this judgement, in which physical characteristics of the living environment were used as predictors. Using a stepwise procedure, the following six characteristics were included in the final regression equation ($n = 3089$):

- percentage of forest within 3 kilometres: B = 0.12; exp(B) = 1.13
- percentage of forest within 12 kilometres: B = 0.05; exp(B) = 1,05
- percentage of nature other than forest within 12 kilometres: B = 0.13; exp(B) = 1.14
- natural logarithm of the number of square metres of forest available per capita within 12 kilometres: B = 0.19; exp(B) = 1.20
- amount of variation within the available forest within 12 kilometres:[1] B = 0.83; exp(B) = 2.30
- percentage of small-scale (closed) agricultural landscape within 12 kilometres: B = 0.03; exp(B) = 1.03

The amount of "explained" variance of this regression model is 30%. The answer, sufficient or not, is predicted correctly for 76% of the respondents. Each of the regression parameters is significant at the 0.001-level.

It is not surprising that most of the included supply characteristics have something to do with the amount of forest. Forests close home has a relatively large influence: they are counted twice (within 3 and 12 kilometre radius). The two supply characteristics that do not deal with forests are the percentage of nature other than forests and small-scale agricultural landscape. It is not clear whether these types of nature can compensate for the absence of forests, or that they also indicate of the presence of (small) forested areas, at least in the perception of the respondents. As usual, we have to be careful with the causal interpretation of correlational results. The regression equation was used to make a map for the whole of the Netherlands, indicating the percentage of inhabitants that is predicted to think there is (more than) sufficient forested area within their living area (see Figure 3). Each class of the legend contains about the same number of neighbourhoods. The map shows that there are large regional variations in the proportion of satisfied people. In some areas less than 25% of the population is satisfied, while in other areas over 90% is satisfied. To give a rough idea of the differences in local supply behind these two extreme legend classes, we calculated the amount of forest within 12 kilometres for the neighbourhoods involved.

Figure 3: percentage of inhabitants that is satisfied with the available amount of forest within the living environment, by neighbourhood



The highest legend class has about 6000 hectares more forested area within 12 kilometres on average than the lowest legend class.

Respondents were also asked to judge the quality of the forested area within their living environment on a 10-point scale (if forest was present at all, which was the case for over 80% of the respondents). A regression analysis of this judgement, using the supply characteristics as predictors, explained 15% of the variance. The following four characteristics were included in the final model (n = 2535), all with parameters significant at the 0.001-level:

- percentage of forest within 12 kilometres: B = 0.03, beta = 0.18
- amount of variation within the available forest within 12 kilometres: B = 0.61; beta = 0.16
- natural logarithm of the number of square metres of nature other than forest available per capita within 12 kilometres: B = 0.10; beta = 0.09

[1] This characteristic is based on the ratio of deciduous and coniferous forest. If no forest is present at all, or only one type of forest, the score is zero. If the ratio of deciduous and coniferous forest is fifty-fifty, the (maximum) score is one.

- natural logarithm of the number of square metres of forest available per capita within 3 kilometres: B = 0.07; beta = 0.08

The regression equation indicates that the more forest is available within the living environment, the higher the quality is judged: 30% more forest increases the quality score by 1 point, everything else remaining equal. For forests nearby especially the amount per capita seems to be important. This may be taken as an indication that quiet forests are more appreciated than crowded forests, with crowding being more likely close to large population concentrations. Also variation between deciduous and coniferous forests is appreciated. The last characteristic in the equation deals with other types of nature (dunes, heath, etc) within 12 kilometres on a per capita basis. The combination of the 12 kilometre radius and the per capita basis may be the result of this type of nature being less common in the Dutch situation, and therefore attracting people over longer distances. However, it remains somewhat unclear why this characteristic is related to the quality judgement of forests.

Effects of Local Supply Conditions on Behaviour

In the previous paragraph we saw that local supply conditions, in terms of GIS-based indicators, were related how people judge their living environment with respect to forests. Furthermore we observed quite large regional differences in (predicted) judgements. A next question is whether and how local supply conditions influence recreational behaviour. We will start by looking at participation in activities. Using the same type of regression analysis as for the judgements, now the dependent variable is the frequency with which one participated in activities such as walking, cycling, and experiencing nature. The analyses for the participation frequencies showed that the effect of the local supply condition tends to be rather small. Moreover, for seven of the thirteen activities under investigation, there was no significant effect at all ($p > 0,001$). The explained variance was never more than one percent. Respondents were also asked to indicate the distance travelled to the location were they performed the activity. Here the explanatory power of the supply characteristics is considerably higher, with a maximum of 10% for roaming natural areas (i.e. not being restricted to the paths and roads). For three activities no significant effect was found. So, local supply conditions have a stronger effect on the distance travelled than on the frequency of participation.

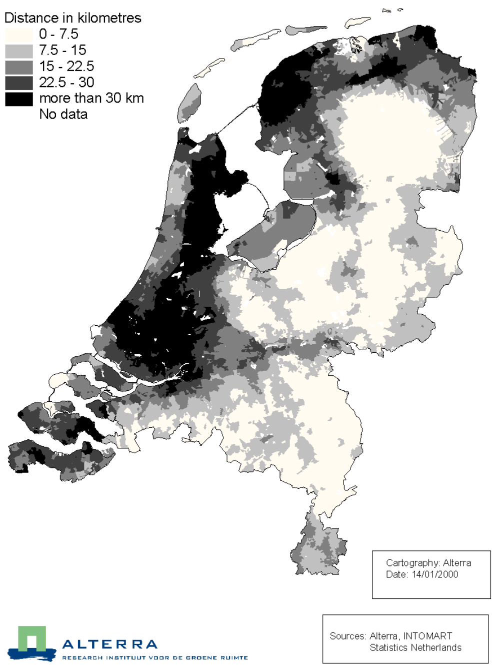
Besides the distance travelled to perform a specific activity, the respondents were also asked to indicate the distance travelled to the most often visited forest site. This question was only asked to those respondents that had visited a forest at least once in the last year. Note that this forest did not have to be located within the own living environment. The final regression equation (n = 2491) explained 17% of the variance in distances. The following supply characteristics were included in this equation (all parameters significant at the 0.001-level):

- amount of variation within the available forest within 12 kilometres: B = -9.64; beta = -0.15
- natural logarithm of the number of square metres of 'dry' nature, other than forest, available per capita within
- 12 kilometres: B = -2.78; beta = -0.15
- the surface of rural area with good cycling possibilities (paths, roads) within 12 kilometres (in 500x500 metres grid cells): B = -0.02; beta = -0.14
- natural logarithm of the number of square metres of forest available per capita within 12 kilometres: B = -1.69; beta = -0.10
- natural logarithm of the number of square metres of forest available per capita within 3 kilometres: B = -1.40; beta = -009

Three of the five characteristics have to do with the amount of available nature per capita. Once again this implies that quietness is an important motive to visit nature. This is supported by the fact that, when asked to rank order a list of potential aspects of natural areas according to attractiveness, quietness scores among the highest (Reneman et al. 1999). However, variation has the largest effect: no variation in forests within the living environment leads to an increase in distance by 10 kilometres, when compared with maximum variation between deciduous and coniferous forests (everything else remaining equal). Also this regression equation was used to generate a

map (see figure 4). Each legend class contains about the name number of neighbourhoods. The map shows a large resemblance with that for the satisfaction with available forests.
The correlation of the two predicted outcomes, calculated over neighbourhoods, is r = -0.89. The map shows the large effect the local supply condition has on the distance travelled. In the lowest legend class this is less than 7.5 kilometres on average, in the highest legend class it is more than 30 kilometres (single distance).

Figure 4: distance travelled to most visited forest area, by neighbourhood (predicted)



Conclusions and Discussion

One of the main conclusions of our study is that spatial differentiation in recreation demands due to the composition of the local population tends to be rather small. Of course this conclusion is based on the type of demand characteristics that we studied: participation in activities. This is a rather global type of characteristic. It is known that certain segments prefer certain types of location (De Vries and De Bruin 1998). If more specific demand characteristics are used, e.g. walking in large forest with a low level of facilities, the differences between segments may become larger, up to the degree that spatial differences become substantial. Another question regarding this first conclusion is whether the segmentation that was used, is optimal with regard to the demand characteristic at hand. It is possible that a more discriminating classification exists. By definition a classification based on the demand characteristic itself will discriminate optimally. However, we would like to make two comments. The first comment is that if this demand characteristic is behavioural in nature, the question arises to which degree the characteristic will still be a *demand* characteristic. Behavioural characteristics may easily incorporate local supply effects. For example, people living close to an important national water sports area are likely to show a higher frequency of participating in water sports activities.

The second comment has to do with using the segmentation to arrive at a detailed demand map. An essential part of the demand model we developed was that the composition of local populations could be estimated by the use of nation-wide available data. This type of data is usually only available on socio-structural characteristics such as age, household composition, level of education, etc. Since our segmentation is defined in terms of this type of characteristics, assessing the composition of local populations according to these segments went rather well. It is possible that the gain of using a more discriminating classification will be lost by a less accurate assessment of the composition of local populations in terms of this classification.

As for differences in local supply conditions, these clearly do exist. More interesting is the conclusion that these objective differences, defined in physical terms, also can be shown to lead to differences in judgements of the own living environment, in this case regarding forests. The observed relationships were quite strong. This suggests that different people in different regions of the Netherlands use more or less the same criteria to arrive at their judgements, for example regarding the amount of forest in their living environment. Furthermore, errors in prediction on an individual basis are likely to average out at the neighbourhood level. This justifies the use of the regression equations to make nation-wide maps, also including neighbourhoods out of which no inhabitants participated in the survey. Nevertheless, there may be some distortions in these maps. Although it is likely that the errors in prediction are not correlated on a person-to-person basis, they may be spatially correlated. The supply characteristics that we have used may not fully characterise the local supply condition. In this respect systematic deviations are possible. For example, older forests may be appreciated higher than younger forests. A first, visual inspection of a map of errors showed no regional clustering of errors in a specific direction. However, further research in this direction is needed.

With regard to the effect of local supply conditions on recreational behaviour, the most striking conclusion seems to be that the local supply has a stronger effect on the distance travelled to the location where the activity is performed than on the frequency with which the activity is performed. Bad local supply conditions do not lead to a drop in demand, as much as to a flight of demand. The analysis of and the map for the distance travelled to the most often visited forest area clearly shows that a bad local supply condition may lead to a considerable increase in leisure mobility, at least on a one trip basis. Unfortunately we did not have data on the frequency with which forests were visited. Therefore it remains the question whether a bad local supply will have (almost) no negative effect on this frequency also, in the same way as for the activities. Note that this implies that the distance that has to be travelled has no strong negative effect on the frequency with which the activity is undertaken. What the available data do enable us to do, is to analyse the effects of demand and supply characteristics on behaviour simultaneously. This is something we hope to report on in the near future.

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A Framework for Relating Aesthetics and Perception for Advancing Research

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Abstract

A framework for relating different approaches to landscape perception and aesthetics is presented. This considers 2 aspects, the means and the nature of the aesthetic response. Each of these is elaborated and connected, using 4 types of aesthetic response, the sensory, the formal, the expressive and the symbolic, to the work of a range of different perception psychologists and aesthetic philosophers. This framework is then developed to propose a number of areas for research, especially in the field of forestry in general and urban forests in particular. As well as research into perceptions and aesthetics, links to other key areas are suggested, including applied landscape ecology and environmental ethics.

Keywords: Landscape, Perception, Aesthetics, Psychology, Philosophy

Introduction

There are many ways in which people interact with their environment, including economic exploitation, subsistence activities, leisure and pastimes. This paper considers the nature, character and importance of the aesthetic relationship between people and their environments, especially forests and in particular urban forests.

Many authors cite a sense of alienation as existing between many people and their environment, especially in urbanised areas of developed countries. The lives of a large number of people are dominated by the indoors, by the enclosed worlds of transport, by the rhythms set by their working lives and so on that remove them from an everyday meaningful direct interaction with nature and with natural forms. At the same time there is an increasing interest in "the environment" but this is, in many ways, a separated world, only experienced vicariously through secondary media such as TV, film etc. That is not to say that urban people do not get out and experience nature. Many do, but they frequently need to make a conscious effort to do so unless they have the good luck to live within easy reach of a park or similar area. Parks provide a number of opportunities for interactions with nature but the size, layout and design of many of these do not permit this to the greatest degree possible. Forests also provide this and possibly do so in particular ways due to their enclosed nature that cut us of from the external scene when we are within them.

When we examine the character of the relationship between people and nature in terms of experiences, there are many interesting themes, only some of which have been thoroughly explored or researched. Urban forests are becoming an increasingly popular vehicle for providing ready access to nature for the large urban populations of many countries. The themes that concern the relationship of people to nature also apply to urban forests but have added contexts due to the possibly special character of forests as entities in their own right.

One of the main ways we experience such landscapes is an aesthetic one. The aesthetic experience can act as the filter through which we move on to build up other relationships. However, because the realm of aesthetics has largely been confined to philosophy, although the mechanisms of perception and the range of preferences exhibited by people comes under psychology, it has not been examined very rigorously, if at all, by mainstream forest research agencies. However, this misses a rich vein for research that should be pursued because unless we thoroughly understand the relevance and importance of aesthetics we will overlook a number of significant aspects which affect secondary modes of preference which may be more likely to be influential on policy and management. These include publicly expressed preferences for certain forms of management that may be argued superficially on rational scientific grounds but unless the aesthetic angle is properly addressed the resulting solutions are likely to miss their mark. Recent examples in forestry include the preservation of old growth or the practice of clear cutting.

The question of aesthetics has often been treated with less than the importance it deserves. This is possibly due to the following reasons:

- Society's concern for style and surface appearance as opposed to the deeper aspects defined here.
- The fragmented and apparently contradictory theoris of aesthetics.
- The tendency to link the subject of aesthetics with art and not with nature
- The prevalence of the traditional scenic mode of landscape aesthetics which sees the experience as separate from everyday life.

What has been lacking is a framework for understanding the relationships between the various schools of aesthetics as they pertain to the environment of the forest, especially the urban forest. The need for this arises because before we can explore more deeply into aesthetics we need to be able to demonstrate that there is a rational basis for further development. We also want to be able to use the tools provided by environmental psychologists in order to work out more of the perceptual mechanisms in terms of their relationship to aesthetics. There has not, to date, been any firm link between perception and aesthetics because they belong to different disciplines. Perception psychology has developed much understanding, particularly in terms of the urban environment (Ulrich 1979,1983, Nasar 1994), but more is needed on the forest landscape.

A framework is therefore proposed that sets out in a logical structure the various schools of aesthetics, in terms of, on the one hand, the **means** of aesthetic response, and on the other the **nature** of the aesthetic response. These represent spectra that enable often apparently opposing aesthetic theories to co-exist. From this links are constructed that relate factors such as the role of knowledge about the environment, the mechanisms of perception and the different approaches for research. For example, these can be divided into those concentrating on looking for general preferences for landscapes in populations versus those that concentrate on the aesthetic experience as purely personal, and those that concentrate on characteristics inherent in landscapes over those concentrating on cognitive aspects.

These links are currently being explored in the context of forests in the UK and are included in a new research strategy being developed. The purpose of this is to help us understand not only what people prefer but why they prefer it, to disentangle aesthetic preference from other preferences and to help develop guiding principles to refine the tools available to designers and managers of the new urban forests that are under development.

A Framework for an Aesthetic Structure

There are a number of apparently conflicting approaches to landscape aesthetics that have caused some degree of confusion amongst the professional and academic community. In fact all these approaches are merely facets of a bigger picture.

The first component of this framework is the **means** of aesthetic response. The second is the **nature** of that response. The following diagrams set the skeleton of this out and will be used as a basis for further development.

Figure 1 shows a gradation or spectrum of response from the position of observer separated from the observed scene (always the case in a landscape painting and scenery becomes the same in this traditional situation) to position of observer as active participant in the landscape. Figure 2 also shows trends or tendencies, but these work in two directions. The list of responses is sometimes shown as a descending order. However, as explained below, movement in the nature of the aesthetic response can occur in both directions. Each part of these diagrams has one or more aesthetic philosophical or psychological movements associated with it. These associations, as elaborated below, demonstrate how the proposed framework brings these competing theories together.

The distant mode of viewing includes the sense that the observer is physically distant from the scene, and therefore cannot use senses except sight and possibly hearing, or "psychically distant" (Bulow), where the observer is psychologically separated (typical of an experience of art but also of some landscapes.)

Figure 1. Means of Aesthetic Response

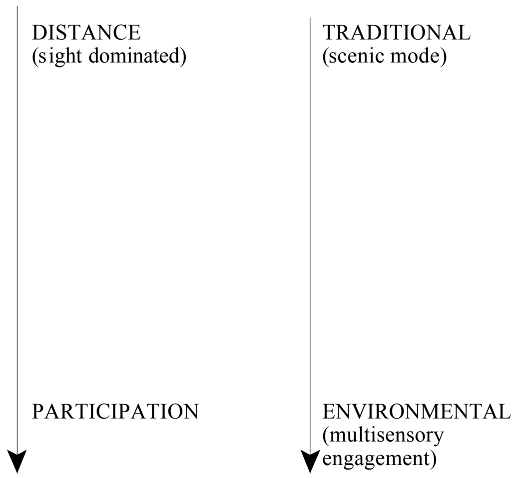


Figure 2. Nature of Aesthetic Response

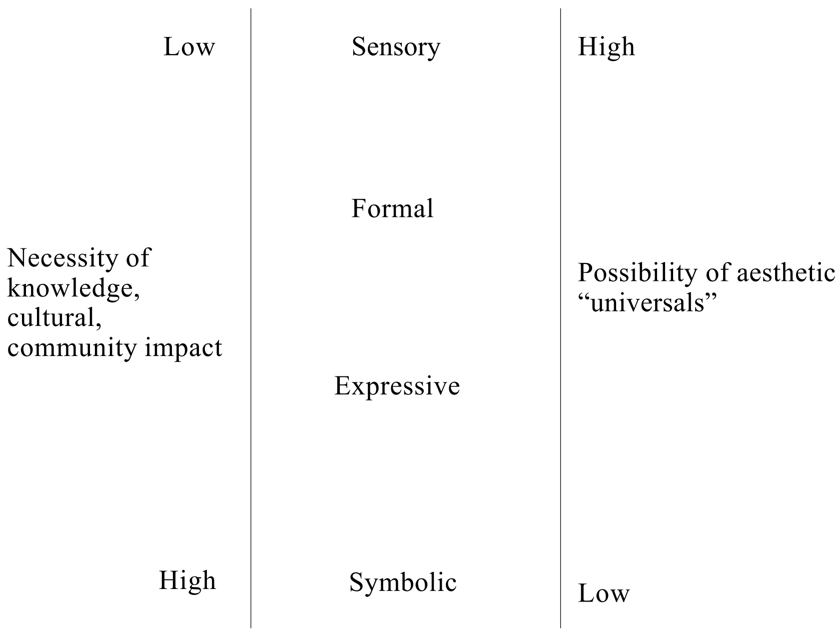
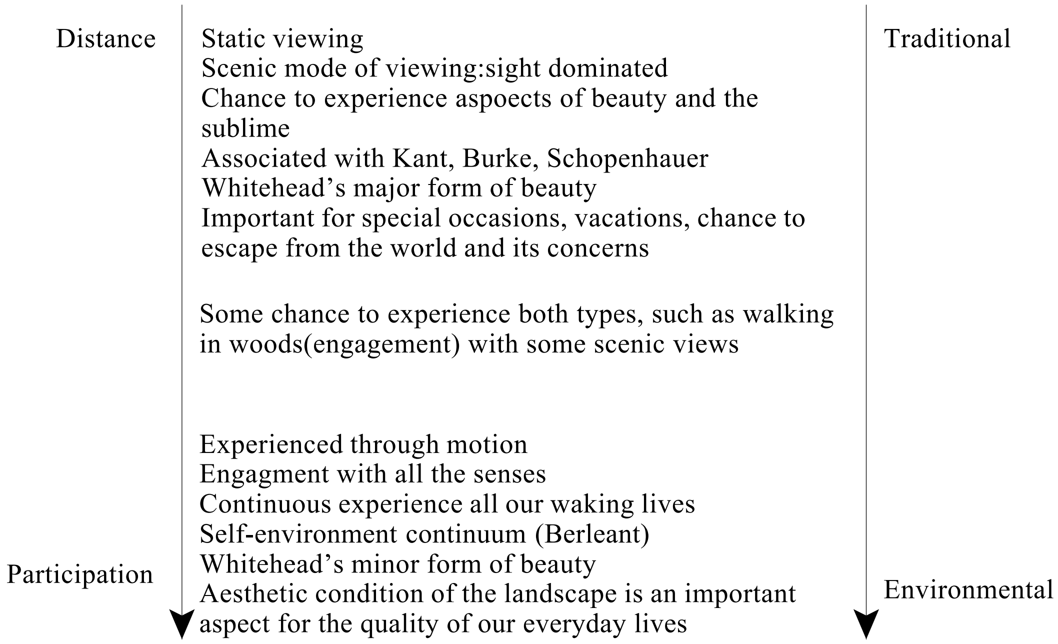


Figure 3. An elaboration of the means of aesthetic response.



This type of viewing is the kind that we tend to experience when at a viewpoint overlooking some dramatic vista or prospect. The occasions where this is experienced do not tend, for most people, to be available everyday. It can be argued that many natural landscapes have been identified and designated as scenically important, for example as national parks. Soaring mountains, yawning abysses, thunderous waterfalls and other large scale scenes demonstrating the power of natural forces offer opportunities to experience the beauty of nature or to generate a sense of the sublime. There has been an aesthetic tradition as far back as Kant (1981), Burke (1958) and Schopenhauer (1969) that has explored and discoursed on these concepts. In the early twentieth Century, Alfred North Whitehead developed a metaphysical theory of aesthetics based on the interactions of organisms (such as ourselves) and our environment. He identified concepts such as "massiveness", "intensity proper" and "strength" as attributes of such landscapes, the culmination of which lead to "the major form of beauty" (Whitehead 1960).

Scenery and landscape aesthetics of this variety have a lot to offer and should not be undervalued, even though more recent trends have emphasised the other end of the spectrum, that of participation in the landscape.

Participatory aesthetics concentrates on the non-static mode of perception, exemplified by the approach of the psychologist J. J. Gibson and his theory of optic flow (Gibson 1966). It also focusses on the use of all the senses (sight, smell, hearing, taste and the haptic or kinaesthetic senses of touch, temperature/humidity detection and spatial awareness through movement and balance using the organs of the inner ear). This multisensory engagement ensures that, as well as many other experiences of everyday life, the aesthetic is a constant response. The main exponent of this approach is the aesthetic philosopher Berleant who describes our relationship to the landscape (or environment) as a self-environment continuum, as opposed to the separation inherent in the traditional types of response (Berleant 1992). The argument that leads from this is that the aesthetic condition of our everyday world is an important contributor towards the quality of our everyday lives. Whitehead's metaphysical theory also applies here: his "minor from of beauty".

The participatory aesthetic is a particularly important concept for forestry, especially urban or community forestry. In many countries such as USA, UK, Canada, New Zealand, the main focus of effort has been on the planning, design and management of forestry landscapes in the context of the traditional type of aesthetic response. The US Forest Services' Scenery Management System (Anon 1995) and the GB Forestry Commission's Forest Landscape Design Guidelines (Forestry Commission 1989) both emphasise this mode. There are good reasons for this: forests are very visible, scenic viewing is a popular pastime and forest landscapes have undergone often quite drastic change through logging or planting.

However, many countries such as Finland or Russia who have vast forests on flatter land do not experience (except in rare places) the scenic prospect. Their people engage with forests on a daily basis: the forest often is the landscape for everyday lives. Thus the participatory aesthetic is the main type of response. Similarly, urban people who venture into urban forests undergo the same experience. The unfortunate thing is that little research so far has been carried out into this field compared with the traditional type of aesthetics.

Figure 4 shows a progressive shift from the first moment of observing a landscape when sensory information is paramount, to the time when we have assimilated this with our knowledge, beliefs and cultural conditioning. The steps progress through a formal stage, by which is meant a discovery of the form, and patterns and underlying structure of the scene, to a stage where we consciously or unconsciously try to come to terms with and understand what we observe, reconciling our pre-existing knowledge with our new perceptions. Finally, in this model, we apply associations to what we observe; these may be meanings or values. However, in reality the actual experience is unlikely to occur in precisely this order and most viewers are unlikely to be aware of these stages. Several authors point to a 2 stage response where the first immediate impression is involuntary and then there is a considered appraisal stage (Purcell 1986, Harvey *et al* in press). In the framework presented in this paper the 4 stages can be deemed to be subdivisions of the second stage of Purcell.

Different people place emphasis on different aspects. Foster emphasizes the initial sensory input (Foster 1992), while I have concentrated on the formal aesthetic (Bell 1993, 1999). Carlson has emphasized the role of knowledge (Carlson and Sadler 1982) and the historian Schama has focussed on the symbolic (Schama 1995). However, each of these types of response can be linked further to other work, particularly in the field of perception psychology (Fig. 5).

Figure 5 shows how each of the stages of response are directly linked to previous or ongoing research. The sensory aesthetic championed by Foster finds links with environmental psychology where some researchers seek universal preferences or responses to certain types of environment as a result of our evolution as a species. Some have suggested that open savannah-like landscapes are such a type as a result of human evolution in such landscapes in east Africa. The psychology and to some extent physiology of perception have pointed to evidence that we seek out and try to understand our environment in terms of patterns. This has been most developed in terms of visual perception by Marr (Marr 1982) and his "primal sketch theory" where he tries to explain how images are processed in the brain so that we form an understanding of the real structure of our environment. Gestalt psychology has been successful in describing many key attributes of how we understand and react to patterns (Kohler 1947). It is not a big step to see that we might respond positively to certain types of pattern because they are easy to understand compared with others. The Kaplans have concluded that coherence and legibility are key features of all attractive landscapes (Kaplan 1988).

The expressive aesthetic has been explained in various ways. Both Kant and Schopenhauer considered the role of knowledge. Schopenhauer considered the presence or absence of the "will" in our aesthetic experience. The psychologist J. J. Gibson developed a theory of "affordance" where we perceive our surroundings in a structured way, looking for what the environment affords us in a utilitarian sense. Carlson is most insistent that knowledge is vital for the aesthetic experience.

An aspect that is of particular concern to forestry aesthetics is that of "deep time", a sense and appreciation of the longevity of the landscape. Rolston has developed this theory and it can be seen to apply to trees and ecosystems whose life spans are many times that of humans. During the internal critical debate that is part of the expressive aesthetic the sense of time and our relationship to the landscape can be a profound element.

Figure 4. Elaboration of the Nature of Aesthetic Response (1)

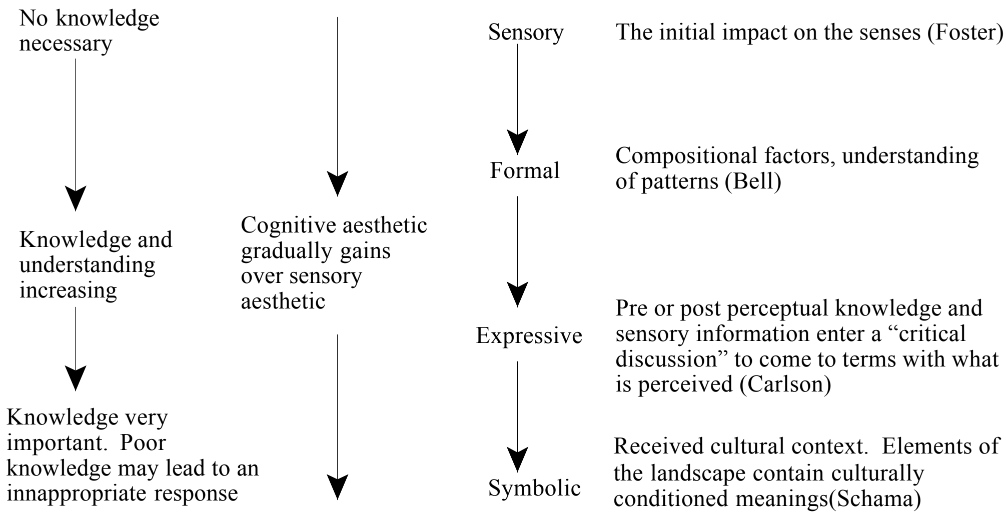
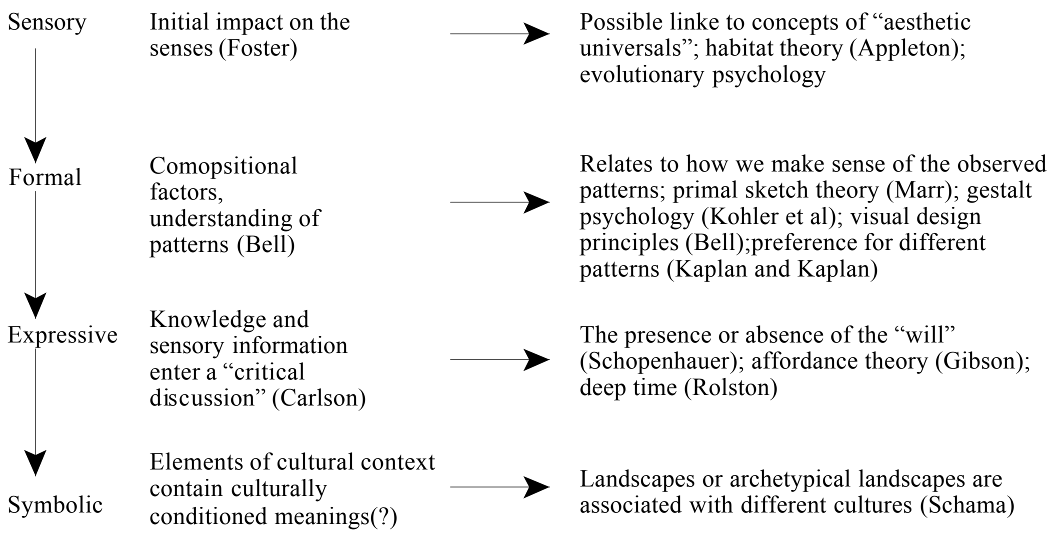


Figure 5. Elaboration of the Nature of Aesthetic Response (2)



Cultural symbolism and landscape has been powerfully demonstrated by the historian Schama who has examined forests one of several archetypal landscapes (Schama 1995). Other cultural geographers and archeologists point to similar examples. Work on fear of forests in the UK by Burgess has demonstrated that forests act as a repository for various fears that remain deeply rooted in society (Countryside Commission 1995). Symbolism can operate in other ways, for example geometric patterns in forests represent man-made intrusion and symbolise something bad, whereas naturalness is equated with goodness.

Application of this Framework to Forests

Forests still cover significant areas of the globe and, in countries where populations have become urbanised and divorced from the land, forests represent, or symbolise, wildness and the means to escape from the stresses of city life. Wilderness is a powerful concept but to have any real utility wild places must be readily accessible. Hence urban forests have an important role to play in providing a means of escape for urban populations, but only as long as they actually contain the potential for a deep aesthetic experience amongst the other possible experiences (recreation, exercise, watching wildlife etc).

If what Berleant says is true, that the quality of the environment has a direct effect on the quality of life, then while forests *per se* may provide benefits merely by their presence, the aesthetic content depends on their characteristics (layout, size, species, structure, degree of naturalness etc) and how well they fulfill the 4 types of aesthetic response (sensory, formal, expressive and symbolic). Complications arise because many large urban centres contain multi-ethnic, multi-cultural populations who are split into a number of different types of community. If urban forests are to satisfy as many people as possible they need to relate to the different ethnic, cultural and social backgrounds. Clearly, approaches to planning, design and management that derive from one single forestry or design tradition are likely to fail. Hence there is a need to explore a variety of aspects relating to preferences for forest landscapes that are generic or cross-cultural.

Within the over-arching context of sustainable management of forests, urban forests must fulfill their role. However, little is really known of the aesthetic implications of many sustainable management practices, such as mimicking or emulating disturbance patterns, or, for that matter, the long term ecological implications of certain practices carried out for "aesthetic" reasons (such as preserving old trees, retaining screens to hide cutting along roadsides, tidying dead wood).

The power of cultural symbolism in landscape can lead to situations where what people are willing to accept as landscape change (manifested as a range of forestry practices) is not conditioned by knowledge of the possibilities contained within a given situation, but by preconceived notions, some of which may be based on erroneous information. Well meaning "eco-warrior" tactics to save trees from development may overlook other significant reasons why the loss of such trees is acceptable in the longer term. This is where aesthetics and ethics start to blend together. Concepts such as equating truth with beauty blur the distinction.

These scenarios suggest several important themes for research aimed at improving the planning, design and management or urban forests. These themes emerge directly from the framework described above but have, in some cases, important linkages to other areas of research. These links, if they currently exist at all are likely to be weak. Most of these themes apply equally to the traditional, distant means of aesthetic response and the participatory, multisensory aesthetic of engagement. However, much of the existing work has concentrated on the scenic mode, so that there is probably more mileage to be obtained from exploring the participatory mode further. These research themes are structured around the 4 types of aesthetic response.

The Sensory

This response is based on the immediate sensory impact and has been linked, in the framework, to the potential to find certain aesthetic universals. Research here should concentrate on the developments arising from evolutionary and environmental psychology to explore how far such generic or cross-cultural preferences can be discovered. This is needed due to the multi-cultural condition of most large urban centres today.

A secondary link is with landscape ecology, where studies of ecological patterns and processes for sustainable ecological management of forests is one focus of research. If at some point the human ecology of forest use can be incorporated more fully, using the output of research outlined above, this will better ensure that conflicts between management objectives can be reduced.

The Formal

Approaches to forest landscape planning, design and management have concentrated on the scenic mode, applying formal design principles to larger scale "exterior" forest landscapes. Such approaches, pioneered in Britain and the US have been empirically based and only tested in limited circumstances. These principles represent the modification of those used in architecture and other fields of applied design. They are often used to promote a certain style of design and to some extent this is also true in forestry, where these principles are used, successfully, to develop "natural appearing" plantation forests (Forestry Commission *ibid,* Lucas 1991).

This use of formal design principles is of interest to designers of urban forests, faced perhaps with planting a new forest from scratch, where the kind of layout, species composition and internal structure must be legible, convey certain qualities to the intended users and offer the greatest aesthetic potential. Research here therefore should concentrate on aspects of pattern reading and understanding, "spatial syntax" and internal navigation of forest landscapes, using techniques developed in environmental psychology.

A secondary link here is with the research into aesthetic universals outlined above, ensuring that the results are converted into practical design tools.

An alternative way is to use the principles to understand the sensory (primarily visual) expression of landscape pattern and how they have evolved, leading to a design approach based on working with the landscape (Bell 1999).

The major research issue here is to develop better means of incorporating human perceptions and needs with the landscape ecological models developing for natural patterns and processes. These models, using geographic information systems, dynamic process models and alternative, probabilistic scenario development, do not yet incorporate sufficient human "habitat" requirements. These requirements need to be described and analysed so that they can properly be taken into account.

The Expressive

This type of response is where the sensory information is mixed with knowledge. At present there is a large body of work on landscape preferences, some of which has examined the differences between people who know about how the landscape has arisen and those who do not. The importance to the aesthetic response of other factors in the reasons people visit or use forests has not been explored, for example if people regularly use such forests for berry and mushroom picking to supplement their diet, is their response different? Research into this area is needed in order to help understand the range of ways people interact with forests, an important area of knowledge when public participation is becoming a key aspect of forestry planning, particularly in, for example, the development of so called community forests. It is another field for environmental psychology.

A secondary aspect here concerns the sense of time inherent in forests. Tree lives often cover several human generations and project a sense of continuity with the past (Rolston's "deep time"). However, modern forest management often curtails that span and, in the urban situation, old trees are often removed for safety reasons. Since this sense of age is a significant aspect of forests and time is an element of our expressive aesthetic (the internal, subconscious discussion to come to terms with what we perceive) this subject deserves further study.

The Symbolic

Earlier in this paper a brief mention was made of the links between aesthetics and ethics. Not enough is known of the ways in which knowledge, ethics and cultural norms are created that lead to the adoption by individuals, communities or whole societies of certain strongly held ethical positions. It would seem that many of the problems of acceptability of various types of forest management hinge on the relationship between professional planners, designers and managers to various levels of communities. This is an area where psychology and philosophy need to work together.

A secondary link here is with applied landscape ecology and the emerging search for an "ecological aesthetic". This could be important for working towards sustainable management and the development of models of management that try to allow for less than tidy, manicured urban forests.

Conclusions

In this paper a framework has been presented that brings together many superficially different elements of theory and practice that, to the uninitiated, seem confusing and contradictory. This framework demonstrates that it is possible to see a much bigger, coherent structure that leads towards a well-defined set of research directions. These directions can be applicable to many aspects of forestry. However, given the growing importance of urban forestry and the issue of dealing increasingly with urban communities who are not part of the land using population, these research topics become more important. Some of this research is already underway in a number of countries. What is needed now is a better network of interdisciplinary workers to exchange information and ideas.

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Sub-Plenary Session: C4

Changes in Environment and Society:

Forest Chronosequences: A tool for Assessing Long Term Sustainability

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Long Term Nutrient Budgets in Forests: Lessons from Chronosequence Studies.

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Abstract:

Variations in nutrient budgets with forest age are compared in two chronosequence studies of conifer plantations. Over the rotation, nutrient budgets are negative at both sites, but the variation with stand age is quite different in relation to soil fertility, stand health and past land use. These variations with stand age demonstrate the need for such studies for forcasting long term soil fertility changes in forests.

Keywords: Forest age, Nutrient cycling, Deposition, Leaching, Budgets

Introduction

Flux budgets in ecosystems are needed both for basic understanding of ecosystem function and for feeding applied models of sustainable management.

Changes of soil fertility associated with forest management are difficult to evaluate due to the combination of both the high spatial variability of soil properties, and the variations of nutrient pools and fluxes across the forest rotation. For this reason it is necessary to have information on the spatial variability of studied parameters and on the dynamics of the system during the the main phases of the stand development including the harvesting and regeneration stages.
Three main approches are generally used:

The diachronic approach consist in observing the same ecosystem during the whole of the rotation time. This method is the most interesting in short rotation forestry, because the whole rotation can be covered, while it is not suitable in classical forestry, where rotation times may reach several hundred years.

Among the synchronic approaches, two main possibilities are offered.

Flux budgets in a chronosequence of stands which represent the main stages of development of a single stand. The major difficulty consist in selecting sites where the only difference is the stand age. All other parameters need to be constant *e.g.* tree species and provenance, past land use, soils, climatic and pollution context. If not, it is of paramount importance to connect the results to the theoretical dynamics of the ecosystem, which is unfortunately unknown and which can vary with time according to systematic constraints. The advantage of this method is that it provides insight in the functional links between changes in fertility and ecological factors.

The statistical comparison of soil properties in a large set of stands is the most often and traditionally used approach (Page 1968). It provides quicker answers than the former method, but does not link changes and assumed causes.

Here, we present two case-studies of flux budgets in chronosequences of productive coniferous plantations, representative of the medium mountain situations in France. The objectives were to measure rotation weighted budgets of soil nutrients and to analyse the main causes for changes in order to give practical recommendations for sustainable management of forests. Results are discussed and compared with data from the literature.

Material and Methods

Sites

- the Aubure chronsosequence is composed of three Norway spruce stands aged 15 (S15), 35 (S35) and 85-year old (S85) in 1988. It is situated in the Vosges mountains at an elevation of about 1100m. Stands are located side by side, on the upper southern facing slope of the Strengbach catchment (Probst et al., 1990). The climate is characterized by a mean annual rainfall of 1400 mm and a mean annual temperature of 6°C. The stands are either a first (S15 and S35) or a second rotation of Norway spruce planted on a former fir forest, that was partly grazzed. The soils have developed from the Brézouard granite, very poor in Ca and Mg. Soil types vary from Alocrisol (S90) to Podzosol (S15), but spatial variability is high. Soils are coarse-textured, strongly acid and desaturated, with a very limited available pool of nutrient (Table II). Texture is slightly richer in clay in S90 than in S15 and S45, because of the influence of a local outcrop of gneiss. Wood production is 22 m^2 $ha^{-1}yr^{-1}$ in S35 and 7 m^2 $ha^{-1}yr^{-1}$ in S85. Needle nutrient content is low at S15 but trees are not deficient. Needle Ca content is very low at S35 and trees are yellow due to Mg deficiency. Needle N contents are higher in S85 but Ca and Mg are very low (Table I).

- the Vauxrenard chronosequence, composed of three Douglas-fir stands 25, 45 and 65-year old, is situated on the Beaujolais Mounts, at an elevation of 750m. The climate is characterized by a mean annual rainfall of 1000 mm and a mean annual temperature of 7°C. Douglas fir plantations were established on previously cultivated land. The rock is a Visean consolidated volcanic tuf, rich in Ca. The soil is a typical Alocrisol, acidic and desaturated. Soil caracteristics are given in Table II. Wood production is 7, 17 and 15 m3 ha-1 yr-1 in D25, D45 and D65 respectively. Trees are healthy and needle nutrient contents are adequate (Marques 1996).

Methods

Inputs of nutrients by atmospheric deposition and outputs in drainage were measured in each stand for generally 3 years.

- Atmospherical deposits were estimated from monthly rainfall and throughfall measurements. At both sites, Na or SO_4 in net throughfall were supposed to derive only from dry deposition. Base cation dry deposition was calculated assuming that the base cation to Na ratios in rain and dry deposition were similar. Dry deposition of N was calculated assuming that NH_4 and NO_3 to SO_4 ratios in rain and dry deposition were similar. Additional studies at Aubure have shown that these assumptions were reasonable (Dambrine et al., 1998, Ignatova and Dambrine 2000).

- Drainage below the rooting zone was quantified from the concentration of elements in soil solution collected by zero-tension plate lysimeters (Probst et al., 1990, Marques 1996) and water flux estimated from a soil water model calibrated for the sites by climatic data and soil water retention curves (Biron 1994; Marques et al., 1997)).

Table 1: General characters of the stands, foliage biomass and concentration in N, Ca, K and Mg

Stand	Mean height m	density tree.ha^{-1}	Foliage biomass tons.ha^{-1}	current Needle N %	current Needle Ca %	current Needle Mg %	current Needle K %
D20	14	922	17.4	1.71	0.40	0.14	0.74
D40	28	490	13.6	1,53	0.26	0.11	0.62
D60	36	312	16.1	1.58	0.38	0.12	0.56
S15	4	3550	24	1.22	0.63	0.07	0.64
S30	15	2200	27	1.34	0.25	0.04	0.54
S85	28	500	9	1.47	0.24	0.06	0.78

Table 2: Soil characteristics of the Spruce stands at Aubure and Douglas fir stands at Vauxrenard

Site	depth cm	gravel % > 2 mm	density g cm^{-3}	clay %<2mm	C/N	pH water	exchange capacity cmol(c) kg	base saturation %
S 85	L+F				23,9	3,8		
	0-10	45,7	1	20,2	15,5	3,5	13,3	7,5
	10-30	47,1	1,3	20,2	14,3	3,9	13,0	4,3
	30-50	49,9	1,3	19,9	13,9	4,2	10,9	4,2
	50-70	56	1,3			4,4	8,0	5,2
S 35	L+F				25,4	4		
	0-10	41,7	0,8	14,3	16,7	3,5	11,1	8,4
	10-30	44,4	1,3	15,2	16,5	3,8	11	4,2
	30-50	54,1	1,1	17	15,7	4,2	10	3,7
	50-70	61,4	1,4			4,4	7,7	4,8
								16.5
S 15	L+F				18.4	4		
	0-10			18.3	14.8	3.6	12	16.5
	10-30			17.5	14.7	4	12.2	9.6
	30-50			18.6	15.4	4.1	11.5	5
	50-70					4.4	8.4	5.1
D65	L+F							
	0-10	16	0,7	21,7	12,8	4,3	7,7	15
	10-20	16	0,9	21,2	10,9	4,6	5,3	12,5
	20-35	25	0,9	23,2	12,1	4,5	4,9	10,8
	35-50	33	1,0	24,1	9,9	4,5	4,7	11,5
	50-65	32	1	20,3	8,4	4,6	4,9	11,5
	65-75	31	1,2	19,2	7,9	4,5	4,9	9,6
D45	L+F							
	0-15	35	0,8	19,9	12,3	4,4	7,8	9,4
	15-30	35	0,9	19,5	11,2	4,4	5,5	7,1
	30-45	42	1,0	23,6	10,8	4,4	5,3	7,1
	45-65	47	1,1	22,0	8,1	4,4	5,0	7,1
	65-85	30	1,0	18,5	8,3	4,4	4,8	7,9
D25	L+F							
	0-12	42	0,6	19,4	12,4	4,2	9,1	15,4
	12,-25	40	0,7	17,8	10,5	4,4	6,2	12,6
	25-40	35	0,73	18,1	11,4	4,4	5,6	13,1
	40-60	39	0,9	16,4	9,7	4,5	5,1	14,6
	60-85	39	1,1	16,0	8,1	4,8	5,1	24,5

- Biomass and stand nutrient content were quantified using a destructive sampling of 3 (S15), 10 (S35), 12 (D25, D45, D65) and 15 (S85) trees per stand. Regressions between biomass, nutrient content and tree DBH established from these samples were than applied to the stand inventory. Nutrient uptake and immobilization according to tree compartments were calculated for each stand (Le Goaster et al., 1991, Ranger et al., 1995). At each site, the nutrients removed in harvested biomass over the complete rotation were obtained by adding to the amount of nutrients in the standing wood biomass of the older stand, the amounts of nutrients removed during the clearings.

- Nutrients originated from the weathering of soil minerals were estimated using different methods: the average historical rate of release of base cations was computed from the vertical variations of the amonts of base cations, Si and Zr. The current rate was calculated using the Profile model (Sverdrup and Warfvinge, 1988). Input parameters were quantitative soil mineralogy, localization of nutrients in the mineral structures, processes of mineral transformation, soil exchangeable phase and solutions characteristics (Fichter et al., 1998 ; Ezzaïm et al., 1999). The weathering flux was considered constant during the rotation time.

Results and Discussion

Table 3 shows the mean annual weighted fluxes of nutrients and budgets in each stand as well as the rotation weighted budgets for the two chronosequences. Open field precipitation brings about 8, 3, 0.6 and 2 kg ha^{-1} yr^{1} of N, Ca, Mg and K respectively. Throughfall N, Ca and Mg increase with stand age. The increase of N in throughfall with stand age is related at Vauxrenard to a higher foliar uptake of N in young stands, while total deposition remains stable. At Aubure, where the stands are close to the mountain ridge and are submitted to frequent wind, this increase is also related to an increase of dry deposition with the development of the canopies (Ignatova and Dambrine 2000). At both sites the increase in throughfall Ca and Mg with stand age seems mainly related to an increase of deposition. Over the whole of the rotation, N deposition is much higher than N requirements for stand growth, while Ca and Mg deposition are closer to stand requirements. Although the contents of Ca and Mg of the rocks differ considerably between the two sites, the mineralogy of the soils is rather similar and poor in weatherable minerals: the clay fraction is dominated by illites and Al-interlayered vermiculites (HIV) and smectites (Aubure). Minor amounts of apatite and albite in the silt fraction are the only sources of Ca. Combining measured Ca, Mg, K and Na fluxes in soil solution, detailed mineralogy and modelling provides a Ca flux lower than 1 kg ha^{-1} yr^{-1}. Weathering of illites or/and smectites from the silt and clay fractions provides about 0.8-1 kg ha^{-1} yr^{-1} of Mg, but a rather large flux of K (6-8 kg ha^{-1} yr^{-1}). The uncertainty in the weathering fluxes are in the range of ±0.5kg for Ca, ± 0.2kg for Mg, and ±2 kg for K.

Growth is much higher at Vauxrenard than at Aubure in relation to tree species and climate. Hence nutrient immobilisation is higher at Vauxrenard. Immobilisation of most nutrients in wood is the highest at mean current increment (MCI). The lowest rate are obtained at Aubure in S85, in relation to the age and bad health of the trees.

Drainage of N, Ca and Mg is much higher at Vauxrenard than at Aubure. Nitrate drainage is the highest at D25 (39 kg N) and decrease continuously to low values (6 kg ha^{-1} yr^{-1} N) at D65. Ca, Mg and K drainage follow the same trend which shows the driving role of nitrate drainage for base cation drainage. We hypothetize that this high nitrate drainage at Vauxrenard reflects the high N mineralization and nitrification potential of formerly cultivated soils and the availability of a labile organic matter pool previously accumulated in the soil when it was cultivated (Jussy 1998). Similar high nitrate drainage was obtained by Mohamed and Ranger (1994) in a mature healthy productive spruce forest planted on formerly cultivated land. Nitrate drainage below the young stands is very low at Aubure. This results from both a very poor nitrification potential in the soil and the uptake of most of the deposited N by the growing stands. N drainage increases strongly in S85 as a result of its poor health and low growth requirements while the deposition is the highest. High leaching of nitrate below declining stands has been demonstrated at many sites.

Base cation drainage is the lowest in S35, when growth is the highest. Base cation concentrations in soil solutions decrease strongly between -5 and -30 cm depth, in relation to root uptake (Dambrine et al., 1992). Base cation drainage is higher at S15, while N drainage is very low and soil solution pH is relatively high (close to 5) in comparison to the other stands (closer to 4.5). As soil minerals are even poorer at this site than at S35, weathering should not be responsible for this flux. This base cation flux in soil solutions might be attributed to the mineralization of the slash from the previous harvest. Base cation and nitrate drainage are the highest in S85.

Across the rotation time, the Vauxrenard plantation on formerly cultivated land continuously loses nutrients but the rate of loss decreases with stand age. Hence, the rotation budget may become equilibrated during the next rotation, except possibly for Ca, which is still curently lost in the older stand. In comparison, over the whole of the rotation, the spruce soil at Aubure loses Ca and accumulates N, while the Mg and K budgets (given the uncertainties) are almost equilibrated. The Mg balance could be expected given the extremely low amounts of exchangeable Mg, but successive soil exchangeable measurements confirmed a current loss (Dambrine et al., 1999). Budget values are questionable as they rely on a number of hypothesis. Deposition is the most uncertain data. The N deposition values used may be overestimated. Using Throughfall N as input, the budgets are still negative at Vauxrenard, but become equilibrated at Aubure. Using throughfall Ca as input, Ca budgets are still negative at both sites and it is unlikely that weathering could compensate the deficit because total Ca amounts in the soils are very low.

Hence, nutrient budgets across the two chronosequence differ widely (Figure 1): Although at Vaurenard, nutrients are lost at a high rate, budgets tend to an equilibrium, which may be reached during the next rotation. On the opposite, at Aubure, N accumulates and Ca is lost continuously during the rotation (Dambrine et al., 1999).

Table 3 : Nutrient fluxes and budgets (kg.ha^{1}.yr^{-1})

	S15				S35				S85				Aubure rotation			
	N	Ca	Mg	K	N	Ca	Mg	K	N	Ca	Mg	K	N	Ca	Mg	K
Bulk precipitation	7.6	2.2	0.6	1.7	9	2.8	0.7	1.8	9	2.8	0.7	1.8	8.7	2.7	0.7	1.8
Throughfall	8.2	5.2	1.3	20.8	7.9	6.3	1.5	22.8	18.7	10.1	2.2	18.6	12.8	7.7	1.8	20.5
Atmospheric deposition	12.9	2.9	0.8	2.2	21.1	4.4	1.1	2.8	25	7	1.7	4.5	21.0	5.2	1.3	3.4
Weathering		0.2	0.85	6		0.2	0.85	6		0.2	0.85	6		0.2	0.85	6
Biomass	5.9	4.7	0.6	4.7	10.2	10.7	1.2	7.5	3.3	3.7	0.4	1.7	4.7	5.2	0.6	2.6
Drainage	1.4	7.7	1.3	7.1	4	2.6	1.3	6.6	22.4	11.5	2.3	11	11.6	7.7	1.7	8.7
Budget	5.6	-9.3	-0.2	-3.6	6.9	-8.7	-0.5	-5.3	-0.7	-8	-0.2	-2.2	4.70	-7.50	-0.2	-1.8

	D25				D45				D65				Vauxrenard rotation			
	N	Ca	Mg	K	N	Ca	Mg	K	N	Ca	Mg	K	N	Ca	Mg	K
Bulk precipitation	8.4	3.1	0.6	2	8.4	3.1	0.6	2	8.4	3.1	0.6	2	8.4	3.1	0.6	2
Throughfall	7.8	6.5	2	27.4	16.1	10.7	2.2	15	19.1	10.1	2.2	13.4	14	9	2	19
Atmospheric deposition	17	4	0.7	2.5	20.6	5.7	1	3.5	19.5	7.3	1.3	4.4	19	5.7	1	3.5
Weathering		0.9	1	7.5		0.9	1	7.5		0.9	1	7.5		0.9	1	7.5
Biomass	4.7	1.7	0.5	6	9.2	5.6	0.8	6.9	6.2	5.8	0.4	7.1	6.7	4.4	0.6	3.3
Drainage	38.9	21.7	9.1	22.7	25.2	10.2	5.1	7.7	6.3	5.1	1.9	4.9	23.5	12.3	5.4	11.8
Budget	-26.6	-18.5	-7.9	-18.7	-13.8	-9.2	-3.9	-3.6	7	-2.7	0	-0.1	-11.2	-10.1	-4	-4.1

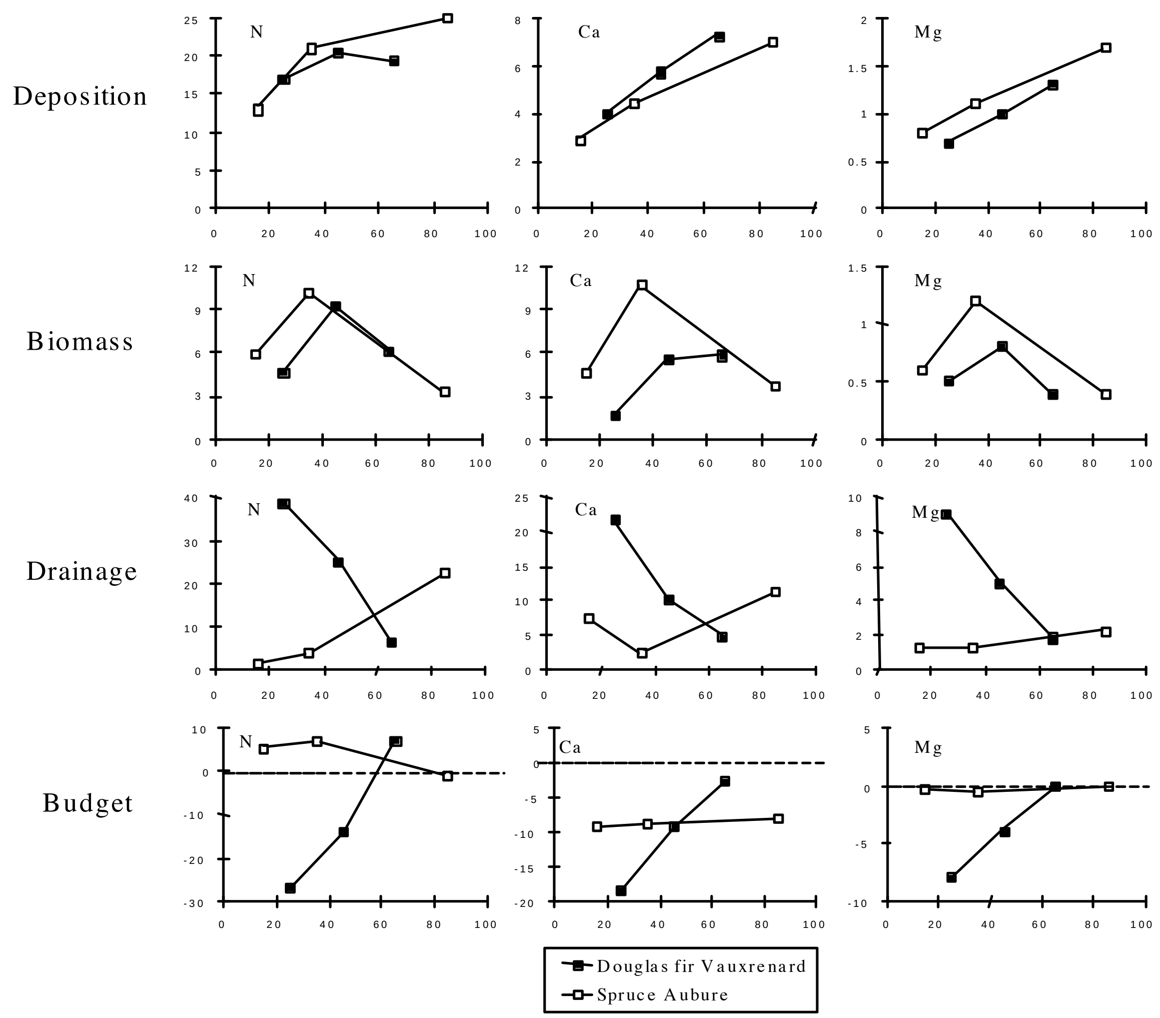

Figure 1: Variations of mineral fluxes and budgets with forest

Comparison with Other Studies

A number of chronosequence studies have been published but rather few offer complete nutrient budgets. There is a general agreement on the increase of base cation, sulfur and nitrogen amounts in throughfall with stand age (Stevens 1987, Helmisaari 1995, Carleton and Kavanagh 1990). This variation with stand age is attributed either to an increase in deposition with the development of the canopy, or to a reduction of N foliar uptake (but the opposite was observed by Carleton and Kavanagh 1990), and/or to an increase of foliar leaching. Nutrient immobilization in wood varies mainly with stand growth and can be derived from growth curves and average wood concentrations. Nutrient drainage increases strongly with stand age in 5 chronosequences of Sitka spruce on former unimproved grasslands in Wales (Hugues et al., 1994). The main cause was the increase in dry and occult deposition of sea salts, nitrogen and sulfur with stand age. Past land use by agriculture and ploughing before plantation was suspected causes for nitrate losses, but N drainage increased with stand age, in contradiction to the Vauxrenard chronosequence. The contradiction may be related to the higher fertility status of the soil at Vauxrenard, in comparison to the Wales. In a chronosequence of Scotts pine in Finland, Helmisaari (1995) measured a strong increase in sulfate and base cation drainage in the older stand, but causes were unclear.

Conclusion

From the results presented here, it appears that one should not expect one single variation in nutrient budget with stand age, but various evolutions in relation to the main ecological factors such as climate, deposition and deposition history (Schaaf et al., 1998), soil fertility, stand health and past land use. Budget variations with stand age highlights the need for such studies for forcasting long term soil fertility changes in forests, but also the difficulties associated to this approach.

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Chronosequence Studies of Forest Ecosystem Development on Post-lignite Mining Sites

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Abstract

The development of pine ecosystems was studied at 2 - 60 years old mine spoils on two typical substrates of the lignite mining area of Lusatia/Germany in a "false-time series" approach. Pyrite contents of varying amounts in the original overburden material can result in extremely phytotoxic site conditions. Soil solutions are often characterized by low pH, high electrical conductivities and high element concentrations. Reclamation of these sites was traditionally carried out using large amounts of bottom or fly ash from lignite power plants.

The temporal development of soil solution composition along the "false-time series" can be explained as a combined effect of intensive weathering of primary minerals including pyrite oxidation, transformation and precipitation of secondary salt and mineral phases, and leaching of salts. Additionally, ash amelioration affects soil chemical properties at least in the topsoils. The element outputs from the systems on pyritic substrates can reach extraordinary high amounts and are manifold increased to comparable sites on natural soils of the region. The chronosequence approach to study post-mining sites has proven to be a very useful tool to identify dominating processes on the ecosystem level.

Keywords: Element budgets, Leaching, *Pinus sylvestris* L., *Pinus nigra* Arnold, Pyrite oxidation, Reclamation, Secondary minerals, Soil solution chemistry

Introduction

In Lusatia, an area of more than 77,000 ha is affected by open-cast lignite-mining activities (Drebenstedt, 1998, Hüttl, 1998). Prior to mining, forestry was the dominating land use in the region. In the post-mining landscapes two main types of substrates can be identified: lignite- and pyrite-containing substrates stemming from Tertiary sediments and lignite- and pyrite-free substrates from Quaternary sediments. The majority of these substrates are pure sands and loamy sands. Due to the mining technology using overburden-conveyer bridges (Häge 1996) about 60 % of the land surface today consist of at least partially lignite- and pyrite-containing substrates and are characterized by low nutrient content and poor water retention capacity (Katzur 1998).

The pyrite content in these substrates exposed to the atmosphere leads to a high potential for acid production and consequently very phytotoxic site conditions. To reclaim or recultivate these sites, high amounts of ashes from lignite power plants were used for amelioration and neutralization of actual and potential acidity (Katzur and Haubold-Rosar 1996). Since reclamation measures lagged behind mining activities during GDR times, an area of about 30,000 ha remains for recultivation. In this context, "recultivation" is defined as supporting "the development of the soils, the vegetation, the wildlife, the water balance and water quality in order to allow future land uses such as agriculture and forestry" (Hüttl 1998). Due to the poor substrates forestry is also the dominating land use in the post-mining landscape covering about 60 % of the area (Preußner 1998). Main tree species are pine (*Pinus sylvestris* L. and *Pinus nigra* Arnold) followed by oak (*Quercus rubra* L. and *Quercus petraea* Matt.) with 54 % and 16 % of the forested area, respectively (Preußner 1998). These forest ecosystems virtually start very close to the "point zero" of development, especially with regard to soil development, plant-soil interactions, and establishment of biogeochemical cycles.

To study the ecosystem development, a chronosequence approach with several pine stands on different mine spoil substrates of different ages was used (Hüttl *et al.* 1999). Water and element fluxes in different ecosystem compartments along these "false time series" were measured, analyzed with respect to differences between substrates, and compared to pine ecosystems on non-mined sites of the region. The main objectives were to identify the dominating processes and temporal trends in ecosystem development and to use flux budgets as an indicator of ecosystem functioning.

Materials and Methods

Seven sites on comparable substrate representing the two prevailing site types were chosen as chronosequences covering periods of up to 60 years of development (Table 1). The lignite- and pyrite-containing substrates (LPCS) were ameliorated with different amounts of lignite ash depending on their calculated potential lime requirements (Katzur 1998). The different incorporation depths represent the available technology at the time. The lignite- and pyrite-free substrates (LPFS) were either left unameliorated or had been limed. All sites received an initial mineral NPK-fertilization before afforestation. For comparison, element cycling data from a 45-year old Scots pine stand on non-mined glacial outwash sands (Spodi-dystric Cambisol) were used (site name: TA; for detailed description see Schaaf *et. al.*, 1995 and 1999b)

Soil samples from different depths were taken at five points within each site and analyzed for pH (1:2.5 water extract), total carbon (C_T), nitrogen (N_T), and sulfur (S_t) content (LECO – CNS analyzer). Effective cation exchange capacity (CEC) was determined with an unbuffered $BaCl_2$ exchange solution based on the original method of Mehlich (1942) modified as a percolation procedure (Meiwes *et al.* 1984) and included specially adapted leaching steps to remove easily soluble salts. Amorphous and crystalline iron and aluminium oxides and hydroxides were determined using the oxalate (Fe_o, Al_o) and dithionite (Fe_d, Al_d) extraction methods (Blume and Schwertmann, 1969).

All sites were intensively instrumented for water and element flux measurements with meteorological stations, bulk and throughfall samplers (10 each), ceramic suction cups (P80 material) for soil solution sampling in 2 - 4 soil depths (6 cups per depth), pressure transducer tensiometers (5 per depth) and TDR/FDR probes (2 per depth) for continuous registration of soil tension and volumetric water content.

The solutions were usually sampled every two weeks and analyzed for pH (Beckmann pH34 glass electrode), electrical conductivity (Hanna HI 8733), main cations (Unicam 701 AAS and Unicam 939 ICP-AES) and anions (Dionex 500 and 120 IC), NH_4-N (Flow Solution Alpkem 301), and dissolved organic carbon (DOC; Shimadzu TOC 5000 Analyzer). Sampling period was 01/1996 – 04/1998 for the LPCS-sites and 04/1996 – 10/1998 for the LPFS-sites.

Daily meteorological data (air temperature, relative air humidity, wind speed, global radiation, and precipitation) were used as driving variables for a one-dimensional soil water model (SOIL, Jansson 1994). The model was parameterized with soil physical data, stand data (root depth distribution, tree height, leaf area index) and calibrated with measured tension data for each site. Simulated soil water fluxes were multiplied with measured soil solution concentrations for each sampling interval to calculate element fluxes.

Results

The geochemistry of the substrate types is very different as reflected in soil solution compositions. Gast *et al.* (2000), Schaaf et al. (1998), and Wilden *et al.* (1999, 2000) described and discussed soil solution chemistry of the sites in detail. Ion pairs and complexes play an important role in highly concentrated solutions (Knoche *et al.* 1999; Schaaf, 1999a), therefore the values given here are total element concentrations.

Table 1**:** Sites of the chronosequence studies on two different substrates (stand age in 1998)

sites on tertiary substrates (LPCS)	
Weissagker Berg (WB)	
dump age:	1991
substrate:	lignite + pyrite containing sand
melioration:	1996, 28 t CaO/ha 0,6-0,8 m
stand age:	2 years (*Pinus sylvestris*)
Baerenbrueck (BB)	
dump age:	1977
substrate:	lignite + pyrite containing loamy sand
melioration:	1978, ca. 190 t CaO/ha 0,4 m
stand age:	16 years (*Pinus nigra*)
Meuro (MR)	
dump age:	1970
substrate:	lignite + pyrite containing loamy sand
melioration:	1971, ca. 160 t CaO/ha 0,6 m
stand age:	20 years (*Pinus sylvestris*)
Domsdorf (DD)	
dump age:	ca. 1946
substrate:	lignite + pyrite containing loamy sand
melioration:	1963, ca. 50 t CaO/ha 0,3 m
stand age:	34 years (*Pinus sylvestris*)
sites on quaternary substrates **(LPFS)**	
Seeblick (SB)	
dump age:	1994
substrate:	sand
melioration:	1995, 7.5 t CaO/ha 1,0 m
stand age:	2 years (*Pinus sylvestris*)
Schipkau (SK)	
dump age:	no data
substrate:	sand
melioration:	no data
stand age:	20 years (*Pinus sylvestris*)
Plessa (PL)	
dump age:	1924
substrate:	sand
melioration:	none
stand age:	62 years (*Pinus sylvestris*)
(for detailed site descriptions s. Hüttl *et al*., 1999 and Schaaf *et al*., 1999a)	

At the LPCS-sites the solutions show high concentrations with electrical conductivities (EC) up to 16 mS cm^{-1}. pH values vary from 4.3 - 5.5 in ameliorated topsoils down to 2.3 – 3.3 in the subsoils (1,0 – 1,3 m depth).

Dominating mean element concentrations are calcium (up to 12.5 mmol Ca_T L^{-1}), magnesium (up to 13 mmol Mg_T L^{-1}), aluminium (up to 105 mmol Al_T L^{-1}), iron (up to 50 mmol Fe_T L^{-1}), and sulfate (up to 160 mmol SO_{4T} L^{-1}).

With increasing site age these high values decrease and clear depth gradients are observed with higher concentrations in the subsoils (Schaaf *et al*., 1998). After amelioration and the induced pH increases in the topsoils especially, Al_T and Fe_T concentrations are reduced considerably. Despite high total carbon contents due to lignite in the substrate, the DOC concentrations are relatively low (10 – 30 mg L^{-1}). Elevated values up to 100 mg DOC L^{-1} paralleled by high ammonium concentrations (up to 2.5 mmol NH_{4T} L^{-1}) were found in extremely acid layers (pH 2.2).

At the LPFS-sites the mean total elemental concentrations are manifold lower compared to LPCS-sites. Mean pH values are 4.0 – 6.6, and EC varies between 0.2 and 1.0 mS cm^{-1} (Schaaf *et al.*, 1998). Soil solution composition is dominated by calcium and sulfate at these sites also , but at very much lower levels (0.5 – 3.8 mmol Ca_T L^{-1} and 0.5 – 5.6 mmol SO_{4T} L^{-1}). Due to the higher pH, aluminium and iron concentrations are below 10 ?mol L^{-1}. Only the youngest site (SB) shows higher concentrations than the two older LPFS-sites. No clear depth gradients can be identified in the soil profiles.

Table 2**:** Soil chemical parameters of the sites

site/depth (horizon)	type	pH (H_2O)	C_T %	N_T mg g^{-1}	S_T mg g^{-1}	CEC $mmol_c$ kg^{-1}	Fe_o mg g^{-1}	Fe_d mg g^{-1}	Al_o mg g^{-1}	Al_d mg g^{-1}
WB 0,2 m*	LPCS	3,7	1,44	0,6	4,4	32,8	3,1	3,9	0,4	0,4
WB 1 m*		2,8	1,64	0,40	5,6	22,0	4,1	4,4	0,6	0,6
BB 0,2 m	LPCS	4,0	5,38	1,0	9,8	97,2	7,5	8,9	1,5	1,0
BB 1 m		2,5	6,20	1,2	13,6	72,1	7,0	6,5	1,9	1,5
MR 0,2 m	LPCS	5,3	3,11	0,7	2,3	99,7	4,2	6,3	0,6	0,6
MR 1 m		2,8	4,46	1,0	3,0	68,3	3,6	4,2	0,3	0,3
DD 0,2 m	LPCS	5,5	5,25	1,1	1,5	203,8	7,1	10,9	0,6	0,7
DD 1 m		2,9	5,80	1,3	2,3	73,5	7,1	9,4	0,4	0,4
SB 0,2 m	LPFS	5,4	0,08	< 0,1	< 0,1	6,5	0,5*	1,0*	0,2*	0,2*
TA (Bhs)** 0,06-0,13m	non	4,2	0,55	0,5	< 0,1	25,1	1,6	2,4	1,0	n.d.
TA (Bw)** 0,13-0,47m	mined	4,4	0,25	0,5	0,1	14,9	0,7	1,7	1,9	n.d.
TA (BC)** 0,47-0,63m		4,4	0,05	0,2.	< 0,1	7,0	0,1	0,4	0,3	n.d.

* data from Heinkele and Weiß (BTUC 1999, pers. comm.);
** data from Schaaf *et al.* (1999b);
n.d. = not detected, Fe_o/Al_o = oxalate extractable iron/aluminium, Fe_d/Al_d = dithionite extractable iron/aluminium

The substrates also differ in a number of other important soil chemical parameters. The lignite content results in higher C_T and N_T contents in the LPCS-sites compared to the LPFS-sites (Table 2).

The higher lignite contents of the LPCS also increases the cation exchange capacity (CEC) of the sandy substrates, with CEC values 10- to 30-fold higher than both the LPFS-sites and the non-mined site (Table 2). Iron and Al contents, as determined by oxalate and dithionite extraction, were clearly elevated also throughout the profiles.The Fe_o and Fe_d values especially were 2- to 5-fold higher even when compared to the contents found in the Bhs horizon of the Cambisol. The low values at the LPFS-sites are comparable to those found for the BC horizon of the non-mined site and are characteristic of low weathering and early stages of pedogenic processes.

Generally, the element input rates with bulk deposition show no significant differences between the investigated sites. Differences between bulk and throughfall deposition are mainly due to differences in water fluxes (interception losses) except for nitrogen where there were indications of N uptake in the canopies of dense stands (about 20 years of age) and potassium which is typically leached in considerable amounts from the needles (Gast et al., 2000). Aluminium and Fe input rates were negligible, with concentrations in precipitation samples are often below 5 mol L^{-1}.

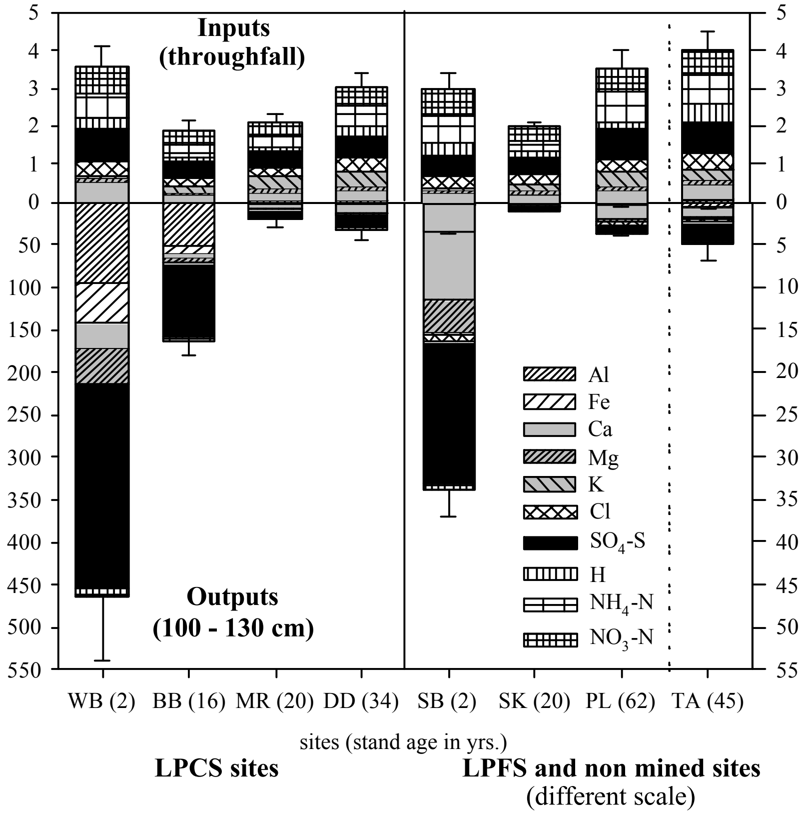
However, these similarities disappear abruptly as soon as soil fluxes are considered. Despite the low water fluxes through the soil profiles, very high element fluxes are calculated for the LPCS-sites as a consequence of the high soil solution concentrations. Output fluxes are generally 10 times higher at the LPCS-sites compared to the LPFS-sites and the non-mined site.

Calcium fluxes in the soil show two trends: the fluxes from the topsoils at the LPCS-sites (ameliorated layers) decline with site age whereas the outputs from the subsoils reflect the amount of water fluxes quite well (Fig. 1). Despite the high fluxes, the Ca outputs (up to 30 kmol Ca $ha^{-1}yr^{-1}$) are generally below 1% of the total stores within the substrates. At the LPFS-sites, Ca outputs are only elevated at the youngest site SB. At the older sites the fluxes are at levels comparable to the non-mined site (TA). Although the Ca budgets are negative for all sites, outputs at the sites SK, PL and TA are much closer to the level of actual inputs compared to all LPCS-sites.

The S fluxes in the soils show a similar pattern. LPCS-sites are characterized by extremely high S outputs up to >200 kmol $ha^{-1}yr^{-1}$ (Fig. 1). Despite decreasing water fluxes, the S fluxes are increasing with soil depth. At the youngest site (WB) S outputs are more than 300-fold above actual deposition inputs. These figures decrease with site age, but at the oldest site (DD) the outputs are still 25-fold above inputs. The S budget is also negative at all LPFS-sites (especially at SB) and at the non-mined site (TA), but on much lower levels. For both Ca and S the budget data of the oldest LPCS-site is very similar to the youngest site on LPFS despite large differences in water fluxes. The differences between the two substrates are even larger for Al and Fe. Both the LPFS-sites and TA show very low input and output fluxes for both elements due to low concentrations that are often below the detection limit. In contrast, Al and Fe fluxes at the LPCS-sites can reach extremely high amounts at the younger sites (up to 95 kmol Al $ha^{-1}yr^{-1}$ and 50 kmol Fe $ha^{-1}yr^{-1}$). Iron fluxes decline very rapidly with site age, especially in the ameliorated topsoils, whereas Al outputs are elevated at the two youngest sites WB and BB. Aluminium fluxes from the topsoils of the older sites show reductions similar to Fe and from the subsoils they are comparable to the non-mined site (TA).

Nitrogen budgets show interesting differences between the sites. In deposition inputs, inorganic N is found in almost equivalent amounts as NH_4-N and NO_3-N at all sites. Generally, N outputs are well below inputs, and at some sites almost zero (Fig. 1). With two exceptions, the dominating $N_{inorg.}$-form in soil solution at all sites is NO_3 (usually > 90 % of $N_{inorg.}$). Elevated NH_4 fluxes from the subsoils (2.4 – 3.4 kmol NH_4-N $ha^{-1}yr^{-1}$) that exceed deposition rates are found only at the younger LPCS-sites. At the site DD, high NO_3 fluxes are detected, especially in the topsoil (1.7 kmol NO_3-N $ha^{-1}yr^{-1}$), resulting in N outputs at the level of deposition inputs.

Figure 1: Budgets of the major elements at the chronosequence sites on lignite and pyrite containing substrates (LPFS-sites: WB – BB – MR – DD), on lignite and pyrite free substrates (LPFS-sites: SB – SK – PL), and at a non-mined site (TA); Inputs: throughfall deposition, except at WB and SB: bulk deposition; Outputs: fluxes in 1,0 m (BB, MR, DD, SK, PL, and TA) or 1,3 m (WB and SB) soil depth; all fluxes are mean values of 2 years in kmol ha^{-1} yr^{-1} (but note different scales), error bars indicate variation between single years



Discussion

The high element concentrations in soil solutions from LPCS-sites are similar to those reported by Knoche *et al.* (1999) at lignite and pyrite containing sites under oak and by Katzur and Liebner (1995) in lysimeter studies with LPCS. Concentrations of comparable magnitudes are also found in soil solution samples from the mining area around Leipzig (Feldhaus and Wilczynski 1998). Low pH and high SO_4 and metal concentrations in surface and ground waters from pyritic dumps and tailings are frequently reported in literature related to acid mine drainage (Karathanasis *et al.*, 1988; Wieder, 1993; Evangelou, 1995; Miller *et al.*, 1996; Banks *et al.*, 1997; Geldenhuis and Bell, 1998).

The temporal development of soil solution composition along the ”false-time series” can be explained as a combined effect of intensive ”weathering” processes (including pyrite oxidation, transformation and precipitation processes) and leaching. Additionally, ash amelioration affects soil chemical properties, at least in the topsoils. Pyrite oxidation as the major source for Fe, SO_4, and acidity is completed within the time frame of the chronosequence as could be shown by the declining pyrite-S contents in the subsoils (Heinkele *et al.*, 1999). Intensive weathering of primary minerals within the substrates explains the high Al and Si concentrations (Gast *et al.*, 2000) and could be verified by microscopy e.g. for feldspars (Heinkele et al., 1999). In the ameliorated layers of the profile, Fe and Al precipitate in the form of oxides and hydroxides (e.g. goethite, gibbsite or copiapite) due to the elevated pH (Wisotzky, 1994; Miller, 1995; Li 1997). This is supported by the elemental composition of precipitates detected by scanning electron microscopy (Schaaf *et al*., 1999a) and explains the low Fe and Al concentrations in the topsoils. Other precipitates of secondary salt and mineral phases found at the LPCS-sites include gypsum, Fe- and Al-sulfates, and K-jarosite (Heinkele *et al*., 1999; Schaaf *et al*., 1999a). Gypsum, found at all sites and all soil depths, controls the Ca concentrations in soil solution which are frequently at the level of maximum gypsum solubility (Schaaf *et al*., 1998). Formation of gypsum as a result of pyrite oxidation and primary mineral weathering is commonly found in acid mine drainage, but also in naturally formed acid sulfate soils (van Breemen 1973; Dent, 1986; Karathansis *et al*. 1990; Evangelou, 1995; Boulet and Larocque, 1998). Sulfates like alunite, basaluminite, jurbanite or schwertmannite could also occur as possible solid phases (Bigham *et al*., 1996; Lin, 1997). This is supported by results from geochemical equilibrium modeling (Schaaf *et al*., 1999a), but could not be clearly identified by scanning electron microscopy (Heinkele *et al*., 1999). These transformation processes for Fe and Al from primary to secondary minerals is further supported by the high amounts of oxalate and dithionite soluble Fe and Al throughout the LPCS profiles.

The lower elemental concentration in soil solutions from the LPFS-chronosequence are comparable to results from oak ecosystems on mine sites derived from Quaternary sediments reported by Knoche (1998). The elevated C_T and N_T content of the LPCS-sites underline the high stability of lignite. Investigations by Rumpel *et al*. (1997) enabled the separation of pedogenic and geogenic carbon in these soils. They showed that pedogenic organic matter derived from recent litter fall contributes to C_T only in the uppermost centimeters of the profile. Although lignite decomposition is much lower compared to pedogenic organic matter due to its composition and high C/N ratio (Rumpel *et al*., 1998), it may play an important role in long-term nutrient cycling. The positive influence of lignite on (potential) CEC is reported by Katzur and Haubold-Rosar (1997). This increase is of high importance for soil ecological functions in these sandy and nutrient poor substrates. The extraordinary high CEC in the topsoil of the oldest site may be a result of the high ash amount used for amelioration. Input rates of all major elements to the soils by throughfall deposition are at the lower end of the range reported for forest sites in Germany and western Europe (cf. Dise *et al*., 1998; Feger, 1998). Differences between bulk and throughfall deposition point to important processes within the canopy, especially for nitrogen (possible uptake) and potassium (leaching).

Besides deposition inputs, litter fall contributes considerably to element cycling in forest ecosystems. Annual pine litter input increases with stand age and amounts to 1.9 - 5.2 t d.m. ha^{-1} yr^{-1} at the LPCS-sites (Dageförde et al., 2000) and 3.4 – 4.2 t d.m. ha^{-1} yr^{-1} at the LPFS-sites (Wilden, pers. comm.). This is in good agreement with the value of 4.9 t d.m. ha^{-1} yr^{-1} reported for the 45-year old reference site (TA) by Bergmann (1998). Additional litter inputs vary between 0 and 2.9 t d.m. ha^{-1} yr^{-1} depending on ground vegetation biomass (Bergmann 1998; Dageförde *et al*, 1999). These litter input rates are mainly influenced by stand age and stand density, but show no significant differences between substrate types. Total element inputs to the soil via litter are high for N (11 – 65 kg ha^{-1} yr^{-1}), Ca (12 – 45 kg ha^{-1} yr^{-1}), Mg (2 – 6 kg ha^{-1} yr^{-1}), and K (2 – 9 kg ha^{-1} yr^{-1}) [cf. Dageförde *et al*. (2000) and Wilden (pers. comm.), no data are available for both youngest chronosequence sites WB and SB]. Litter fall inputs of these nutrients are generally higher than atmospheric deposition rates and up to 3-fold higher than throughfall inputs.

Changes in the N fluxes in the topsoils indicate differences in mineralization and nitrification. Whereas at most sites both NH_4-N and NO_3-N fluxes at 0,2 m soil depth are very low, the oldest LPCS-site shows elevated nitrate fluxes resulting in an internal proton production of 1.8 kmol H^+ ha^{-1} yr^{-1} that is more than 5-fold above actual deposition input and exceeds by far all other measured proton fluxes at that site. The elevated NH_4-N outputs from the subsoils at the younger LPCS-sites can not be connected to input or topsoil processes and can only be explained by NH_4 release from lignite under very acid conditions. High NH_4 concentrations in leachates from pyritic spoils are also reported by Katzur and Liebner (1995) and Cravotta (1998). Hons and Hossner (1980) found that lignite has a high potential for NH_4 sorption. It remains to be shown whether this nitrogen originally derives from lignite or if it is only adsorbed to its surface. The same question has to be asked regarding the original source of Ca that is found in high amounts throughout all LPCS-sites in the form of gypsum that is formed after aeration of the substrate and pyrite oxidation. With regard to plant nutrition it is important that most sites on both substrate types act as a sink for N and K. Increasing amounts of both nutrients are moving within a ”small cycle” between plant uptake, growing biomass, accumulating organic surface layer, and the ameliorated topsoil as stands grow in age. However, the exception at the oldest LPCS-site (DD) with clear net N losses makes it difficult to predict future development and long-term ecosystem stability.

Conclusions

The chronosequence approach to study ”false-time series” of post-mining sites has proven to be a very useful tool to identify dominating processes at the ecosystem level. The results reveal fundamental differences of element budgets between the two substrate types due to their different geochemistry. The fluxes of almost all elements under investigation at the LPFS-sites are similar or even lower compared to a non-mined site which can be explained by low weathering rates of the dumped material consisting mainly of quartz and low atmospheric input rates. In contrast, the LPCS-sites show very high dynamics of initial development induced by substrate composition and are characterized by high element flux rates and intensive transformation processes, i.e. changes and redistribution of element pools.

Summarizing the major processes over time at these sites it is important to note that, with regard to transformation processes, the development starts before the actual mining and dumping activities. Pumping of groundwater and leveling of the groundwater table below the lignite seam leads to an aeration of the pyritic sediments resulting in initial pyrite oxidation and partial in-situ buffering of produced acidity, e.g. by feldspar weathering (Heinkele *et al*., 1999). This is important, because it shows that initial processes of transformation have already taken place when the substrate is dumped. At the well aerated dump sites the major processes are:

> Continued pyrite oxidation resulting in the release of large amount of acidity, sulfate, and iron, intensive weathering of primary minerals within the substrate releasing considerable amounts of Al, Ca, Mg or K depending on the specific mineral composition of the substrate, and precipitation of secondary salt and mineral phases like gypsum or oxides, hydroxides and sulfates of alumnium and iron. Since pyrite oxidation can be a rather fast process depending on its control by chemical or microbial oxidation, a pyrite-free zone is developing from the surface to increasing soil depths over time.
>
> Leaching of easily soluble or labile secondary salt and mineral phases like gypsum, anhydrite or epsom salt. Over time this zone develops down the profile, too, forming a zone free of pyrite and salts.
>
> Both processes are affected by the amelioration measures undertaken as a part of the recultivation practices. Large amounts of lignite ash are incorporated in the topsoils resulting in an input of high amounts of Ca and Mg, but also to a lesser extent sulfur. This introduces a large acid neutralization capacity compared to the substrate-internal buffering and also enhances formation of gypsum and other sulfate salts like $MgSO_4$ that is leached very fast in high amounts from the profiles. The raising of soil pH on the other hand induces precipitation of Fe - and Al – oxides/hydroxides.

Within the time frame of the chronosequence a trend at least in the topsoils towards ”undisturbed” conditions can be found, but for the prediction of future soil and ecosystem development there are still some important questionmarks left. First, even after complete pyrite oxidation and leaching of salts, the geochemistry of the LPCS remains quite different from LPFS-sites as well as from non-mined sites of the region. The lignite particles show a high stability and resistance to microbial or fungal decomposition. They will therefore resemble a long-term constituent of the soil with the effects discussed above. Secondary minerals may be stable or labile in further soil development. The stability of some of them, like aluminiumhydroxosulfates, is strongly pH-dependent. Reaction kinetics of amorphous forms but also of the incorporated ashes are very difficult to predict. The formation of Fe and Al oxides and hydroxides due to intensive weathering provides increased sorption capacity. Although actual base saturation is high only in the ameliorated topsoils, the potential for sorption of base cations available for plant uptake is clearly elevated compared to the LPFS-sites.

Second, to fully understand processes and to enable reliable predictions it is necessary to know the real ”zero point” of geochemistry – that is the mineral composition at the pre-mining state before ground water leveling and aeration. Finally, it should be stressed that the chronosequences are indeed ”false” time series and the approach is limited by site-induced differences like substrate composition, amounts, incorporation depths, and composition of amelioration ashes, micro-meteorological conditions, and seasonal or stand induced differences in water fluxes. A number of processes discussed above have to be investigated in more detail both in quality and quantity. In addition, despite the high dynamics that are observed especially at the LPCS-sites, the time frames of our chronosequences obviously are too short to reliably predict long-term soil and ecosystem development. However, at the very least, the chronosequence approach on an ecosystem level provides a very useful tool to find the right questions.

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Canopy and Soil Modification of Precipitation Chemistry in a Clonal Eucalypt Stand in Congo.Comparison with an Ajacent Savanna Ecosystem.

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Abstract

The dynamics of nutrients are compared in a clonal eucalypt plantation and in a native savanna in Congo. This paper focuses on the changes of the precipitation chemistry during the transfer of solutions in both ecosystems. During the rainy and the dry seasons rainfall was on average respectively 151 mm and 7 mm per month. Chemical analyses performed during 17 months show that the concentration of all the elements in rainfall increases sharply during the dry season. Precipitation solutions are acid with a dominance of Ca^{2+} and Cl^- Throughfall and stemflow are enriched for most of the elements but a N foliar uptake was observed in both stands.

The concentration of the majority of elements increases during the transfer of the solutions through the litter. This enrichment is particularly marked for H^+ and DOC in both stands. A severe water repellency observed at the surface of the soil in the eucalypt stand increases the time of contact between the solution and the forest floor and a net uptake of Ca^{2+} is observed. In the savanna, a net uptake of $N\text{-}NH_4^+$, K^+ and Mg^{2+} is also measured. The soil solutions are collected by ceramic cups connected to a succion of -600 hPa, between the depths of 15 cm and 6 m. The concentrations of all the elements are very low in these “capillary solutions”, excepted for Si and DOC. These results show a very efficient uptake of the elements by both stands and losses by deep drainage very low in this poor ferrallitic soil.

Keywords: Eucalyptus, savanna, biogeochemical cycles, precipitation, soil solution.

Introduction

Eucalyptus species were introduced in the littoral savannas of Congo in the early fifties. A tree breeding program has been carried out since that time and highly productive varieties of 2 hybrids were developed. Since 1978, 42 000 ha of clonal plantations have therefore been set up around Pointe-Noire. Their main outlet is the production of pulpwood.

In southern Congo, savanna soils are very poor chemically. In order to assess the sustainability of the eucalypt commercial plantations, a study of biogeochemical cycles started in 1997. It is based on a model which stratifies the ecosystem into homogenous compartments linked by flows (Ranger et Bonneau 1984). The native ecosystem of savanna is compared with an adjacent mature stand of clonal eucalypt. The aim of this study is to establish nutrient budgets in both ecosystems and to assess the impact of the plantation on soil fertility. It should contribute to adapt the fertilisations to the requirements of the stands for a sustainable yield.

This paper focuses on the changes of the precipitation chemistry during the transfer of solutions in both ecosystems. Special care was taken to identify the processes contributing to the chemical composition of the solutions.

Materials and Methods

Site Characterization

Both ecosystems studied are located on a plateau at an elevation of about 100 m and a distance from the sea of 10 km. The area is flat and the distance between the experimental designs in the eucalypt stand and the savanna is about 500 m.

The geological bedrock is composed of thick detritic formations of continental origin dated from plio-pleistocene. The soils are ferrallitic and highly desaturated on sandy material. These acidic soils are very deep and (>50 m) are characterised by their homogeneity in color (greyish on the surface and ochre in depth), texture (the sand content is more than 85%), structure and chemical poverty (CEC < 0.5 $cmol_c\ kg^{-1}$ even in the upper horizons). Their water retention ability is very low.

The climate is mainly characterised by an atmospheric humidity of about 85 % on average with low seasonal variations (2 %), an average annual rainfall around 1200 mm with a dry season between may and september. The average temperature is high (25 °C) with seasonal variations around 5 °C.

Vegetal Material

The experimental design was set up in a stand of the most productive clone of the hybrid *E. PF1*. This hybrid comes from natural crosses in Congo between 2 or 3 individuals of *Eucalyptus alba* Reinw. ex Blume (female tree) and a group of Eucalypts hybrid not well identified (male tree). The stand was planted in January 1992 at a density of 530 stems per hectare. A starter fertilisation (150 g per cutting of NPK 13-13-21) and chemical weeding were applied. The stand was mature at the start of the study (6 years old). It had a mean height of 26 m and a mean circumference at breast height of 58 cm.

In Congo the herbaceous savanna is burnt every year during the dry season. The graminaceae *Loudetia arundinacea* represents more than 80 % of the aerial biomass which reaches about 5 t ha^{-1} of dry matter at the end of the rainy season. In the experimental design, the savanna was burnt each year at the beginning of august. The savanna growth occurs mainly at the beginning of the rainy season, between september and january.

Collection and Analysis of Solutions

Precipitation Solutions

The results presented here concern the collection and measurements made from april 1998 to july 1999. Rainfall was collected above the savanna by 3 PVC gutters (area 0.23 m^2) connected to polyethylene containers. Throughfall was collected by 3 replicates of 3 PVC gutters (the same as mentioned previously) in the eucalypt stand to integrate the discontinuity of the canopy. In the savanna, throughfall was collected by 4 replicates of 2 polyethylene collectors (0.8 m x 0.15 m). Throughfall collectors were connected to plastic containers. Stemflow was collected by plastic collars around 10 tree trunks, connected to polyethylene containers.

The containers collecting rainfall, throughfall and stemflow were placed in closed pits where they were protected from light and sharp variations in temperature.

Soil Solutions

Gravitational solutions were collected in each stand at the forest floor level by 4 sets of 9 thin tensionless lysimeters (40 x 2.5 cm). In the savanna, owing to the annual fires, the litter layer was very thin. Therefore the lysimeters were installed in the soil at a depth of about 2 cm. At the depths of 15 cm, 50 cm, 1 m and 2 m, 4 replicates of zero tension plate lysimeters (ZTL, 40 x 30 cm) were introduced in december 1997 in a pit which was backfilled after installation with the horizons in their natural arrangement. Solutions were collected in polyethylene containers situated downhill in closed pits.

Soil solutions were also collected between the depths of 15 cm and 6 m from ceramic cup lysimeters connected to a vacuum pump. A constant succion of about –600 hPa was maintained (when soil moisture was sufficient). Four replicates of tension lysimeters (TL) were set up horizontally at the depths of 15 cm, 40 cm, 1 m, 2 m, 3 m and 4 m, from the side of the pits where the plate lysimeters were installed. The soil solutions were collected in glass bottles. Four replicates of ceramic cups where also installed at the depth of 6 m in this soil in order to assess the deep seepage flux below the eucalypts.

The average distance between the replicates of lysimeters was 15 m in the eucalypt stand and 5 m in the savanna.

Solutions Analyses

Once a week, after volume measurements and sampling, the solutions were collected and carried to the laboratory where they were maintained at + 4 °C. These solutions were four-weekly bulked for chemical analyses. Each replicate of solution collected was analysed separately, excepted for Dissolved Organic Carbon (DOC). The solutions were filtered (0.45 µm) in Congo and measurements of pH (HI 9321) and SO_4^{2-} by colorimetry (ANA 8 Prolabo) were performed as quickly as possible. The samples were then acidified with H_2SO_4, sent to a laboratory in France where nitrate and ammonium were measured by colorimetry (INTEGRAL PLUS – Alliance instruments), chloride was also measured by colorimetry (TECHNICON I) and total Si, P, K, Ca, Mg, Na, Al, Mn, Fe by ICP emission spectroscopy (JOBIN-YVON JY50). DOC was measured on a SHIMADZU TOC 5050.

Results

Composition of Solutions

The ionic charge was calculated to verify if the attribution of ionic-charge to elements was correct (part of them were measured in their atomic form). Negative and positive charges were rather well balanced for the majority of samples but for the other ones a general trend of deficit of negative charges was observed (data not presented here). A significant correlation (p<1‰) between DOC and charge balance deficit was noticed, indicating that organic ions would participate to the charge balance.

Nutrients in the Precipitation Solutions

The amounts of precipitation are very different according to the season in Congo. Thus the compositions of solutions are given for both seasons : the rainy season from September to May and the dry season from June to August.

The composition of solutions is modified during the transfer of precipitations through the canopy (Table 1). The differences between solutions are significant (p<5%) for P-H_2PO4^-, K^+, Mg^{2+}, Na^+, Mn^{2+}, Cl^-, DOC and pH in the eucalypt stand and for P-$H_2PO_2^-$ and K^+, Si and pH in the savanna. During the rainy season the behaviour of both stands is similar for most elements and an enrichment of throughfall and stemflow for N-NH^{4+}, P-H_2PO4^-, K^+, Mg^{2+}, Na^+, Mn^{2+}, S-SO_4^{2-} and DOC is noticed. Enrichment factors (Table 2) are very close for P-$H_2PO_4^-$, K^+ and Mg^{2+} in throughfall in the savanna and in stemflow (between 8 and 24). In the eucalypt stand, when an enrichment of the solutions occurs through the canopy, the enrichment factors are usually 2 to 5 times higher in stemflow than in throughfall. In both stands, a foliar uptake of N-NO_3^- and H^+ is observed. Main difference of behaviour between stands concern Cl^- with an enrichment of solutions in Cl^- through the eucalypt canopy while in the savanna the concentrations are lower in throughfall than in rainfall.

Seasons affect the composition of solutions. A significant increase (p<1‰) of the concentrations of all elements (excepted Si) is measured in both ecosystems in rainfall, stemflow and throughfall during the dry season, when the volume of solutions are very low. The main changes of behaviour observed in both stands between the seasons are a high enrichment during the dry season of throughfall and stemflow for Al and a foliar uptake of N-NH_4^+ and S-SO_4^{2-}. In the savanna, the enrichment of throughfall for most elements observed during the rainy season does not occur anymore excepted for Al^{3+} and DOC. A foliar uptake of N-NH_4^+, N-NO_3^-, Ca^{2+}, Na^+, Mn^{2+}, H^+, S-SO_4^{2-}, Cl^- and Si is on the contrary noticed.

Nutrients in the Soil Solutions

Changes of the Soil Solution Composition with Depth

The composition of soil solutions collected between the depths of 15 cm and 6 m with tension lysimeters (TL) are given without distinction of the seasons (Table 3). During the dry season, the very low soil moisture prevented from collecting solutions (excepted in the deep layers of soil in the savanna).

Table 1 : Comparison among composition of rainfall, throughfall and stemflow.

	Vol.	$N\text{-}NH_4^+$	$N\text{-}NO_3^-$	$P\text{-}H_2PO_4^-$	K^+	Ca^{2+}	Mg^{2+}	Na^+	Mn^{2+}	Al^{3+}	$S\text{-}SO_4^{2-}$	Cl^-	Si	DOC	pH
Solutions	mm						□eq l^{1}						□mol l^{1}	mg l^{-1}	
Rainy season															
Rainfall	151.4 (67)	5.8 (1.7)	10.8 (3.9)	0.5 (0.3)	5.0 (2.8)	66.3 (39.2)	6.9 (3.0)	17.8 (5.8)	0.3 (0.2)	4.5 (2.4)	10.3 (12.4)	95.3 (45.7)	5.1 (6.7)	5.6 (1.3)	4.3 (0.2)
Throughfall Eucalypt	139.5 (64)	6.0 (3.2)	7.4 (4.9)	2.2 (1.4)	13.4 (13.8)	57.3 (12.3)	21.4 (15.5)	44.8 (12.1)	0.6 (0.2)	5.9 (4.8)	15.9 (11.4)	114.2 (87.9)	7.2 (8.1)	8.5 (1.8)	4.7 (0.3)
Stemflow Eucalypt	2.2 (1)	11.1 (21.2)	1.9 (3.6)	12.2 (8.2)	39.1 (14.8)	76.3 (38.0)	95.3 (67.5)	331.5 (347.8)	3.2 (1.9)	4.7 (2.0)	26.4 (16.4)	350.8 (329)	3.5 (2.8)	43.4 (21.1)	5.1 (0.5)
Throughfall Savanna	127.9 (58)	11.6 (11.0)	1.4 (1.8)	12.1 (9.2)	44.0 (32.0)	44.8 (21.0)	76.2 (31.7)	20.1 (6.2)	0.5 (0.2)	5.9 (1.7)	15.9 (11.3)	63.8 (35.4)	18.8 (7.0)	14.9 (10.3)	5.5 (0.7)
Dry season															
Rainfall	6.8 (5.7)	159.0 (120.6)	282.3 (227.4)	23.1 (16.8)	80.3 (42.6)	1274 (836)	189.7 (133.4)	415.9 (271.1)	8.3 (6.9)	100.8 (67.9)	211.6 (127.1)	2076 (1323)	22.3 (12.3)	29.6 (19.8)	3.5 (0.3)
Throughfall Eucalypt	5.0 (5.1)	42.4 (57.7)	306.0 (277.4)	37.4 (27.5)	120.9 (72.6)	1368 (1044)	372.5 (264.4)	727.6 (467.4)	12.4 (9.2)	58.6 (37.1)	173.4 (236.2)	1763 (1208)	29.8 (14.1)	52.6 (38.5)	4.1 (0.3)
Stemflow Eucalypt	0.01 (0.03)	25.7 (27.4)	12.4 (9.1)	94.3 (89.1)	208.0 (243)	1608 (1164)	2135 (1522)	4682 (3624)	70.6 (51.0)	63.4 (42.8)	50.3 (17.3)	5947 (4311)	39.6 (9.6)	393.8 (253.8)	4.5 (0.5)
Throughfall Savanna	3.6 (5.3)	71.2 (58.2)	94.2 (91.1)	47.3 (57.0)	146.2 (163)	689.6 (533)	200.8 (174.2)	172.6 (90.5)	4.4 (2.0)	58.6 (46.6)	144.1 (127.1)	1077 (534.4)	15.4 (11.1)	43.8 (36.5)	4.2 (1.1)
Eucalypt stand															
Solution effect	****	N.S.	N.S.	*	*	N.S.	**	**	**	N.S.	N.S.	*	N.S.	**	****
Season effect	****	****	****	****	****	****	****	****	****	****	****	****	****	***	****
Savanna															
Solution effect	N.S.	N.S.	N.S.	*	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.	****
Season effect	****	****	****	***	***	****	****	****	****	****	****	****	*	***	****

Mean from 6 months of dry season and 11 months of rainy season, N.S., *, **, ***, **** indicate respectively non significant differences at $p < 5\%$ and significant differences at $p < 5\%$, 1%, 1/1000 and 1/10000. ( ) Standard deviation.

Table 2 : Concentration ratios (Enrichment factors) throughfall/rainfall (THR/R), stemflow/rainfall(SF/R) and stemflow/througfall (SF/THR) in the eucalypt stand (euc) and the savanna (sav).

Elements	$N\text{-}NH_4^+$	$N\text{-}NO_3^-$	$P\text{-}H_2PO_4^-$	K^+	Ca^{2+}	Mg^{2+}	Na^+	Mn^{2+}	Al^{3+}	H^+	$S\text{-}SO_4^{2-}$	Cl^-	Si	DOC
Rainy season														
THR euc / R	1.0	0.7	4.4	2.7	0.9	3.1	2.5	2.0	1.3	0.4	1.5	1.2	1.4	1.5
THR sav / R	2.0	0.1	24.2	8.8	0.6	11.0	1.1	1.7	1.3	0.1	1.5	0.7	3.7	2.7
SF euc / R	1.9	0.2	24.4	7.8	1.2	13.8	18.6	10.7	1.0	0.2	2.6	3.7	0.7	7.8
SF / THR euc	1.9	0.3	5.5	2.9	1.3	4.5	7.4	5.3	0.8	0.4	1.7	3.1	0.5	5.1
Dry season														
THR euc / R	0.3	1.1	1.6	1.5	1.1	2.0	1.7	1.5	13.0	0.3	0.8	0.8	1.3	1.8
THR sav / R	0.4	0.3	2.0	1.8	0.5	1.1	0.4	0.5	13.0	0.2	0.7	0.5	0.7	1.5
SF euc / R	0.2	0.0	4.1	2.6	1.3	11.3	11.3	8.5	14.1	0.1	0.2	2.9	1.8	13.3
SF / THR euc	0.6	0.0	2.5	1.7	1.2	5.7	6.4	5.7	1.1	0.4	0.3	3.4	1.3	7.5

Table 3 : Comparison among composition of soil solutions in the eucalypt stand and the savanna.

Element	$N\text{-}NH_4^+$	$N\text{-}NO_3^-$	$P\text{-}H_2PO_4^-$	K^+	Ca^{2+}	Mg^{2+}	Na^+	Al^{3+}	$S\text{-}SO_4^{2-}$	Cl^-	Si	DOC	pH
Solutions						µeq l^{-1}					µmol l^{-1}	mg l^{-1}	
Eucalypt floor	13.1 a (24.0)	7.6 a (30.9)	9.8 a (10.4)	11.6 a (10.8)	37.9 a (32.8)	31.6 a (32.0)	90.8 a (106)	45.4 a (33.5)	25.1 a (21.0)	108.7 a (199)	42.0 a (54.3)	83.0 a (106)	3.9 a (0.3)
Savanna floor	7.8 a (7.2)	1.8 a (1.8)	13.8 a (11.8)	27.7 b (27.9)	117.5 b (77.9)	55.3 b (29.5)	40.3 b (33.2)	40.1 a (31.1)	46.3 b (49.9)	57.5 a (37.5)	86.2 b (82.6)	123.9 a (82.1)	3.8 a (0.5)
Depth 15 cm Eucalypt	19.9 a (31.7)	8.3 a (17.1)	2.9 a (12.9)	4.3 a (3.9)	6.1 a (3.4)	14.1 a (17.1)	44.9 a (59.5)	21.4 a (22.7)	49.3 a (87.1)	76.1 a (102.5)	162.1 a (103.7)	293.7 a (30.4)	4.8 a (0.8)
Depth 15 cm Savanna	16.4 a (21.1)	1.1 b (1.4)	9.6 a (58.3)	4.6 a (7.9)	10.2 b (6.8)	8.2 b (7.3)	33.6 a (18.4)	10.9 b (11.4)	18.2 b (18.3)	39.3 b (32.7)	77.2 b (33.0)	117.1 b (21.5)	5.2 b (0.5)
Depth 50 cm Eucalypt	27.9 a (71.6)	7.9 a (10.8)	0.7 a (0.6)	5.1 a (8.0)	7.0 a (4.8)	10.1 a (10.4)	37.9 a (46.3)	20.9 a (17.2)	36.9 a (111.4)	65.8 a (65.1)	127.4 a (60.9)	291.2 a (29.3)	4.8 a (0.4)
Depth 50 cm Savanna	30.7 a (56.6)	2.4 b (3.9)	1.2 a (2.2)	7.9 a (23.3)	10.3 b (10.0)	5.7 b (5.3)	30.7 a (22.9)	13.8 a (17.7)	22.8 a (27.9)	23.0 b (18.8)	93.6 b (76.4)	133.8 b (20.9)	5.1 b (0.7)
Depth 1 m Eucalypt	23.7 a (61.8)	5.8 a (7.9)	0.8 a (0.8)	8.6 a (24.0)	5.8 a (5.5)	10.6 a (8.6)	21.9 a (15.2)	6.4 a (6.3)	11.8 a (21.8)	51.6 a (44.6)	84.4 a (31.5)	193.1 a (52.3)	5.3 a (0.6)
Depth 1 m Savanna	7.3 a (19.4)	1.7 b (2.5)	0.9 a (1.7)	4.4 a (7.6)	8.1 a (7.7)	3.1 b (6.2)	29.5 b (12.0)	6.9 a (13.2)	13.2 a (19.9)	23.5 b (24.8)	65.1 b (29.1)	158.1 b (46.9)	5.5 a (0.5)
Depth 2 m Eucalypt	13.8 a (32.1)	2.8 a (3.7)	0.8 a (0.9)	7.5 a (11.6)	6.9 a (4.0)	9.6 a (12.9)	37.3 a (61.4)	28.1 a (57.3)	16.9 a (38.8)	94.1 a (131.9)	85.6 a (41.6)	212.6 a (61.2)	5.2 a (0.6)
Depth 2 m Savanna	15.2 a (33.8)	8.8 a (21.9)	0.5 a (0.8)	4.4 a (5.2)	6.1 a (4.9)	2.4 b (2.1)	32.3 a (10.8)	13.2 a (29.9)	25.9 a (38.7)	30.9 b (25.8)	80.4 a (23.5)	215.1 a (41.7)	5.3 a (0.6)
Depth 3 m Eucalypt	49.3 a (52.6)	2.1 a (2.1)	1.5 a (3.1)	4.3 a (5.3)	6.0 a (3.8)	7.3 a (10.6)	38.4 a (36.0)	19.6 a (26.3)	97.8 a (128.7)	78.6 a (78.9)	98.5 a (49.0)	110.9 a (43.1)	4.5 a (0.6)
Depth 3 m Savanna	19.0 b (17.5)	8.7 b (7.2)	0.3 b (0.5)	3.3 a (4.9)	7.8 b (5.6)	4.5 a (5.5)	47.8 a (25.4)	7.9 b (4.4)	36.4 b (47.9)	44.7 b (29.8)	68.8 b (10.9)	47.9 b (21.7)	4.5 a (0.4)
Depth 4 m Eucalypt	88.4 a (114.9)	1.5 a (1.8)	1.9 a (3.3)	6.7 a (11.7)	9.1 a (6.9)	5.7 a (4.2)	22.1 a (16.6)	8.5 a (4.9)	83.1 a (117.3)	39.3 a (50.4)	131.7 a (39.6)	166.5 a (79.5)	4.5 a (0.6)
Depth 4 m Savanna	22.2 b (29.6)	11.0 b (8.7)	0.4 b (1.0)	3.0 b (3.5)	4.8 b (3.4)	2.6 b (2.1)	52.4 b (23.1)	7.3 a (4.9)	34.7 b (42.7)	44.2 a (29.5)	77.2 b (13.1)	47.1 b (19.9)	4.6 a (0.4)
Depth 6 m Eucalypt	33.6 (43.7)	1.7 (1.8)	1.3 (1.5)	5.8 (10.4)	9.7 (8.4)	8.5 (6.5)	21.7 (24.8)	5.8 (5.6)	57.9 (90.7)	29.8 (24.0)	124.4 (29.6)	188.1 (72.6)	4.8 (0.7)

Mean and standard deviation () from 17 months and 4 replicates of samples collected at each depth in each ecosystem. Different letter between solutions composition indicate significant difference at the 95% level of confidence.

In both stands, the solutions collected at the litter level are dominated by the cations Ca^{2+}, Na^{+}, H^{+} and the anions S-SO_4^{2-}, Cl^{-} and DOC. In the solutions collected at the depth of 15 cm, a decrease of concentration is observed for all the elements excepted N-NH_4^{+}, N-NO3^{-}, S-SO_4^{2-}, Si and DOC. This decrease is marked for P-$H_2PO_4^{-}$, $K^{+,}$ Ca^{2+}, Mg^{2+}, $Na^{+,}$ Al^{3+}, H^{+} in the eucalypt stand and K^{+}, Ca^{2+}, Mg^{2+}, Al^{3+}, S-SO_4^{2-} and H^{+} in the savanna. Throughout the profiles the concentration of all the elements remains very low excepted for Si and DOC. Very high concentrations of DOC are observed in the eucalypt ecosystem with 188 mg l^{-1} on average at the depth of 6 m. In the savanna the DOC concentrations decreases sharply beyond 2 m deep

The solutions collected in each soil layer are compared between stands. At the litter level the concentrations of $K^{+,}$ Ca^{2+}, Mg^{2+}, S-SO_4^{2-} and Si in the solutions are significantly higher (p<5%) in the savanna than in the eucalypt stand. By contrast, the Na^{+} concentration is significantly higher in the eucalypt stand.

In the A_1 horizon (depths 15 and 50 cm), the concentrations of N-NO_3^{-}, Ca^{2+}, Mg^{2+}, $Cl^{-,}$ Si, DOC and H^{+} differ significantly between the ecosystems. They are higher in the eucalypt stand excepted for Ca^{2+}. Even if the differences between the stands are not significant, the concentrations of Na^{+}, Al^{3+} and S-SO_4^{2-} are also higher on average in the eucalypt ecosystem.

In the intermediary layer (depths 1 and 2 m), the differences of soil solution composition between the stands are lower. Mainly, higher concentrations of Mg^{2+} and Cl^{-} in the eucalypt stand are observed, as in the A_1 horizon. The trend observed in the upper layers of higher N-NO^{3-} concentration in the eucalypt stand become reversed beyond the depth 1 m.

In the deep layers (> 2 m), the concentrations of N-NH_4^{+}, P-$H_2PO_4^{-}$, S-SO_4^{2-}, Si and DOC are significantly higher in the eucalypt stand while the concentration of N-NO_3^{-} and Na^{+} is higher in the savanna.

The concentration of all the elements excepted DOC and Si is extremely low in the deep seepage waters (< 60 µeq l^{-1}) compared with other forests (Cortez 1996, Marques *et al*. 1997a, Ranger *et al*. 1993). In both stands, H^{+}, N-NH_4^{+} and Na^{+} are the dominant cations in these solutions and S-SO_4^{2-}, Cl^{-}, DOC the dominant anions.

Comparison of the solutions collected by ZTL and TL

In this soil, gravitational solutions were collected by ZTL only at the depth of 15 cm. In deeper layers the number of samples collected was very low. At 15 cm deep, the concentration of H^{+}, Ca^{2+}, K^{+}, Na^{+}, Al^{3+} and Si is significantly higher (p<5%) in the gravitational solutions than in solutions collected by TL in both stands (Figure 1). The concentrations of Mg^{2+} and Cl^{-} are also significantly lower in the solutions collected by TL in the savanna, by contrast the concentration of DOC is higher in the "capillary solutions" in the eucalypt ecosystem.

In both stands the respect for the electrical neutrality of the gravitational solutions show that the dominant anions are organic while H^{+} and Na^{+} are the dominant cations. In the "capillary solutions" collected in both ecosystems, the marked decrease of the cationic charge shows that changes of the organic compounds occur, leading to a decrease of their anionic charge.

Discussion

Precipitation Solutions

The amounts of precipitation are very limited during the dry season (<10 mm month^{-1}). Therefore, the mean concentrations during the rainy season are very close to the annual mean concentrations weighted by the fluxes of precipitation in these ecosystems.

Rainfall

During both seasons the composition of rainfall is dominated by the cation Ca^{2+} and the anion Cl^{-}. Total deposition (dry plus wet) of rainfall are collected by gutters. With another collector opened only during the rain events, only wet depositions were collected during 2 months. The comparison with the total deposition collected in the gutters showed a very similar composition of rainfall for all the elements excepted for Ca^{2+} and Cl^-. The concentrations of Ca^{2+} and Cl^- were much lower in the wet depositions. These results and the comparison with a pyramidal collector designed to assess total depositions in West Africa (Orange *et al*. 1990) showed that high concentrations of Ca^{2+} and Cl^- measured in rainfall are probably an artefact due to the characteristics of the gutters, increasing the dry depositions of these elements.

The washout of gases and particles from the atmosphere by rainfall events of very low intensity (<1mm) during the dry season leads to a considerable enrichment of the precipitations for all the elements. The negative relationship between the amount of precipitation and the concentration of the majority of elements was also pointed out in a previous study of precipitation chemistry carried out in an area situated 100 km North(Lacaux *et al.* 1992). The enrichment was mainly attributed to biogenic sources due to annual fires of the savanna. However the concentrations measured were lower than in the present study for all the elements and particularly for Ca^{2+} and Cl^-. In this work only wet depositions were collected and the distance from the sea of about 100 km led to lower depositions from marine source.

Throughfall

The chemical changes between rainfall and throughfall are attributed to the dissolution and washoff of aerosol and particule deposits on the leaves or to ionic exchanges between rainfall and elements in the internal plant parts (Lovet and Lindberg 1985). The interception of rainfall by leaves leads also to an increase of the concentrations of elements.

In the savanna, a comparison of Ca^{2+} and Cl- concentrations in throughfall and in rainfall shows a considerable foliar uptake, of the same extent as the accumulation of these elements in the biomass. However, it is likely that the foliar exchanges of Ca^{2+} and Cl^- are negligible if the inputs of Ca^{2+} and Cl^- in rainfall were over-assessed of about 30 µeq l^{-1} (table 1), due to the characteristics of the gutters which enhance the dry deposition of these elements. Whatever the season, a high foliar uptake of N-NO_{3-} and H^+ is observed in the savanna, associated with an enrichment of throughfall solutions for P-$H_2PO_4^-$, K^+, Mg^{2+} and DOC. By contrast, the foliar exchanges of N-NH_4^+, S-SO_4^{2-} and Si differ according to the season. Owing to the low height of the savanna (1 m) dry depositions in this stand are likely to be of the same extent (or lower) than in gutters. Therefore, the enrichment of throughfall solutions might mainly originate from internal cycle (leaching process). An enrichment of throughfall for P, K^+, Mg^{2+} and Cl^- was also observed in a savanna with *Loudetia* sp. in Ivory Coast (Villecourt and Roose 1978).

Dry depositions in the canopy are usually high in forest stands. The depositions differ according to the elements (size of particles, vapor) and are likely to be highly superior to the atmospheric inputs measured by collectors of bulk deposition (Lindberg *et al.* 1986). Thus, it is difficult to assess the importance of canopy exchanges *vs* dry depositions in the enrichment of throughfall. The most rigorous methodology would be i) to measure the aerosol concentrations in the air, ii) to establish a model of dispersion of air masses and more difficult, iii) to establish a deposition model fitting with the characteristics of the canopy. A similar methodology should be used for the deposition of particles. In some studies an assessment of the extent of dry depositions is calculated considering one (or several) element(s) tracer(s) for which one(s) canopy exchanges are assumed to be negligible (Marques *et al.* 1997b).

Figure 1 :Composition of solutions collected by TL and ZTL lysimeters in the eucalypt stand (A) and the savanna (B). Different letters between solutions composition indicate significant difference at the 95% level of confidence.

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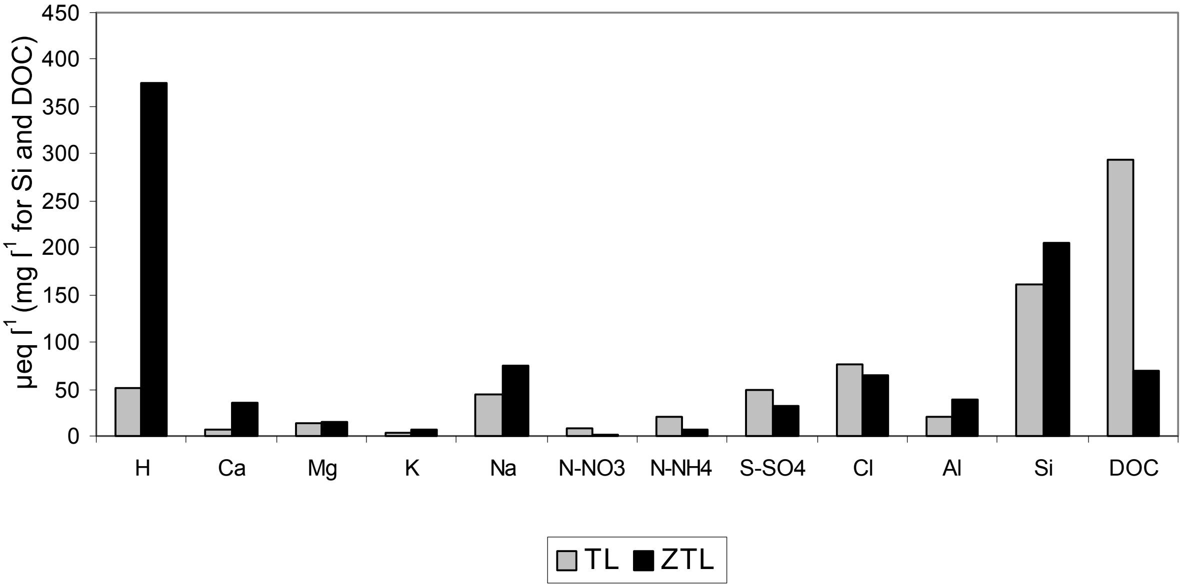

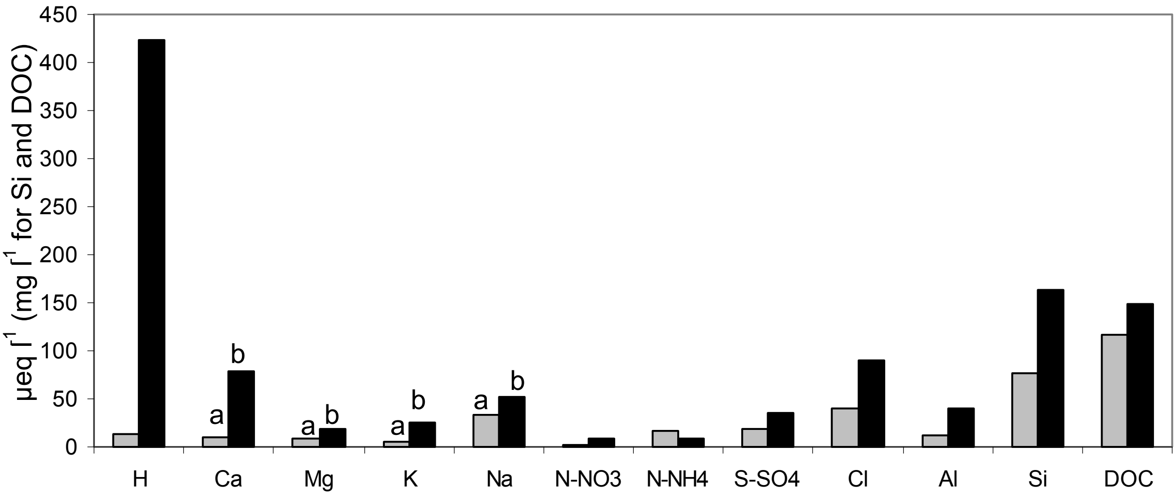

Then, the proportion of enrichment of throughfall solutions for the tracer is attributed to dry depositions and this proportion of dry deposition is assumed to be identical for the others elements. In the eucalypt stand if Si is considered as a tracer, the dry depositions in the canopy would represent 40 % of the atmospheric inputs measured with gutters during the rainy season and 34 % during the dry season. These dry deposition proportions are intermediary during the rainy season between the values calculated if $S\text{-}SO_4^{2-}$ or Cl^- were considered as tracers. With these proportions of dry deposition, a foliar uptake of $N\text{-}NO_3^-$, Ca^{2+} and H^+ occurs during the rainy season and of $N\text{-}NH_4^+$, Ca^{2+}, $S\text{-}SO_4^{2-}$ and Cl^- during the dry season. A nitrogen foliar uptake has been observed in many forest ecosystems when the N requirement of the stands are high (Lindberg *et al.* 1986, Adams and Attiwill 1991, Brumme *et al*. 1992, Marques *et al.* 1997a). A foliar uptake of Ca^{2+} is also reported in the literature (Lovet and Lindberg 1985) but an uptake of $S\text{-}SO_4^{2-}$ and Cl^- is more unusual. This behaviour has to be confirmed because measurements concern only one dry season in this study.

During the rainy season, the tracer Si shows that the enrichment of throughfall solutions for $P\text{-}H_2PO_4^-$, Mg^{2+} and Na^+ originates mainly from internal cycle while for the other elements the origin is mainly dry depositions. During the dry season, the enrichment for P, K^+, Mg^{2+}, Na^+, and Mn^{2+} in throughfall solutions comes mainly from internal cycle while dry deposition is the main source of enrichment for the other elements. This information is relevant if input-output budgets are established in the ecosystem.

Stemflow

The changes of rainfall chemistry observed in throughfall solutions are more pronounced in stemflow but they follow the same patterns (Table 2). The solutions flowing along the trunk surface already contain the solution caught in the canopy but also collect large amounts of elements during contact with the stembark. The uptake of $N\text{-}NO_3^-$ and H^+ observed in throughfall is much higher in stemflow while the enrichment for $P\text{-}H_2PO_4^-$, Mg^{2+}, Na^+, Mn^{2+}, Cl^- and DOC is much more pronounced. A greater enrichment of stemflow solutions relative to throughfall is usual in forest ecosystems (Cortez 1996, Marques *et al.* 1997a). A $N\text{-}NO_3^-$ uptake was also observed in an eucalypt stand in Cameroon. (Harmand 1998). It probably indicates an absorption by the epiphytic vegetation (Mina 1965 cited by Marques *et al.* 1997a).

During the dry season most elements behave like during the rainy season. However an uptake of $N\text{-}NH_4^+$ and $S\text{-}SO_4^{2-}$ is observed. These concentrations in stemflow during the dry season must be interpreted cautiously because the number of samples collected was very low.

Soil Solutions

The composition of soil solutions collected is the result of the inputs of elements by throughfall and stemflow, mineralisation of organic matter, weathering, the ion exchange complex equilibrium and the outputs with the uptake by roots and microbiota and the leaching.

Great modifications of the solution chemistry are observed during the transfer through the litter. In both ecosystems, a marked increase of the concentrations compared with throughfall is observed for Na^+, Al^{3+}, $S\text{-}SO_4^{2-}$, Si, DOC and H^+. An enrichment for $N\text{-}NH_4^+$, K^+ and Mg^{2+} is also measured in the eucalypt stand and for Ca^{2+} in the savanna. This enrichment can be partially attributed in the savanna to the deposition of large amounts of ashes at the surface of the soil after the annual fires and in the eucalypt stand, to the mineralisation of organic matter. Bernhard-Reversat (1999) has shown that large amounts of acid organic compounds are released during the eucalypt litter decomposition. The Si and Al^{3+} enrichment in the soil solution originates generally from weathering processes (Marques *et al.* 1996).

However, it is also interesting to notice a marked decrease of Ca^{2+} and $N\text{-}NO_3^-$ concentrations during the transfer through the forest floor in the eucalypt stand. A high water repellency was observed at the surface of this soil, which leads to an increase of the time of contact between the solution and the forest floor, specially when the soil is dry (Laclau *et al.* 1999a). A high density of thin roots was observed inside the forest floor (about 500 kg ha^{-1} of dry matter). The uptake of nutrients inside the forest floor is likely to be relevant for the mineral nutrition of the stand during the dry season when the rainfall is very low and the soil moisture in the upper layers at wilting point. In the savanna, an uptake of K^+ and Mg^{2+} is also observed in the surface soil.

A soil moisture monitoring using TDR probes in both stands showed preferential drainage ways in the upper layers of soil and a drainage much more uniform beyond a depth of 2 m. Soil water repellency leads to these type of drainage (Ritsema 1998).

Preferential drainage ways lead to a fast drainage in this sandy soil, with very weak ion exchanges among the gravitational solutions, the soil and the vegetation. These characteristics of drainage are consistent with the low changes of composition observed between the gravitational solutions collected at the forest floor level and at a depth of 15 cm. In the deep layers of soil, the difference between gravitational solutions and the solutions collected with TL should be much lower, owing to the uniformity of the drainage flux.

At the depth of 15 cm, the concentration of most elements in the solutions collected by TL was lower than in the gravitational solutions. This result is original because solutions collected by TL are usually enriched by weathering processes and the activity of micro-organisms (Ranger *et al.* 1993, Marques *et al.* 1996). With a succion of –600 hPa, gravitational solutions but also solutions located in a lower soil porosity, in equilibrium with the soil and the vegetation are collected by TL. In this ferrallitic soil, the release of base cations by weathering must be very low. Furthermore, the availability of exchangeable cations is weak in this soil and the very low concentrations of $N\text{-}NO_3^-$, $N\text{-}NH_4^+$ and base cations measured in solutions collected by TL show a very efficient uptake by the vegetation. A very dense network of thin roots in the upper layer of soil was observed in both stands and allows a very quick uptake of nutrients. When the time of contact between the solution and the soil increases, the H^+ concentration decreases sharply in both stands. The main processes of H^+ neutralisation can't be attributed to a desaturation of the ion-exchange site because the CEC is very low (<0.5 $cmol_c$ kg^{-1}) or to mineral breakdown because Si and Al^{3+} concentrations are lower in solutions collected by TL than in gravitational solutions. By contrast, changes of organic compounds leading to a H^+ fixation and a decrease of the anionic charge of DOC are likely to be involved in this neutralisation.

The changes of "capillary solutions" composition with depth is low in both stands. In the savanna, 80% of the underground biomass is observed in the 50 cm of surface soil but roots have been found up to a depth of 2.50 m. In the eucalypt stand, even if thin roots were observed up to a depth of 9 m, most of the volume of soil is not prospected beyond a depth of 3 m. Whatever the depth, the dominant cations remains H^+ and Na^+ while the dominant anions are $S\text{-}SO_4^{2-}$, Cl^- and DOC. The lack of significant increase of the base cations concentration in the deeper layers of soil where the uptake by roots is absent (or very low) confirms that the nutrient release by weathering must be very weak in this soil.

Conclusion

The general trends of the impact of canopy and soil in the modification of precipitation chemistry are similar in a mature stand of eucalypt and a native savanna, even if differences of behaviour are observed for some elements. Rainfall composition is dominated by Ca^{2+} and Cl^-. An enrichment during the transfer through the canopy is observed for most elements but a N uptake is observed in both stands. In the savanna, changes of Ca^{2+} and Cl^- concentration in throughfall solutions are difficult to interpret owing to high amounts of dry deposition of these elements in rainfall. In the eucalypt stand, the enrichment observed in throughfall is much more prounonced in stemflow (excepted for N) but this flux represents only 1.5% of the amount of solution reaching the soil.

During the transfer through the litter layer, an enrichment of solutions is observed for most elements (and particularly for H^+) but an uptake by roots occurs also in both ecosystems. A water repellency of the surface soil more severe in the eucalypt stand increases the time of contact between the forest floor and the solution during the dry season. It must also lead to preferential drainage ways in the upper layers. The composition of gravitational solutions is not very modified in the upper layer of soil owing probably to a very fast drainage. When the time of contact with the soil increases, the H^+ and base cations concentrations decrease sharply, excepted for Mg^{2+} in the eucalypt stand. A modification of the organic compounds with protonation might be responsible for the increase of pH.

The sharp decrease of concentrations of mineral N and base cations in the solutions collected by TL compared to the solutions collected by ZTL underscores the efficiency of the savanna and the eucalypt stand to take up the nutrients available in the soil solution. In these ecosystems, the function of external inputs seems fundamental. The extremely low losses of nutrients by deep drainage show that an optimisation of silviculture adapting the inputs of nutrients (fertilisations, management of organic matter) to the requirements of the stands should improve the production of the eucalypt plantations without damage on the quality of surface waters.

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Nutrient Cycling in a Chronosequence of Norway Spruce (*Picea abies* Karst.) on Shallow Calcareous Soils in the Northern Limestone Alps (Austria)

by

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Abstract

On a heavily karstified site in the Northern Limestone Alps (Austria) water- and nutrient household of Norway spruce stands was investigated along a chronosequence (clearcut, 10 year old artificial regeneration, mature stand). Both nutrient stores in soil and in biomass were calculated. Bulk deposition, throughfall and seepage were sampled weekly during three growth periods (4-5 months each) and analyzed for main chemical constituents. Water fluxes were calculated using the BROOK90 model (Federer et al., 1995). The soils (lithic Leptosols) consisted of moderhumus overlaying a very pure limestone. Only in the regeneration plot signs of a mineral soil horizon could be dedected. In the mature stand twenty percent of nitrogen, thirty percent of phosphorus, nineteen percent of sulfur and fifty-eight percent of potassium pools were stored in biomass. Assuming an utilization of eighty percent of stemwood with bark, conventional harvest removed approximately four percent of the nitrogen, seven percent of the phosphorus, seven percent of sulfur and twenty-three percent of the potassium pools. Despite inorganic nitrogen inputs during these periods between 5 and 10 kg.ha^{-1} with precipitation, inorganic nitrogen output with seepage from the mature stand and the regeneration plot was only 0.5-1.2 kg.ha^{-1}. In the first and second growing season after clearcut, inorganic N fluxes with seepage increased to 20 and 30 kg.ha^{-1} respectively, declining in the third growth period to 8 kg.ha^{-1}. DON output was between 3 and 6 kg.ha^{-1} in the mature stand and 7 to 11 kg.ha^{-1} at the clearcut and the regeneration plot. Therefore, DON is an important fraction of the N-cycle of this ecosystem. Total differences between nitrogen stores of the mature stand and the regeneration were 270 kg.ha^{-1} of N. Less than half of the difference can be attributed to biomass removal, the rest may be attributed to leaching losses. However, total annual N-input is high at this site and will over-compensate losses. The P-stores were only affected by biomass removal, not by leaching of inorganic P-compounds. The mature stand seems to be S-saturated, input and output rates of sulfate are balanced. Regeneration is a net sink for inorganic S, as can be seen from declining fluxes with seepage for both the clearcut and the regeneration with time. K losses were between 30 kg.ha^{-1} in the first, 20 kg.ha^{-1} in the second and 9 kg in the third growth period after clearcut while output rates were less than 2 kg in the mature stand and the regeneration plot. K pools in the humus layer were only 150 to 200 kg.ha^{-1}, total pools in the mature stand were 360 kg.ha^{-1}. With annual input rates of less than 2 kg.ha^{-1} of K, harvesting and post harvesting losses may cause problems. Since precipitation is high in this area, forest growth is rather limited by nutrient than by water supply. Needle analyses show already deficient potassium supply. Harvesting and post harvesting losses of K, in combination with elevated nitrogen deposition may have negative influences on the stability of forest stands on these sites. Subsequently, negative influences on water supply from such areas are possible. As the demand on drinking water resources from karst regions is increasing, a careful evaluation of forest management practices on vulnerable sites in the limestone Alps is necessary.

Keywords: Nutrient cycling, Nitrogen, Potassium, Harvest, Spruce.

Sub-Plenary Session: D1

Cultural Diversity in Forest Management:

Agroforestry

Coordinators:

Fergus Sinclair
Prem Khosla

FLORES: Helping People to Realize Sustainable Futures…

by
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Abstract

People usually know *how they want their situation to change* to secure a better future – but they do not always know *how to change their situation*. Initiatives intended to secure a better future do not always work as intended, and may have unintended side effects. Computer models can help advocates explore consequences of proposed initiatives, so they can make informed selections of alternatives, secure in the knowledge that consequences have been thoroughly investigated. By encouraging people to explore scenarios, models empower people to be more innovative and less dependent on technocrats. New software solves technical limitations, but the real issue is not software, but rather the provision of a supportive framework within which people can express and experiment with ideas. FLORES, the Forest Land Oriented Resource Envisioning System, provides such a framework to stimulate interdisciplinary collaboration between researchers, practitioners and clients. A recent prototype demonstrated the feasibility of FLORES. However, FLORES is not about software; it is about providing the means to explore the consequences of alternative scenarios. Ultimately, FLORES is not a physical package, but a user group and the interactions they have amongst themselves, and with the people involved in policy-making. Fostering this emerging network through workshops and technical support will enhance FLORES by offering a better understanding of the concept, and by allowing more people, especially those from developing countries, to influence the development of FLORES and the issues that can be explored within it.

Keywords: Decision support system, Adaptive modelling, Land use alternatives, Policy analysis

Introduction

Policies and incentives to promote sustainable forestry and better land use do not always achieve the desired effect. Proponents rarely foresee all the consequences, and that those best able to offer alternative views may be unable to contribute to the decision-making process. This leads to inefficient, and sometimes counter-effective, initiatives. How can we better equip policy makers and their advisors to envisage fully the efficacy and consequences of initiatives? One way is to provide a simulator that helps people to visualize possible outcomes of proposed initiatives. FLORES is an attempt to build such a simulator. Work on FLORES is still in progress, so a traditional methods-results format is inappropriate, and we offer a narrative highlighting trials, tribulations and insights gained.

What is FLORES, and where did the idea come from?

FLORES, the Forest Land Oriented Resource Envisioning System, aims to improve our understanding of land use patterns in time and space, especially in forested landscapes, and to facilitate rigorous analyses of policy options intended to manipulate these patterns.

The idea for FLORES arose from several initiatives, among which were the desires to create a platform that would allow researchers to integrate their research, to make it possible for them to work together to reveal the bigger picture, and to provide the ability to test propositions rigorously within a realistic framework. These remain important influences in the development of FLORES. Accordingly, FLORES is spatially explicit, and operates at the landscape scale, spanning both forest and agricultural lands. Agricultural lands and villages form a critical component of the landscape, and must be modelled to fully understand the processes at work in and near the forest.

The basic concepts of this work are not new; what is new is the way concepts are integrated and applied. FLORES seems most closely related to work by Bousquet *et al.* (1993, 1994), who constructed a multi-agent simulation (MAS) model of an inland fishery in the Central Niger Delta as a basis for focusing discussion, evaluating options and formulating recommendations. There is an interesting contrast between FLORES and MAS: both are concerned with *agents* that can modify and respond to their environment, but the emphasis differs. Generally, MAS attempts to find the simplest set of rules that can reproduce a particular pattern from a defined scenario. In essence, the usual question for MAS is: what are the rules that might explain this pattern that we have observed? FLORES considers the converse: given what we know about human behaviour, can we predict future outcomes for a range of scenarios? Generally we do not know what future outcomes should look like, except in a few specific cases that may be used to test the model. FLORES also recognises that people may have complex reasons for their behaviour, and attempts to represent our present understanding of those reasons, rather than seeking the simplest rules that may reproduce a given pattern.

Why do we need FLORES?

We offer some analogies to illustrate why FLORES is important. Anyone who has played Fish Banks[1], the Beer Game[2] or a similar management game should appreciate the need for up-to-date information. With Fish Banks, a game about sustainable resource utilization, players often destroy a fishery because they rely on information from a previous game cycle. It is only when players learn to predict current and future fish stocks that they can achieve a sustainable outcome. Using old information for resource management is like driving a car without forward vision, and relying on rear-view mirrors for information. Up-to-date information (cf. looking out of the side mirrors to see the side of the road) helps, but we can only drive safely when we can see forwards (cf. predicting future outcomes).

We can also draw a useful contrast with air travel. What makes air transport so safe and pilot error so rare? Good design, careful planning, diligent maintenance and competent supervision are factors, but pilot training is crucial. Before crew members take the controls of a commercial airliner, they will have studied the theory of flight, trained in light aircraft, spent hours in a flight simulator, and flown with more experienced colleagues. They know how to read the indicators, what every button and every lever does, and when and how these controls should be used. They know instinctively how to respond when something goes wrong, and what to do if the plane deviates from its planned course. And they rarely need to use their training, because our knowledge of flight has been synthesised into an autopilot that takes care of most situations.

Now contrast this with our management of forests:

> Do we know what to do when things go wrong?
>
> Can we tell when things are beginning to go wrong?
>
> Do we know which controls we can use to change things?
>
> Do we know what the controls are, where to find them, and how to activate them?
>
> Can we recognise and interpret the indicators?
>
> Why don't we have an "autopilot" to give advice?

Why is it that so many amongst those who make important decisions about the world's forests have never raised a tree, tended a garden, gathered food from the forest, or used a simulator to explore the implications of an impending decision? Would a forest landscape simulator make a difference?

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[1] http://www.unh.edu/ipssr/Lab/FishBank.html
[2] http://learning.mit.edu/pra/tool/beer.html

The computer game SimCity[3] provides an interesting analogy for a user interface that we would like to develop for FLORES. The Maxis Corporation provides a simulator in the form of a game. The game offers the player an "aerial view" of a city, a menu of policies and incentives (e.g., expenditure on education, transport, sanitation, etc.), and indicators of performance (e.g., unemployment, GNP, pollution, etc.). Scenarios are available freely on the Internet[4], and range from real cities to fantasies.

In FLORES, we replace the cityscape with a landscape of forest and non-forest land. Its menu includes a range of options to manipulate the forest and land use patterns, and performance indicators could include biodiversity and rural poverty. It must have a strong factual basis, and must be able to be customised to suit different situations. It will:

- synthesise existing knowledge and identify gaps and other deficiencies;
- express present knowledge concisely, completely, explicitly and unambiguously as a model;
- create a framework to promote collaborative interdisciplinary research;
- provide a basis for strong empirical tests of hypotheses relating to land use policy;
- create a planning tool to allow planners and policy makers to explore future scenarios; and
- provide an educational game to improve general knowledge of tropical forest environments.

What has been Achieved?

The FLORES concept was developed during 1995 (Vanclay 1995), but it was not until 1997 that work began in earnest and a prototype[5] was produced (Muetzelfeldt *et al*. 1997). Significant progress[6] was made during 1999, and at the time of writing, the FLORES team are about to embark on another workshop to test the applicability and ability to adapt the Rantau Pandan version to a Zimbabwe situation. Progress to date is the outcome of collaboration between the Institute of Ecology and Resource Management at the University of Edinburgh and the Center for International Forestry Research (CIFOR), and a group of fifty people[7] who contributed to a model design workshop held in Sumatra in 1999 with support from the UK Department for International Development.

The present version of FLORES is still rather simplistic, but provides the basis for on-going work over a long period. This platform is not, and must not be, a "black box", opaque to participants. It is not enough that it should be transparent; it should be enlightening, and should empower participants to make better analyses and draw more revealing insights than they could working in isolation. We have tried to provide this, and hope that it will be used as a basis for testing a wide range of propositions, and will be modified as necessary to make these tests and incorporate findings into the model. We must begin with simple models, and should progressively enrich these as we refute inappropriate simplifications. Models excel at exposing counter-intuitive consequences of simple assumptions. Even if initial prototypes of the model are of little practical relevance, they may offer valuable insights, and their main purpose may be to focus questions rather than to provide answers. The challenge is to construct a framework that is broad enough to accommodate a wide variety of propositions, and sufficiently accessible that researchers from a range of disciplines are stimulated to collaborate and test their propositions in this integrated way.

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3 See http://www.maxis.com

4 For example, http://www.simcity.com/exchange/exchange.html and http://www.sc3000.com/cities

5 See http://www.ed.ac.uk/~ebfr28/flores/version1/index.htm

6 See http://helios.bto.ed.ac.uk/ierm/flores/RantauPandan/index.html

7 See http://www.cgiar.org/cifor/research/flores/flores_participants.html

How does itWwork, and will it give the Right Answers?

FLORES relies on four basic assumptions, namely that:

1. Land use patterns are created by *actors*, individuals or groups of individuals who collaborate as families, clans, associations and corporations.

2. These actors make *rational* decisions based on available information, obligations and expectations, social as well as economic. Note that an actor's *perception* is what influences decision-making.

3. When choosing an *activity*, actors explore all options available to them, within the constraints imposed by resources (land, time, capital, etc.), knowledge, and their comfort zone (cultural attachments, willingness to attempt novel activities, etc.).

4. Actors tend to undertake activities that maximise expected benefits or minimise anticipated risks to themselves and their beneficiaries (families, clans, shareholders, etc.). It may be possible to model both benefit-seeking and risk-avoiding behaviour by considering risk-adjusted benefits.

The constraints implied by an actor's comfort zone and previous experience mean that many actors consider a rather small number of activities, often only those done in the past, plus a few new activities pursued profitably by neighbours. However, there are usually a few innovators who consider an extended list of activities and may attempt a diverse range of enterprises. Typically, innovators are more willing to attempt risky enterprises than their more conservative fellows. Disposition is only one determinant of willingness to accept risk, and age, assets and income also feature prominently in many explanations.

Decision-making by actors is just one component of FLORES, and several other sub-models are needed to predict the growth of trees and crops, changes in the soil and water balance, interactions between key plant and animal species, and other ecosystem processes. Fortunately, many such models already exist (e.g., Vanclay 1994, Anon 1997), and some are amenable to calibration and integration within the FLORES framework.

We have implemented FLORES in AME to minimize the amount of computer code, in the hope that we can engage potential participants who are not conversant with computer languages. AME[8], the Agroforestry Modelling Environment (Muetzelfeldt and Taylor 1997), has a graphical interface that makes the model accessible to researchers who are not fluent in computer programming, while allowing access to the underlying code. Thus it offers a powerful and flexible platform that does not exclude less computer-literate participants in the project. There are other advantages in using AME, some of which include the ability to:

represent relationships as simple sketches, mathematical equations, or as sets of rules;
substitute alternative models easily via the Windows click-and-drag facility; and
create customised user interfaces with software "helpers" that can be developed independently and "plugged in" later.

So what does it mean for Resource Managers and Planners?

Too many models languish, under-utilised, because they do not satisfy the needs of potential users and because system developers did not explicitly contact clients, ascertain their needs, and stimulate their interest. To encourage uptake, potential users must be involved in the development of the model. Obviously, users may not be interested in all aspects of model design and construction, but they should have the opportunity to participate in specification and design of the user interface. It is not enough to ask them what they want and how they want it. Team members have to engender enthusiasm and involvement through mutual understanding and collaboration. This means that the model has to be explained in an accessible way, and that simple prototypes and mock-ups need to be built so that ideas can be demonstrated, tested and modified.

[8] See http://www.simile.co.uk

FLORES will provide a range of outputs to suit different user requirements. One output will be the forested landscape of a SimForest implementation. One great contribution that information science could make for conservation and wise use of forests would be to provide a virtual reality interface for forest management planning (Vanclay 1993). This could allow a minister and his advisors to put on a virtual reality headset and take a “magic carpet” ride over a forest estate. They could observe the spatial pattern of their forest and watch how it changes over time, and under different scenarios. They could “zoom in” to examine particular issues, and stand back to get an overall perspective. The technology to do this exists, and it is possible to link forest inventory systems, growth models, geographic information systems and virtual reality systems in this way. However, it has not been done at this time, and awaits further software and hardware development to make it more affordable. In developing FLORES, we have been mindful that the eventual user interface may well be a virtual reality system, and we should deliberately design an open and flexible system that does not foreclose this possibility. However, the SimCity-style interface is adequate for many applications, and would be particularly useful for educational applications and general information dissemination.

What’s next? When will it be Useful to Others?

There are several specific problems that need to be addressed before this model can be realised as anything more than a simple prototype. Many of these challenges can be addressed as separate tasks, and are amenable to research by others, including students. Some of the more obvious issues are listed below.

In the proposed model formulation, the underlying functional relationships may be relatively simple, but the data requirements are rather demanding. Most utility functions appear innocent enough, but they require a lot of data: anticipated yields and prices of all possible crops under a range of situations, detailed tenure and demographic data, and a good understanding of the socio-economic culture of the community. This is a major undertaking, and may be one limitation of the model. We envisage that initial prototypes will be restricted to a limited geographic area, allowing a complete census of all inhabitants for thorough model testing. However, subsequent operational implementations may sample only selected actors to reduce the burden of data acquisition. Crop yields may be inferred from models, but prices and elasticities must be gleaned from field survey work. This task may be particularly onerous for non-timber forest products such as medicinal plants.

Superficially, the model appears tractable, but it involves many challenges. Is it really possible to quantify the social profile of all actors in a community in sufficient detail to provide meaningful predictions from a simple utility function? There is no clear answer, and only an empirical test can elucidate if numerical approximations of complex social structures provide an adequate basis for planning. Two further issues for methodological research are evident at this stage: whether to model individual actors or classes of actors, and how to quantify risk and willingness of actors to accept risk. Both are central to the FLORES approach, and in both cases, the issue is whether the preliminary approach is a necessary and sufficient representation of reality. There are some advantages in modelling individual actors: it is conceptually elegant and facilitates empirical testing, but it imposes a substantial computational load. Simulation based on a few classes of actors (e.g., classified by age and gender) would speed up simulations, and may ease data input requirements, but it is not clear if this would lead to the same result as individual-based modelling. The issue may be best resolved through empirical trials and sensitivity tests.

It is presently assumed that an actor’s willingness to accept risk can be quantified, in part through the historic variation in benefits accruing from a particular activity, and from the actor’s age, tangible assets and income. However, this assumption warrants closer scrutiny since attitudes to risk have a major influence on land use decisions. Our ability to quantify risks and attitudes to risk will have a major influence on the accuracy of FLORES predictions.

Satisfactory ways to value the intangibles involved with land use decisions pose a major challenge. One particular aspect that needs to be addressed is how to value prestige. Prestige may take many forms, and may explain land purchases at prices inconsistent with production (e.g., prestige of owning a bigger estate), herd sizes (e.g., prestige of large flocks leads to overstocking, even though smaller flocks may offer equivalent returns and lower risks), and possession or production of certain items.

A further challenge for later versions will be to model selected species interactions in both plant and animal species, especially for apparently pivotal or keystone species. It is not sufficient to model the food web, because energy flows are only one of the aspects. It is also important to consider relationships such as mycorrhizal and other symbiotic relationships, pollination and transport of seeds, microclimate and other modifications of the environment that may facilitate the establishment of plant and animal species. It is probably impossible to model all of these relationships in a tropical forest, but it is important to recognise and include the pivotal relationships in our model.

A FLORES-type model is easy to conceive for a small village, where we can simulate every individual actor. However, when we scale up our efforts to model larger landscapes, it may become impractical to examine decision-making by all actors, and it may be necessary to extrapolate from a sample of actors. The choice of sample may be critical to the outcome, and suitable sampling strategies must be investigated before the approach can be scaled-up to the provincial or national level. A crucial part of this investigation will be to identify the minimum essential set of prime determinants.

FLORES seeks to provide a framework for testing and refining ideas. This means that the basic framework of FLORES must be carefully tested, and that baseline data should be acquired for detailed empirical testing. Two components of these tests warrant special attention and preparation: sensitivity tests and benchmark tests (Vanclay and Skovsgaard 1997). Ideally, a thorough program of sensitivity testing should examine each input, every parameter, and all assumptions to see how much influence they have on predicted outputs. This is useful information that can be used to direct further development of a model, with a lower priority assigned to parameters and assumptions that have little influence on predicted outputs.

Thorough benchmark testing is another big job that requires planning and preparation. It requires comprehensive data about a series of sites for at least two points in time, preferably over a reasonable interval. Ideally, the situation at some sites should remain more-or-less unchanged, while substantial changes should be evident at other sites. There are always difficult issues to be addressed if these sites involve only passive monitoring, and empirical tests are strengthened if experimental data are available. In agricultural situations, it is customary to use paired and replicated experiments to compare treatments against control plots. Such data are more difficult to obtain at the landscape scale and when people are involved, so greater ingenuity is required. Survey data pose special problems, since many factors may vary and it can be difficult to make reliable inferences. In theory, it is possible to conduct experiments to gather rigorous data to test FLORES, but there are ethical questions that would need to be considered carefully. For example, it is feasible go to a village and buy locally produced goods at prices higher than the prevailing market rate, and watch how the community responds. Fortunately, this experiment is not necessary, because in many developing countries, governments conduct such “experiments” all the time. For instance, new bridges and roads can markedly change transport costs. Thus the data required for model testing may be obtained by strategically choosing and monitoring selected communities over an extended period.

Perhaps the best test of a model is how well can the modeller answer the questions ‘What do you know now that you did not know before?’ and ‘How can you find out if it is true?’. FLORES has many limitations, but it provides a fertile test-bed for ideas, and offers ample scope for furthering our knowledge of policies, incentives and land use patterns in forested landscapes. We need the product, and we need the process. We need to bring together scientists from diverse disciplines to work towards a common goal. We also need to add more rigour to forest policy research. FLORES can help realise it.

Where can I get it and how can I use it?

FLORES, its documentation, and the AME software are available freely via the internet from http://helios.bto.ed.ac.uk/ierm/flores/. You will need a PC running Linux or Windows 95, 98 or NT.

How can I help to make it better?

FLORES is a continuing research project, the product of close collaboration by many individuals, and we invite others to participate. For more information on the current status of FLORES or on how to become involved, contact one of the authors.

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Ecological Scales and Use Rights: the Use of Multiagent Systems

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Abstract

The interactions between natural forest dynamics and social dynamics have to be taken into account when managing the use of forest resources. We have developed simulation models to improve our understanding of this complex system of interactions. Models of multiagent systems are effective tools for studying the dynamics of complex adaptive systems. We have developed several simulation models in order to study the use of forest resources. This paper presents a model designed to understand the interaction between fuelwood consumption and landscape dynamics. The hypothesis put forward suggests that fuelwood consumption can explain the landscape changes that occur in the Kayanza region of Burundi. The second hypothesis is that a sustainable use of resource must keep steady the fuelwood consumption level per capita over time. A preliminary map was outlined: agents use fuelwood, have access to different parts of space and have the capacity to exchange use rights. The population increases and agent migration — from overpopulated areas to unoccupied plots — is simulated. The impact of changing rules on foraging, exchange and access is then observed on a landscape level. The model describes here the behaviour of different agents (farmers, local consumers, exporters and traders). The impact of their behaviour and interactions are evaluated on different scales, ranging from the individual plot to the forest and the landscape. Models and multiagent systems can effectively represent processes that occur at levels of varying complexity and simulate their interactions so that landscape dynamics can be understood from the bottom up.

Keywords: Multi-agent systems, Fuelwood, Access rights, Social exchanges, Spatial scales

Introduction

At the interface between natural and social dynamics, environmental research is tackling development problems by examining questions that relate to resources and externalities. These include the management of renewable resources, externalities of production (pollution, effluent, etc.) and areas with multiple uses. Natural dynamics are made up of numerous interweaving processes involving different resources on different spatial and temporal scales. Social processes involve different stakeholders at various levels of organization, ranging from individuals or communities that use resources and spaces to large development institutions. The issues focus on the regulation of resource use — that is adapted to natural dynamics — through the application of economic, legal or institutional management tools. In all cases, the issues relate to problems of collective management where ecological processes have to be reconciled with social processes for resource use.

The essence of ecology is to examine ways of approaching the study of complex systems. A complex entity (Fogelman Soulié 1991, Gell-Mann 1994) is made up of different elements that interact and combine in such a way that is not immediately obvious: the complexity of a system is in the eye of the beholder. The idea that perception is inextricably linked to the notion of complexity is not impartial: it reflects the importance of the levels chosen for observing a given system. In ecology, there is no natural scale for observing all types of phenomena. Conventionally, the hierarchy of scales (Allen and Starr 1982) refers to levels of organization: cell, organism, population, community, ecosystem, landscape, biome and biosphere. One of the major challenges facing ecology is being able to take into account a multiplicity of scales of study in order to integrate — during a phase called "transfer of scale" — each of the phenomena studied at their specific level. Indeed, one of the problems facing modelling is how to represent dynamics on different scales.

Natural resource and environmental economics propose a range of theories and concepts with tools for monitoring, analysis, evaluation and regulation (Dales 1968, Arrow and Fisher 1974, Bromley 1991). In particular, economics provides a model for the use of renewable resources that aims to control sustainability of use by applying regulatory or incentive mechanisms, such as taxes, quotas, licences, grants, standards, permits, definition and exchange of property rights. It is also important to understand decision-making processes which are defined as the interactions between stakeholders with different representations and power. The problem is understanding how resource use is regulated. This can be achieved by modelling the representations and exchanges (of goods, services, currency and information) and the global constraints expressed by the use of regulatory or incentive mechanisms.

Therefore, the interaction between ecological and socioeconomic dynamics can be understood by modelling interactions on different scales. We have chosen multiagent systems (MAS) for this purpose. In this article, we start by introducing the MAS that we used. We then go on to describe an example of a model that takes into account ecological dynamics on several levels as well as the exchanges between agents with different representations.

Materials and Methods: Multiagent Systems

Multiagent Systems

The aim of multiagent systems (Ferber 1999) is to understand how independent processes in direct competition are coordinated. An agent is thus a computerized process, something that comes between a computer programme and a robot. An agent can be described as autonomous because it has the capacity to adapt when its environment changes. A multiagent system is made up of a set of computer processes that occur at the same time, ie several agents that exist at the same time, share common resources and communicate with each other. The key issue in the theory of multiagent universes is formalizing the necessary coordination between agents. The theory of agents is therefore a theory of:

1. Decision-making: what decision-making mechanisms are available to the agent? What are the links between their perceptions, representations and actions ?
2. Control: what are the hierarchic relationships between agents? How are they synchronized?
3. Communication: what kinds of message do they send each other? What syntax do these messages obey?

for which elaborate formulas are put forward.

Multiagent systems can be applied to artificial intelligence. They simplify problem-solving by: dividing the necessary knowledge into subunits, by associating an intelligent independent agent to each subunit, and by coordinating the agents' activity. Thus, we refer to distributed artificial intelligence. This theory can be applied to monitoring an industrial process, for example, where it adopts the sensible solution which consists of coordinating several specialized monitors rather than a single omniscient one. Fundamental research is being conducted on the problems associated with the representation of agents' decisions and protocols for communication. The main applications for MAS are in telecommunications, internet and physical agents, such as robots (Weiss 1999). There is a group of scientists that specializes in the simulations of agents' societies in ecology and social sciences.

Research has been conducted in parallel by computer scientists, ecologists and social scientists on the principle of modelling distributed systems. Here, we discuss a few references and some of the issues involved.

MAS and Ecology

In ecology, the distributed approaches, known as individual-based models (IBM) were developed at the end of the 1980s. The article written by Huston *et al.* (1988) is the most frequently quoted. The authors argue that there are two reasons for developing this approach: first, the need to take into account the individual because of their genetic uniqueness and, secondly, the fact that each individual is situated and their interactions are local. The argument clearly had an impact because numerous publications refer to this approach. Shortly after this publication, Hogeweg and Hesper (1990) published a similar article on "individual-oriented modelling". This had more influence on scientists working in the field of artificial life. Then, in 1990, there was a congress in Knoxville on "Individual-based models and approaches in ecology". The congress' proceedings were published and have since been the main reference text on the subject (DeAngelis and Gross 1992).

Above all, truly individual-based models, or so-called i-state configuration models (Maley and Caswell 1993), have been used for the object-oriented approach, for example, the work by Silvert (1993), Derry (1998) and Roese *et al*. (1991). There are several models of forests (Deutschman *et al.* 1997, Liu and Ashton 1998). The most striking application is undoubtedly the Across Trophic Level System Simulation (ATLSS) model which attempts to simulate the ecological function of the Everglades in Florida (Abott *et al*. 1995). This model represents abiotic factors — such as hydrology, fire and hurricanes — and different trophic levels simultaneously. Within the models, which can be mathematical compartmental models, different animal populations are simulated (deer, cats) with the help of individual-based models.

MAS and Social Sciences

MAS are developing rapidly in the field of social sciences. Society simulation is the subject of numerous conferences, for example, Multi Agent systems and Agent Based Simulation (MABS) (Sichman *et al.* 1998) among others (Conte *et al*. 1997). Research on the subject is published in the electronic journal Jass (Journal of artificial societies and simulation). In addition, a group called Agent-based Computational Economics (ACE) (Tefstation 1997) has been set up.

In social sciences, the application of the theory of multiagent universes to simulate social phenomena is generally associated with the methodological individualism (Havelange 1994, Lenay 1994) in which the singular individual is considered as the elementary unit or the atom of society (Weber 1971). The overlap is, in fact, in the bottom-up approach which characterizes MAS. However, the assimilation between individuals from a society and agents from a multiagent universe can be misleading: it is quite possible for social groups and institutions to be considered as agents with their own standards and rules for functioning (Livet 1987). The agents are directed by constraints or rules that are expressed on a group level, ie they are no more than entities that act and are placed in a dynamic environment.

This straightforward comment — which is natural when MAS are used for modelling — shows how the simple duality that exists between individualism and holism can be called into question, which is a major preoccupation for researchers working on renewable resource management and MAS:

(i) individuals, products of history are driven by collective values and rules,

(ii) collective values and rules evolve because of the interaction between individuals and between groups,

(iii) the individuals are neither similar nor equal but have their own specific roles and social status.

How do individuals make up a group? How is an institution created? The individual cannot be considered as an autonomous entity that is independent of its social environment. How are individuals constrained by collective structures that they themselves have set up and how do they make these structures evolve (Gilbert 1995)? What degrees of freedom are given to the definition of individual practices? Here are just some of the questions that can be explored using MAS and which can be expressed as follows: "how are collective structures set up and how do they function when they are based on agents with different capacities of representation, that exchange information, goods or services, etc., draw up contracts and are thrust into a dynamic environment which responds to their actions?"

MAS and Interactions between Societies and Resources

The problem with modelling common resource management is the simulation of the interaction between groups of agents and dynamic resources. Empirically, there are several ways of modelling these interactions.

The first method involves simulating how social networks are managed. Here, we consider that the relationships between people and resources should, in fact, be formulated as the relationships between people that concern resources. Agents that exchange messages within networks or so-called contact networks can be simulated with MAS. In this way, exchanges of information and services, contracts and agreements between agents can be simulated. For example, in the case of irrigated systems, farmer agents can send each other messages so that they know what the water levels are in different plots, they can ask for or exchange services or addresses. In this way, it has been shown (Barreteau and Bousquet, in press) that the evolution of a system can be very sensitive to the structure and dynamics of social networks.

In the second method, emphasis is put on the cognitive processes or representations that determine how agents and resources interact. Each agent develops and then acts on its own representation of a resource. In so doing, the agent transforms the resource for the other agents. This model represents interactions that are close to what economists call externalities. We study the problem of managing common renewable resources by examining the different representations of actions that affect the resources in question. The resulting resource use may or may not be satisfactory for the agents. This can be described as coordination through the environment.

This method of classification provides a framework, but there have been studies that take into account the agents' interactions as well as systems of exchange through the environment.

Cormas: Multiagent Simulation Software

For several years now, multiagent simulation software has been available. User groups (including ecologists and sociologists) are organized around generic tools that facilitate the construction of models and offer facilities ("virtual laboratories") for monitoring and analysing simulation trials. The example of Swarm[1]—which uses the object-oriented language Objective-C for writing code and Tcl/Tk for developing interfaces—clearly reflects the current trend. Since the launch of the project at the Santa Fe Institute in 1994, groups using Swarm have joined forces to try and resolve common problems. As a result, new software based on Swarm, with specific applications for different disciplinary fields (ecology, for example), has been developed.

Our team is particularly interested in models for resource management. Hence, the multiagent simulation software that we have developed is based on the concept that space holds resources. The software Cormas is an environment for constructing multiagent models based on the software VisualWorks which, in turn, is a programming environment within Smalltalk. Cincom, the American company that markets VisualWorks distributes the software freely (for educational and research purposes). Cormas is also available to the scientific community[2] in the form of a set of programmes that are downloaded in VisualWorks.

Cormas is made up of different sets of programmes. The first is for modelling agents and interactions; these interactions are mediated either through a simulation space in the form of a set of cells or via messages. The second set of programmes involves the control of the dynamics of the simulation, whereas the third set of programmes is for defining the observer's different points of view.

Several types of entity can be defined using Cormas. All the entities in Cormas possess **primitives** (programmes) which allow the exchange of resources on request (be it *pro rata*, **the most sought after** or as a function of the agents' characteristics, etc.).

Here, we describe the entities used for the model presented below.

> The first is called the situated agent. A situated entity has spatial references (the cell). It is characterized by its perception range.

[1] http://www.swarm.org

[2] http://www.cirad.fr/presentation/programmes/espace/cormas/

The second is the cell. Space is a component that is taken into account by Cormas. Above all, it is the support for situated agents. Thus, the cell has a list of located agents that are situated on it. The cell provides primitives for access to neighbouring cells within a varied radius. The space also has its own dynamics. As with cellular robots, the cells are characterized by a state that can change dynamically depending on rules that take into account the state of neighbouring cells.

The third is the spatial aggregate. When MAS are used to simulate spatial dynamics, the question is how can the spatial agents and the rules that govern their spatial interactions be simulated on different levels? We simulated spatial dynamics—with their own specific behaviour patterns—based on geographic entities (forest, town, road, etc.) at a higher level of organization than that of the cell.

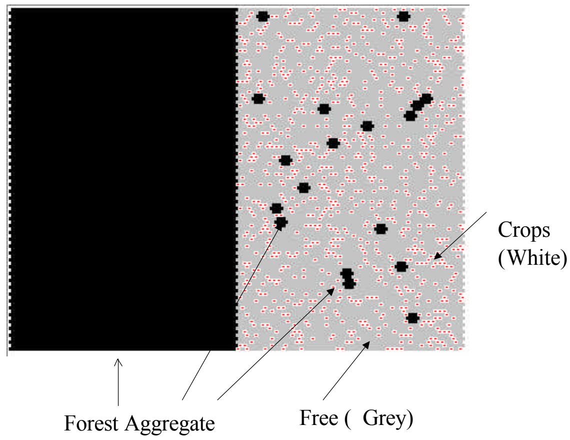
An Example of Results: a Model for Fuelwood Consumption

The model described here was developed for research concerning fuelwood consumption in the Kayanza region of Burundi.

The Model

We developed a model with three different entities: the cell — which represents 1 ha of space — the forest, which is an aggregate entity that represents forests — and the household agent, which represents a family living on one cell. We describe the three entities and then go on to describe the control algorithm which determines how the three different entities behave. The time step chosen for the simulation is equal to 1 year. The space under study is made up of a set of 10 000 hexagonal cells which have six adjacent cells. Thus, a region of 100 km² is represented (Figure 1).

Figure 1. Initial state.



Description and Dynamics of a Cell

The cell is characterized by six variables:

- state: this variable relates to one of five values (forest, degraded forest, pasture, cropland and agroforestry). The transitional function of the cell, ie the rules that determine a change of state, is outlined in Figure 2.
- Live wood: this variable represents the quantity of standing wood (measured in m³) on the cell. When the cells are initialized, the variable is set at 300 m³ if the cell is in the forest state. The dynamic of this variable is simulated according to the logistic model. When a cell is in the agroforestry state, which simulates the fact that the agent on the cell has planted trees, the initial stock of live wood is 20 m³.

The Household Agent

The household agent is characterized by six variables:

- Population: Population growth is simulated at 3%. For every time step, a random distribution simulates this growth. The phenomenon of migration is also simulated. The probability of migration is 10% for a household of four people, 30% (five people), 50% (six people), 70% (seven people), 90% (eight people) and 100% for households of nine or more. There is a random draw in these distributions and the population size is eventually reduced by one unit. There are four people per household to start with.

- Wood space: this corresponds to the agent's spatial perception. It consists of all the forest cells within a perception range of 2 km (Figure 3).
- Live wood: the amount of live wood collected during one time step.
- Dead wood: the amount of dead wood collected during one time step.
- Consumption: the total amount of green and dead wood collected.
- Satisfaction: this has a true or false Boolean value depending on consumption. If consumption is greater than 90% of potential consumption ($1m^3$ $person^{-1}$ $year^{-1}$), satisfaction is equal to the true value otherwise it is equal to the false value.

Three supplementary programmes were written for the household agent. They relate to behaviour patterns for harvesting wood. The agent calculates how much live wood (consumption of live wood) or dead wood (consumption of dead wood) they need. It then asks the cells in its perception range (wood space) for this amount of wood. The third programme (local consumption) corresponds to the amount of wood consumed by agents on an agroforestry cell. The quantity of consumable wood on the cell is the quantity of surplus live wood compared to the maximum production level (75 m^3). In this way, the sustainable management of the agroforestry cell is simulated

Controlling the Simulation

Once the different interacting entities have been defined, the programmes needed to organize the simulation have to be defined. These are as follows:

- Initialization: to initialize the simulation, a map has to be downloaded (Figure 1). This represents the initial spatial situation. The household agents are then positioned on the cropland cells. Each household agent has four members (population = four). The aggregates are then created in order to group together the sets of contiguous forest cells. Lastly, the agents develop their perception on the forest cells that are in their variable wood space within a 2 km radius.
- Control: (Figure 4) at every time step, a number of operations are carried out in order. First of all, the cells calculate wood production. Then, the agents activate the local consumption programme. The cells process the demand. If the agents are unsatisfied, they consume dead wood. The cells process the demand. If the agents are still unsatisfied, they consume live wood. The cells process the demand. Eventually, the cells change state. The cells that belonged to the forest aggregate and which are no longer in a forest state are removed from the forest aggregate. Lastly, for each migration, a new population agent equal to one is created and set up on a cell in a free state. This agent's perception range is calculated.

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The Scenarios Tested

In this article, we test different scenarios. The first scenario (sc1) corresponds to the model described above. In the second scenario (sc2), simple rules of exchange of use rights are taken into account. Thus, every agent that is unsatisfied with its wood harvest has a look at agroforestry cells in the immediate vicinity to see if there is any surplus wood, before planting trees and transforming their own cell into an agroforestry state. If this is the case, the agent makes a request for wood. In the third scenario (sc3), rules governing access are taken into account. Thus, in the small natural forests in the east (right hand side of the map) cutting live wood is prohibited. Finally, a fourth scenario (sc4) combines rules of exchange and rules of access.

Figure 2. Transitional function. Each circle represents a potential state that a cell can adopt. The arrows represent the possible transitions and the text describes the conditions necessary for the transitions.

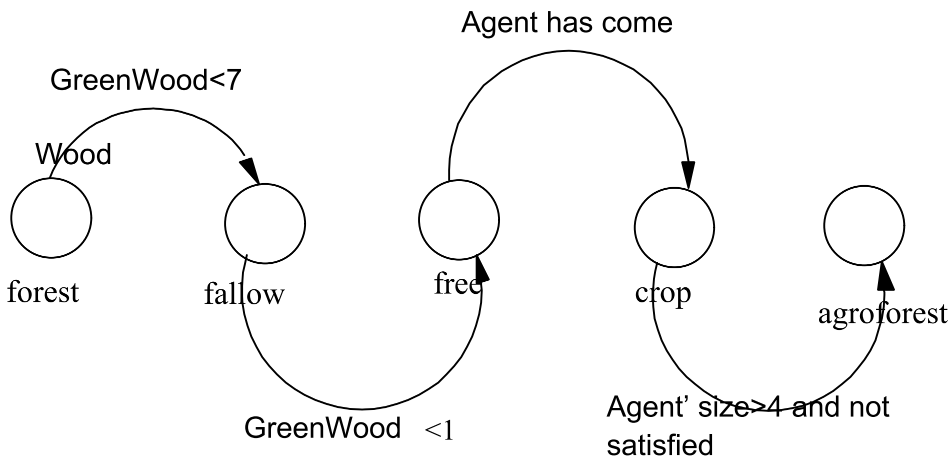


Figure 3. An agent's perception range

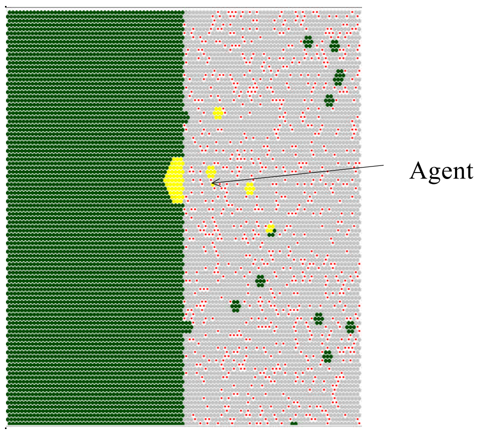
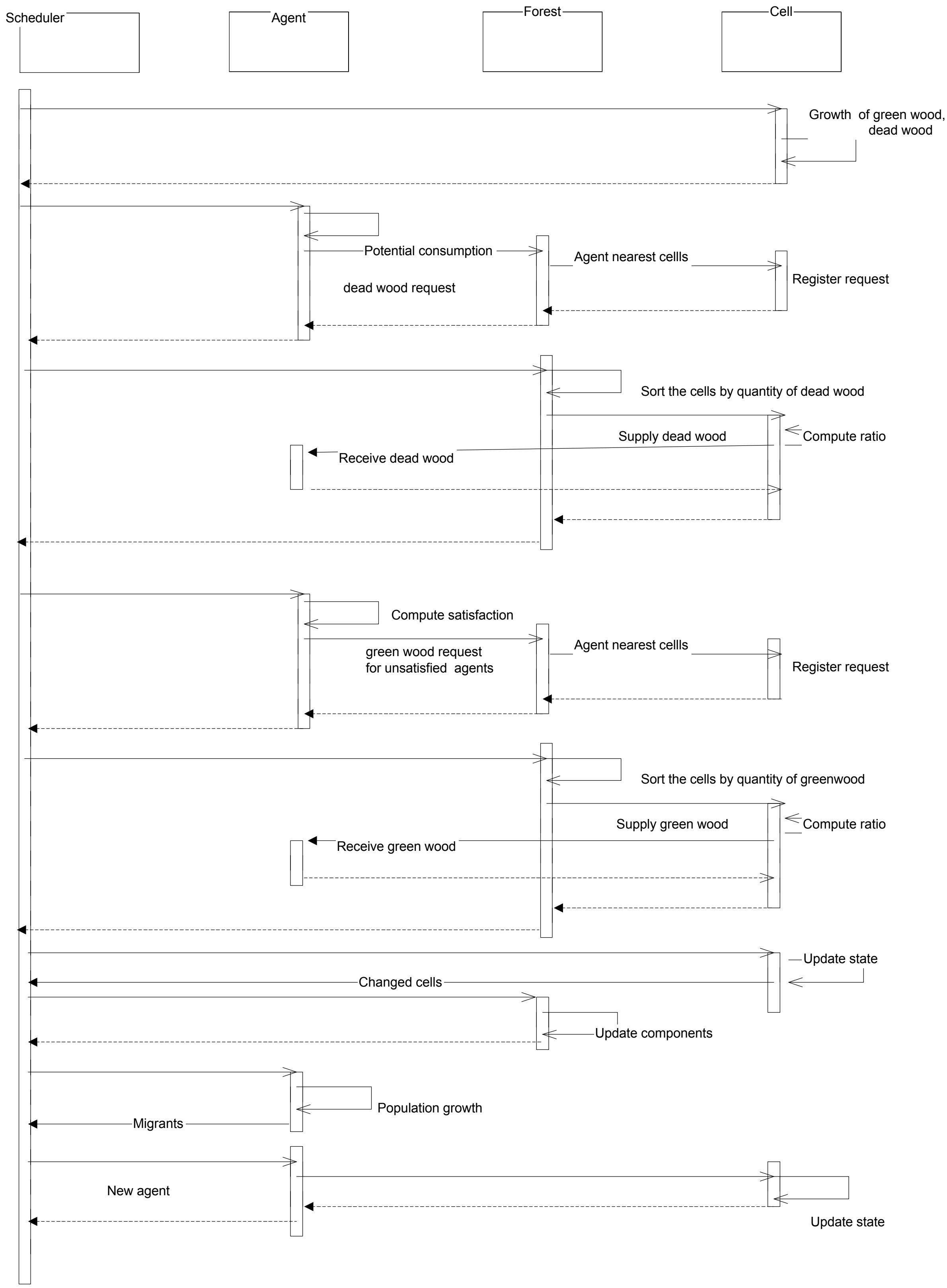


Figure 4. Sequence diagram.



Results

We have identified three indicators to compare the results from the different scenarios.

- Consumption/inhabitant: this is the total amount of wood consumed divided by the total population. It reflects the degree of satisfaction. Potential consumption is 1 $m^3person^{-1}$.
- The number of forest cells: this measures deforestation.
- The number of agroforestry cells: this is the number of cells where agents have planted trees.
- Population density in the region: this indicates the control of the simulation.
- Results are shown in Figures 5, 6 and 7.

Figure 5. Individual consumption.

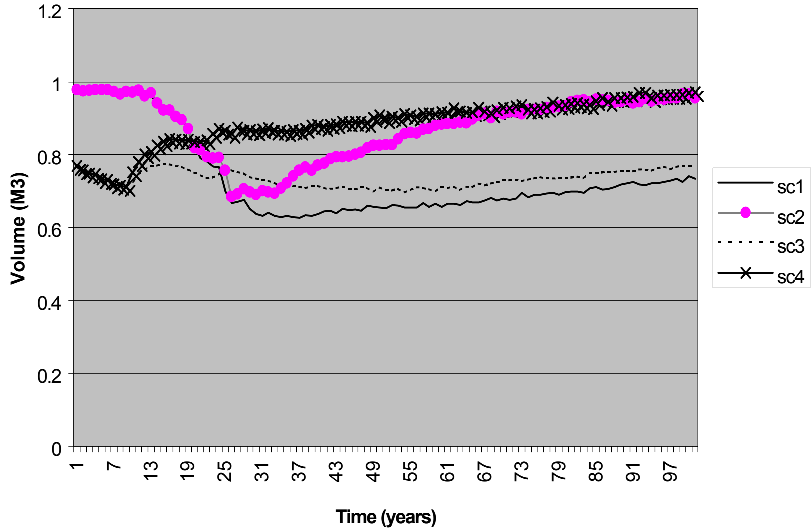


Figure 6. Deforestation: evolution in the number of forest cells.

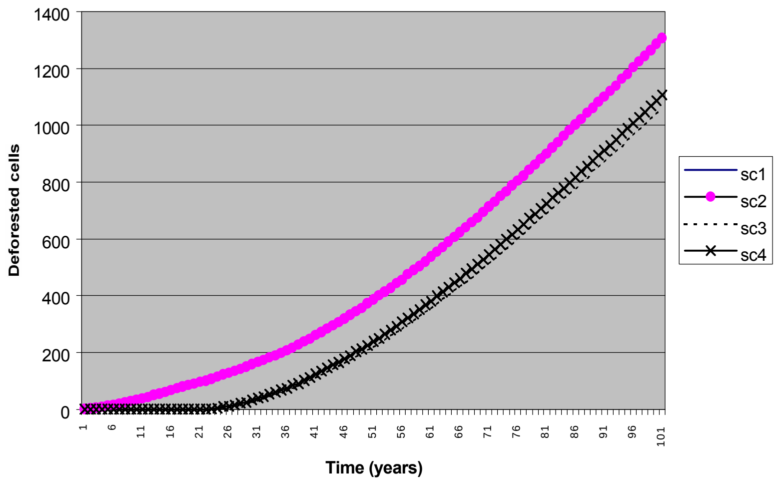
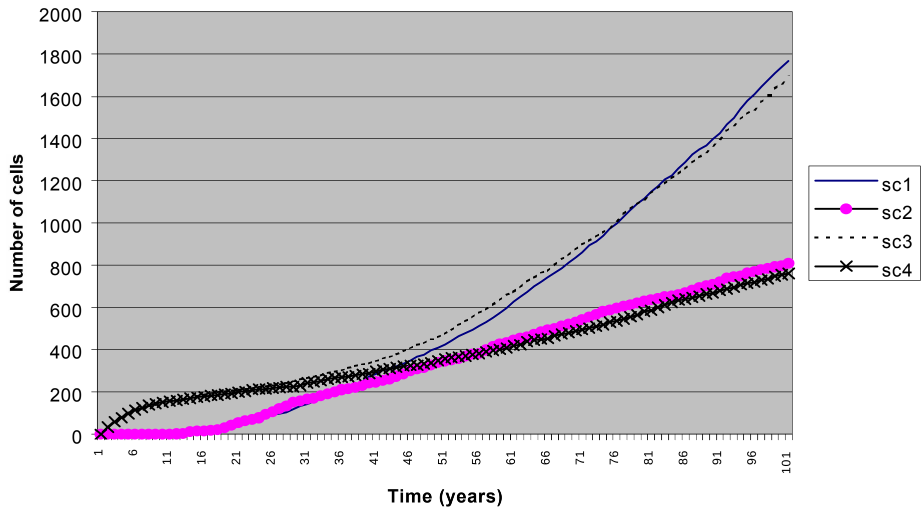


Figure 7. Evolution in the number of agroforestry cells.



The figures show the different evolutions which can be divided into two periods, namely, when consumption falls and when it increases again.

The Drop in Consumption

At the start of the simulation, the simulations can be divided into those with free access (sc1 and sc2) and those with differentiated access (sc3 and sc4).

In the case of free access, a few agents use the small forests in the east as a resource and take live wood (Figure 6). Around 100 forest cells disappear which corresponds to the small forests. The small forests satisfy the agents' demand and the agents consume 1 m^3 wherever possible. There is a crisis after about 10 years because, once the small forests have disappeared, all the agents in the east (right hand side of the map) find that they are too far away from the forest. Agents that are able to plant trees on their plots do so (Figure 7). It takes 10 years for the planted trees to start producing, which explains why the drop in consumption levels out after about 25 years.

In the case of differentiated access, the crisis is immediate because there is not enough dead wood in the small forests in the east to satisfy demand. Consequently, the agents plant trees quickly (Figure 7). There is not much pressure on the forest to start with (low population density and wood is taken from a wide area, cf. Figure 6). Therefore, there is less deforestation.

Increase in Consumption

The increase in consumption is different in each simulation. In the case of the scenarios with differentiated access (sc3 and sc4), consumption goes up sooner because trees are planted earlier. However, we observed that the evolution is influenced by whether or not wood can be exchanged. The two simulations involving exchanges (sc2 and sc4) produce much better results and satisfaction is almost perfect at the end of the simulation. In the simulations without exchange, results from sc3 are slightly better at the end of the simulation. This is due to the fact that the small forests in the east that are not cut down continue producing dead wood that the agents collect. We also observed that the possibility for exchange limited the need for planting (Figure 7). We observed that in the cases with differentiated access, deforestation did not occur until year 40. The difference between differentiated access and free access is in the order of 100 cells, which corresponds to the number of cells in the small forests that were felled. The rate of deforestation is the same in the four scenarios.

Discussion

The results obtained from the above simulations can be interpreted logically by reconstructing the past. However, when the results are examined from a wider perspective, one can see that the observed changes seem paradoxical when considered at a different scale and with static reasoning.

The simulation with the most forest cover (sc1) experiences the most severe crisis (in terms of consumption). This calls into question the logic of matching the supply of natural resources with demand. In fact, in these simulations, once the small forests have been destroyed—their resources are exhausted because of free access — each household independently attempts to deal with the crisis. With the simulations involving exchange mechanisms, fuelwood can be distributed.

In the simulations, the fact that wood cutting is prohibited in certain places does not exacerbate deforestation in other areas. A number of complex phenomena arise. The small forests that are not cut down provide dead wood. If this is insufficient, agents who are in a position to plant trees on their cells have time to do so and this provides a new source of wood for exchange in future.

In this example, we can see that the spatial distributions of initial resources are combined with stakeholders' behaviour. With this type of methodology, it is possible to study problems that relate to:

1. Fragmented spaces where resources are renewed, which can be observed on several organizational levels.
2. Exchange mechanisms (for goods, services, currency and information) between heterogeneous agents that have different representations.

Complex tools, particularly MAS like the ones described here or by Epstein and Axtell, are effective for representing knowledge of processes and for simulating their interactions.

Without going into too much detail, one of the milestones of economic theory — which does nonetheless have an important contribution to make to the debate — is the theory of the tragedy of the commons (Hardin 1968). Hardin suggests that a common resource subject to rational economic forces is condemned to disappear from overexploitation because of free access. This problem can be solved by privatization or by setting up a central authority responsible for managing access to the resources, in other words by controlling access using regulatory or incentive mechanisms (Krutilla *et al.* 1983). In our model we can see that controlling access (scenario 3 and 4) delays deforestation but without modifying the rate of deforestation.

Another interpretation of resource degradation conversely focuses on under-exploitation or under investment in natural resources. In this model we can see that differentiated access allows a rapid investment in agroforestry. But a satisfying level of consumption is rapidly reached only when the control of access is associated with exchanges of use rights on agroforestry cells. Then this investment does not allow a global sustainable consumption when available only to an individual.

A number of authors including Ostrom (1990), Berkes *et al.* (1989) and Stevenson (1991) disagree with the privative management theory. They describe the foundations of an institutional approach which involves the application of formal or informal regulatory mechanisms for governing the viability of ecosystems. The word govern refers to representations of stakeholders and is based on a principle of negotiation of use or property rights. The model shows how the issue of exchange of local use rights is of importance in the management of renewable resources.

It can be difficult to put a local approach into practice because of outside interference or restrictions imposed at different levels, therefore, the current trend in research is to support the idea of co-management (McCay and Jones 1997). Co-management can be applied to resource management within a user group (fishermen) or between several groups that use the same resource for the same purpose (association of catchment areas). Therefore, with other forms of regulation and collective decision-making, it could be extended and applied to the management of resources with multiple uses. This is a question of coordinating the local and global processes involved in managing resources with multiple uses. We consider that simulations using MAS have an important role to play here.

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The Interactive Role of Fodder Trees in Hillside Landscapes: Using Fuzzy Sets to Combine Farmers' Knowledge with Science

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Abstract

In many developing countries, tree fodder is important for increasing protein supplies for livestock and improving the utilisation of poor quality straws during dry seasons when little feed is available. Farmers in Nepal possess a considerable breadth of indigenous knowledge (IK) to assist them in making effective use of tree fodder. Attempts by researchers to support the development of tree fodder resources need to account for this IK in order to both avoid re-inventing the wheel and to ensure the acceptability of any innovations. This paper describes the use of model, based on fuzzy logic, for integrating the Nepalese tree fodder IK system with quantitative descriptions of the biological processes associated with tree fodder use in order to facilitate this process. In Nepal, farmers describe tree fodder quality using two scales, *posilopan* and *obanopan*. *Posilo* fodder is said to promote milk and butter fat production in lactating animals, rapid liveweight gain and animal health. *Obano* fodder "fills the animal", is highly palatable, particularly during colder months, and is eaten voraciously, although causing constipation if fed in excess. An earlier study examined the nutritional implications of these farmers' terms and suggested that the *obanopan* criterion relates to a fodder's digestibility and the *posilopan* criterion to its ability to supply protein. These observations were consistent with the characteristics assigned by farmers. The model described here used these associations to examine the outcomes of feeding strategies for dairy cattle formulated with reference to farmers' criteria and based on the information available to them regarding the quality of tree fodder. The model's predictions were consistent with farmers' expressed objectives of optimising milk production whilst ensuring that animals remained adequately fed in times of feed shortage.

Keywords: Tree fodder, Indigenous knowledge, Fuzzy logic, Dairy cow, Nutrition

Introduction

In many developing countries, tree fodder - from forest land and on-farm plantings - plays an important role in increasing protein supplies for livestock and improving the utilisation of the poor quality straws that predominate in diets during dry seasons when feed is in short supply. In turn, livestock support production from and sustainability of crops and trees on arable land through the provision of labile plant nutrients in manure and draught power to ease the difficulties of land preparation and maintenance. In short, these tree-crop-livestock systems are often highly integrated and, as a result, highly productive too.

Such tightly integrated systems, in which management decisions with immediate impacts in one component can have considerable knock-on effects in others, clearly require quite sophisticated managerial skills based on a reliable, if empirical, knowledge of the likely outcomes of the management decisions that are made. An appreciation of this "indigenous knowledge" (IK) is now seen by many as a prerequisite for researchers to make a tangible contribution to the generation of technologies that can be seamlessly integrated into existing, complex agricultural systems to promote long-term improvements in the sustainability of livelihoods (Sillitoe 1998). Indeed, a lack of this appreciation in the past may have at least contributed to the limited extent and durability of impacts generated by applied agricultural research targeted on the farming systems of developing countries.

A detailed discussion of the historical perspectives and methodological intricacies associated with the assimilation of IK by social and biological researchers is beyond the scope of this paper. However, a key constraint to achieving such assimilation would appear to lie in the difficulties associated with generating comprehensible interpretations of indigenous knowledge systems that can be interfaced with the "biology" in order to underpin relevant research and improve its focus. This paper describes the use of fuzzy logic to facilitate the integration of IK, in particular, and qualitative information, in general, with quantitative descriptions of biological processes. A case study based on the interpretation and assimilation of an IK system for tree fodder quality, applied by farmers in Nepal, is presented in illustration of the potential utility of the approach.

Why use Fuzzy Logic?

The notion that bi-modal or boolean logic may be extended to include values between true and false may be traced back to Plato. A little more recently, the application of an "infinitely-valued" logic to classical set theory led to the development of the mathematics of fuzzy sets (Zadeh 1965) and its associated branch of logic, fuzzy logic. Fuzzy logic has now found widespread practical application in situations where there is uncertainty, or disagreement, about the semantic interpretation of a set variable.

Figure 1 illustrates the specification of an intrinsically fuzzy concept in agriculture using both boolean and fuzzy sets. In this simple example, it is assumed that there is a need to characterize crop production as high or low yielding, perhaps in order to target, more effectively, interventions aimed at increasing yield. Clearly, the restriction on the crisp membership function to a value of zero or unity (i.e. true or false) necessitates that a crisp value is assigned to the level of yield at which a crop may be considered to be high yielding. This approach has two major limitations:

The selection of a value of, for example, 4.5 t ha^{-1} as the threshold for a "high yielding" crop may be used as a premise for statements such as "crop A, yielding 4.4 t ha^{-1} is low-yielding, and crop B, yielding 4.6 t ha^{-1}, is high-yielding". Semantically, this is nonsense;

Conceptualizing the term "high yielding" as a moveable feast implies that the threshold should depend on a variety of factors such as crop variety, type of farm, production objectives and perhaps even external factors such as marketability. The complexity of these factors and their interactions means that a deterministic approach to including them implicitly in the crisp specification of the concept is likely to be infeasible.

In contrast, the fuzzy set allows a perception of a growing degree of "high yieldingness" from a situation in which, for any variety and by anyone's standards, the yield may be viewed as low to the other extreme at which yield may be considered to be unequivocally high. A membership function may be specified that includes the effects of factors such as those described above and, depending on the situation, a set of decision rules may be formulated according to the degree of membership calculated.

Fuzzy Sets for the Representation of Indigenous Knowledge

In general, there is a lack of certainty attached to statements of IK that makes them suited to representation as fuzzy sets. This arises, in the first instance, from their diverse sources. For any individual, these are likely to range from personal experience to orally transferred information from others who, because of distance or even death, may never have been in direct contact.

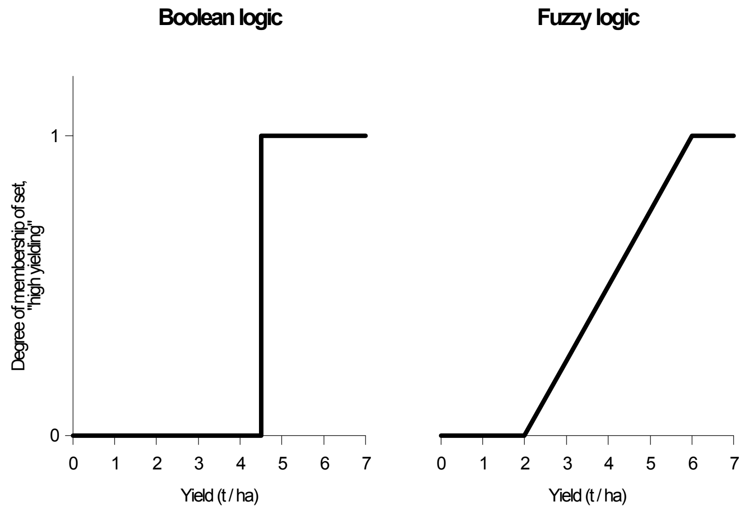

Figure 1. Applying boolean and fuzzy sets to the characterisation fo crop yield

The dynamic nature of the farming system constitutes a further source of uncertainty in indigenous knowledge systems. Levels of production from any agricultural enterprise must generally be maintained under environmental and market conditions that fluctuate, often in multiple cycles of varying amplitude. On top of this short-term variability are superimposed the long-term degradation that arises from increasing population pressures or climatic changes and the long-term improvements achieved, it is to be hoped, through agricultural development in the broadest sense. It must not, of course, be forgotten that *people* manage farms and that their objectives may also change independently of the need to respond to extraneous changes such as those described above. Currently, the pace of change in resource availability in smallholder farming systems is generally perceived to be escalating. It seems likely that, given its diffuse derivation, indigenous knowledge may not, in all cases, be sufficiently responsive to these changes. In this situation, practicable methods for systematically integrating indigenous and scientific knowledge would appear to offer the potential for improved support to farmers' decision making.

Case Study: A Biological Model of Ruminant Digestion Driven by Indigenous Technical Knowledge of Tree Fodder Quality

Fodder Quality Knowledge Systems in Nepal

Resource-poor farmers in Nepal have a detailed IK system for describing the nutritive value of the fodder from a wide range of tree species that are used as dietary supplements for ruminant livestock (Rusten and Gold 1991, Thapa *et al*. 1997). These studies revealed two local classification systems for tree fodder; *posilo* - *kam posilo* (*posilopan*) and *obano* - *chiso* (*obanopan*) which were found to be fundamental to farmers' perceptions of tree fodder quality.

The literal translation of the Nepali terms *posilo* and *kam posilo* are nutritious (high nutritive value) and less nutritious (low nutritive value) respectively. Farmers state that *posilo* fodder promotes milk and butter fat production in lactating animals, rapid live weight gain and animal health. They are generally considered to be palatable and to satisfy appetite although these effects are, at least to some extent, dependent on the type of livestock involved. In contrast, feeding *kam posilo* fodder does not result in high milk yields and rapid growth rates of animals and, if fed as a sole fodder, may cause weight loss, reductions in milk and butter fat yields and a general deterioration in health.

Obano is translated as 'dry and warm' and *chiso* as 'cold and wet'. The terms have been taken by Rusten and Gold (1991) to refer, specifically, to the consistency of dung produced by animals consuming the different types of fodder. However, farmers also state that *obano* fodder is highly palatable, particularly during colder months, and is eaten voraciously, often causing constipation if fed in excess. *Obano* fodder is said to improve animal health and generally contributes to milk and *ghee* (clarified butter) production. It produces (literally) dry, firm dung - which must be viewed as significant in a system in which the manual collection and application of manure-compost is the primary means of maintaining soil fertility. C*hiso* fodder is less palatable and, if fed in cold months, often result in animals producing watery dung that is difficult to collect and spread.

Walker *et al.* (1999) and Thorne *et al.* (1999) have described a biological interpretation of the *obanopan* and *posilopan* IK systems. These studies suggested that the knowledge of tree fodder quality possessed by farmers is quite consistent with the level of information that may be generated from the laboratory analyses that are commonly used by nutritional researchers for the same purpose. The *obanopan* system appeared to relate to digestibility of tree fodder (as predicted by an *in vitro* test) whilst the *posilopan* system was perceived as an indicator of general nutritional quality related to the ability of a tree fodder to promote the supply of protein at the duodenum. These findings appear to be consistent with farmers' descriptions of the characteristics of *obano* and *posilo* fodder. Interestingly the relationship observed in the study between *obanopan* and *in vitro* digestibility indicated that Nepalese farmers, in preferring to use *obano* fodder, also preferred a less digestible fodder. This highlights the paramount importance of interpretation of nutritional information against farmers' objectives under any particular set of circumstances. This point was strongly reinforced by the fact that recommendations derived from a panel of nutritionists viewing a set of laboratory indicators describing the tree fodder studied did not appear to account, in any way, for the *posilopan* criterion judged important by farmers.

An initial analysis of complementarity (Thorne *et al.* 1999) between the information provided by farmers' perceptions of fodder quality and those that might be generated in a laboratory was encouraging for a the more integrated approach to assessing fodder quality for the smallholder farmer that is addressed in this paper.

Model Construction

Four fuzzy variables were used to define farmers perceptions of the quality (*obano* and *posilo* status) of the eight tree fodders for which data were available (Walker *et al.* 1999) and the outcomes associated with their use (Table 1). The membership functions (FV1 - FV4) for the linguistic values associated with each of the fuzzy variables are shown in Figure 2. For each of the linguistic values of each fuzzy variable, the membership function was used to calculate a degree of membership (DOM) as follows:

FV1 *obano* status – the degree of membership of the *obano*, intermediate and *chiso* linguistic values were inferred from the farmers' mean ranks for *obano* status. In general, farmers exhibited a relatively high degree of consensus regarding the status of the most obano and most chiso tree fodders. Therefore, a hedge $FV1^2$ was used to generate the two, further linguistic values, very *obano* and very *chiso*;

FV2, *posilo* status – the degree of membership of the *posilo*, intermediate and *kam posilo* linguistic values were inferred from the farmers' mean ranks for *posilo* status. Again, hedging $FV2^2$ was used to generate the linguistic values, very *posilo* and very *kam posilo*;

Table 1. Fuzzy variables used in the model and their linguistic values.

Fuzzy variable	*Linguistic values*
Obano status	*Obano*, intermediate, *chiso*
Posilo status	*Posilo*, intermediate, *kam posilo*
Ability to satisfy appetite	Acceptable, low
Level of milk production	High, medium, low

Table 2. Assignments of values for fill units to the linguistic values describing obano status.

Obano *status*	*Fill unit*
Very *chiso*	0.6
Chiso	0.75
Intermediate	1
Obano	1.25
Very *obano*	1.4

FV3, acceptability of fill ratio – the acceptability of a range of fill ratios (actual intake / potential voluntary intake) to unity was inferred from a longitudinal monitoring dataset described by Thorne *et al*. (1998);

FV4, level of milk production – DOMs for levels of milk production were assigned on the basis of observed values on typical farms in the eastern hills of Nepal contained in the dataset of Thorne *et al*. (1998).

The inverse relationship observed between *obano* status and digestibility (Thorne *et al*. 1999) was used to associate the values of the linguistic variable for *obano* status with a mean level of fill units (UEL; as defined by Jarrige 1988). These are used in the "French" rationing system for ruminants, on which the biological component of the model is based, to describe the maximum voluntary intake of a feed by a defined animal relative to that of a reference material. These assignments are shown in Table 2.

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Similarly, the association of *posilo* status and protein supply at the duodenum postulated by Thorne *et al*. (1999) was used to establish the protein component of the model. Values for PDIN (degradable, nitrogen limited microbial nitrogen supply) and PDIE (energy limited microbial nitrogen supply) were assigned to different values of the linguistic variable for *posilo* status using the data of Pozy and Dehareng (1996) as a reference point (Table 3).

Calculated values for PDIN and PDIE were used in the calculation of PDI (duodenal protein supplies) using the equation:

PDI = MIN[PDIN, PDIE]

PDI was then used to derive a crude prediction of milk yield:

Milk yield = MAX[PDI intake – PDI required for maintenance, 0.5

Figure 2. Membership functions for the four fuzzy variables used in the model.

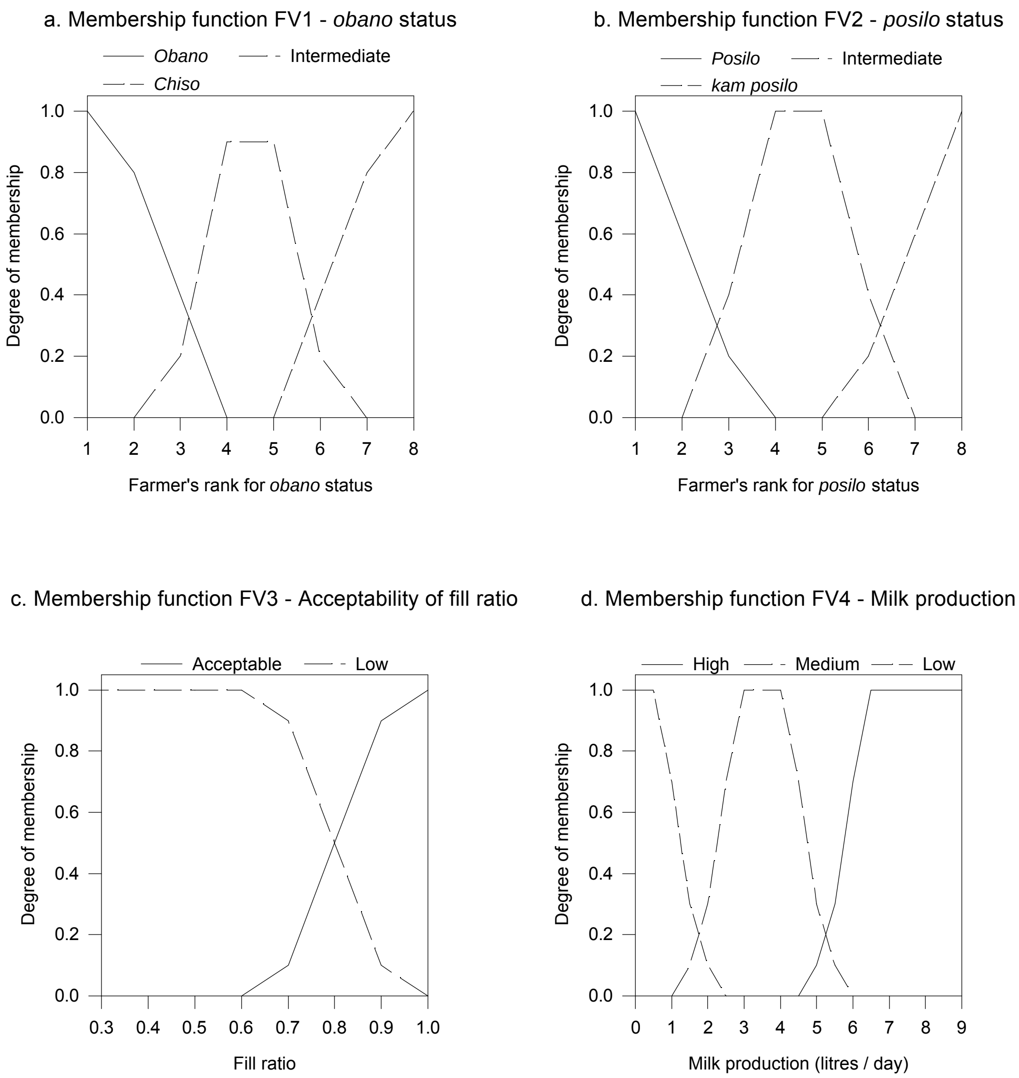


Table 3. Assignments of values for parameters describing nitrogen supply to the linguistic values describing posilo status.

Posilo *status*	*PDIN*	*PDIE*
Very *kam posilo*	53	138
Kam posilo	84.5	123
Intermediate	116	108
Posilo	162	121.5
Very *posilo*	208	135

Omitting the relatively complex contribution of body reserves to milk production was justified in this simplified model as it was proposed to use the model in the prediction of trends and not absolute values.

Dietary UEL values were used to determine the fill ratio for the current ration and describe the extent to which the appetite of the animal would be satisfied. These could then be integrated into a set of rules to suggest interventions in feeding strategies that would allow increased milk production whilst maintaining adequate fill ratios.

The Model's Predictions

In this section, two aspects of the predictions suggested by the model in relation to fill effects and trade-offs with potential stimulation of milk production are examined. In order to test the potential utility of the model it was assumed that, during periods of feed shortage, farmers will wish to maintain milk production at as high a level as possible. However, they are operating under difficult management conditions under which animals are confined in stalls. This means that the actual intake of a particular combination of feeds needs to match potential intake quite closely in order to avoid the behavioural problems that can arise in hungry animals. As feed supplies decline during a dry season, successful matching of intake to appetite implies a need to reduce feed quality that can compromise milk yields.

Figure 3 illustrates how the model can be used to predict the implications of this situation as the supply of rice straw available for animal feeding diminishes. *Ficus nemoralis* is a *chiso* fodder and is therefore less valued by farmers for satisfying appetite during feed shortages. In contrast, *Albizzia julibrissin* is regarded as *obano*. As fodder supply is reduced, the model predicts that the ability to satisfy appetite will be sustained until rice straw availability falls below 2 kg day^{-1} (see membership function for FV3) when the *obano* tree fodder is used as a supplement. However, using the *chiso* tree fodder would require levels of rice straw availablity of 4 kg day^{-1} in order to avoid the risk of behavioural problems. This assessment of trade-offs suggest that this modeling approach might be used in deriving more dynamic recommendations on tree fodder use that take better account of the changing availability of basal feeds as seasons progress.

The predictions summarised in Figure 4 illustrate how the model has been used to consider both the *obanopan* and *posilopan* criteria applied by farmers for most effective feeding in times of relative plenty. Points on the plot represent predicted milk yields for three types of fodder, of contrasting *posilopan* characteristics), at different levels of supplementation. Points falling on the lines represent feasible levels of supplementation in terms of the appetite restrictions imposed by the *obanopan* characteristics of the different fodders. A simple interpretation of *posilopan* (which we suggest correlates with protein supply) is that the use of a *posilo* fodder should promote milk yields. However, the model predicts that a fodder that is intermediate in terms of the *posilopan* criterion, *Ficus nemoralis*, ought to deliver maximum milk production as the animal is able to consume more of it. Whilst this prediction may be unremarkable in itself, the fact that it has been generated by a model that uses only data provided directly by farmers to describe the feeds used suggests considerable potential for this approach.

Discussion

Research on the interpretation of indigenous knowledge has been variously criticized for its folksy-romanticism or, almost conversely, for ethnocentrism, for a reliance on the inferred validity of, possibly dubious, cross-comparisons, and for a general irrelevance resulting from a perception that this knowledge is entirely context-sensitive.

It is, perhaps, not surprising that there have been few structured attempts to derive biological interpretations of indigenous knowledge systems and even fewer studies directed at the methodical integration of indigenous and deterministic parameters. This study, and the IK evaluations on which is based, demonstrate at least the feasibility of integrating deterministic biological knowledge and IK in a complementary manner.

Figure 3. Effects of obano status on the ability of crop residue-tree fodder combinations to satisfy appetite (point labels are fill ratios where a value of unity represents a combination fed at satiety).

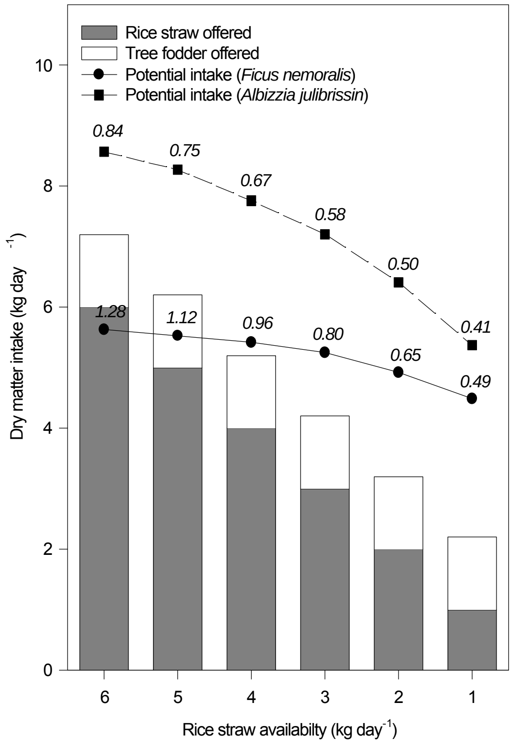
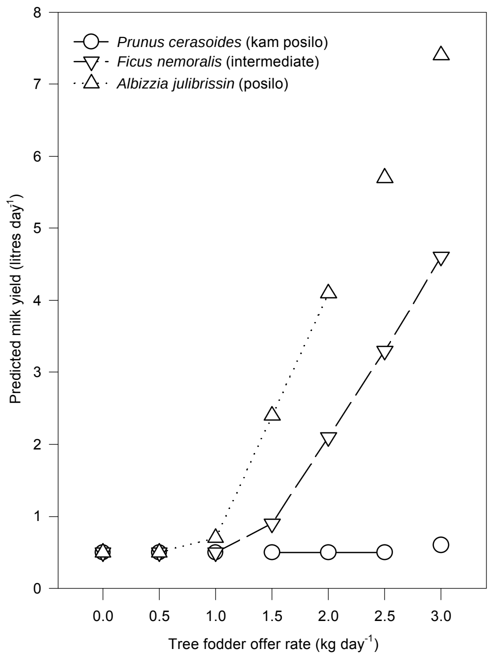


Figure 4. Prediction of the milk yield-appetite satisfaction trade-off for fodders with differing combinations of obanopan and posilopan status.



This approach could confer a number of potential advantages. The work has broad implications for research aimed at the development of improved feeding strategies. For example, routine data on the chemical composition of tree fodder are difficult to collect because of the range of trees used by farmers and the extent to which their nutritive value varies as a result of seasonal and other environmental factors. Farmers' knowledge encompasses this range of fodder types and environmental effects and the objectives of feeding strategies are implicit in their perceptions of the relative value of different fodders. Provided that a sound biological interpretation of farmers' knowledge systems is available - and currently, we stand at the beginning of this process - it should be possible to integrate this knowledge with more mechanistic descriptions of nutrient utilisation in livestock. Such an approach could provide the types of predictive systems that we require to promote more effective utilisation of tree fodder on farms. Conversely, some of the laboratory methods used in this study are also used routinely by breeding programmes in the assessment of new species or lines for fodder quality. A more detailed knowledge of the biological basis of farmers' knowledge will allow us to focus these evaluations more effectively on farmers' objectives and to deliver their results to farmers in terms that they can understand.

The model described in this paper was developed to illustrate an approach and is simplistic in practical terms. However, a number of initiatives have sought to develop the approach further. Notably it has been adapted to the assimilation of a set of qualitative indicators of fodder quality (e.g. forage colour, days of regrowth) into a predictive rationing system for dairy cattle (Thorne 1999). This system (DRASTIC) has already been applied with some success to the planning of practical management strategies under field conditions.

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The Future of Trees is on Farm: Tree Domestication in Africa

by
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Abstract

Current levels of deforestation suggest that the rising demand for tree products will have to be met by increased levels of tree planting. While traditional forest plantations will satisfy some of this demand, it is likely that there will be a substantial increase in the planting of trees on farmland. Farmers in areas of increased population density are already motivated to plant trees on their land because of the benefits they bring and this trend will continue. However, a great deal of potential exists to improve the tree species cultivated on farmland through a process of tree domestication, which involves not only tree breeding but species priority setting, nursery work, tree management, extension, marketing and policy interventions, and it is important that farmers participate in this process. Domestication of trees with high value products (timber, fruit, medicinal products) will provide small-scale farmers with income and an entry point to the commercial marketplace.

Keywords: Farmers, Tree products, High value

Introduction

Trees provide a wide variety of products (timber, poles, paper, fuelwood, fruit, medicines, fodder, etc.) as well as services (erosion control, carbon sequestration, soil fertility replenishment, hydrological functioning, boundary delineation, cultural significance, etc.). Traditionally there was no need to cultivate trees, as the nearby forest was a vast entity to be exploited but human population pressures have radically changed the situation. The world's forests are declining at unprecedented rates (30,000 ha day^{-1}). Massive changes in forest cover in the tropics will continue as rural populations and forest concessions continue to expand. Reports indicate that well over half of remaining forests are under threat for conversion to agriculture, to logging, and to meeting energy needs (WRI 1998). Agriculture, already the dominant land use in the tropics, will take over another 90 million hectares by the year 2010, a large proportion of which is now in forests (FAO 1997). Although improved management of natural forests may contribute to their more sustainable use, it is clear that if the increasing demand for tree products is to be satisfied, there must be increased deliberate planting of trees.

Although the total area under tree plantations in developing countries doubled between 1980 and 1995 from 40 to 81 million hectares (FAO 1997), reductions in Forestry Department budgets in many parts of the tropics have resulted in poor management of these plantations. In Africa, current afforestation efforts are unable to keep pace with loss of natural forests (FAO 1997). Plantations in most tropical countries consist of fast-growing exotic species such as eucalypts, pines and acacias. In Kenya, of the total plantation area of 164,000 hectares only 15,800 hectares is planted to indigenous hardwoods (Muchiri 1997) and this is a relatively high percentage compared to other countries. In tropical America, pines and eucalypts alone make up over 80% of the total plantation area (FAO 1997). The low species diversity of plantations is thought to make them more susceptible to pests and diseases then trees in natural forests or in agroforest ecosystems, where a greater number of species provides more of a buffering against pest attack. It is worrying, although perhaps not unexpected, that the vast *Eucalyptus camaldulensis* plantations in Asia are proving to be susceptible to leaf blight, and *Acacia mangium* plantations are being increasingly attacked by a heart rot fungus (Old *et al*. 1995).

Community forestry has enjoyed significant donor investment in Asia and to a lesser extent in Africa. While some successes have been noted in Asia, they apply mainly in hillside areas protecting valuable valley bottoms and where forest products are relatively low-value, requiring little management. In Africa, community forestry programmes have been much less successful. Some, such as the Village Forest Areas in Malawi, are very small in size and operate under strict conservation rules. In addition to shrinking niches for the development of community forests, generating proper incentives for productive investment in these types of schemes is notoriously difficult.

This suggests that other tree planting options need to be explored. Agroforestry broadly defines tree planting on farms in all its various forms: single trees, scattered trees in fields, lines or small blocks of trees, farm forestry, tree-crop rotations, trees in multistrata systems or trees in home-gardens. Governments and donors are already looking to agroforestry to provide simultaneously tree products and environmental benefits. More importantly, farmers themselves are planting more trees than commercial forestry enterprises in the tropics as a result of increased returns to land and labour. For example, in Sri Lanka currently 73% of timber and 80% of fuelwood is produced in home-gardens and trees on farmlands (Gunasena 1997). In China, there are estimated to be 1.8 billion eucalyptus trees planted on farms compared to only 0.95 billion trees in industrial plantations and in Thailand and Vietnam, there are 15 times more trees planted on farms than in plantations (Harwood 1997). A recent study in Uganda based on aerial photos from 42 parishes found that in 1960 agriculture contributed 35% of total tree cover, but this had risen to 58% by 1995 (Place and Otsuka 1997).

Trees on Farms

The revised Forestry Master Plans of tropical countries are now recognising the contribution that agroforestry can make to the supply of timber, fuelwood and non-wood products for both domestic and industrial needs (FAO 1997). The Indonesian Forestry Action Plan projects that for wood alone, the total demand for both domestic and export markets will double within the next 25 years, leaving an annual shortfall of approximately 30 million m^3. To help meet the shortfall, Indonesia plans to establish the equivalent of 500,000 hectares of forested land on farmers' fields (Moestrup 1997).

Following the application of traditional benefit-cost analyses to afforestation projects in Africa, donor agencies are also encouraging such initiatives (Anderson 1987). This is in recognition of the fact that agroforestry compares favourably with other development options (e.g. agriculture, livestock) when forest services (effect on production, preventive expenditure/replacement cost, and contingent valuation) are valued. Even when only conventional financial analysis was done in 56 agroforestry projects in Central America and the Caribbean, 75% of them produced positive net present values at 20% real discount rate (Current and Scherr 1995).

Current Situation

Several studies have shown that tree planting increases with human population densities in continuously cultivated small farms (Bradley *et al*. 1985, Patel *et al*. 1995, and Pretty *et al*. 1995 in Kenya; Place 1995 in Burundi; Place and Otsuka 1997, in Uganda; Cline-Cole *et al*. 1990 and Harris 1996 in Nigeria; Gilmour 1995 in Nepal). When populations have risen to the extent that most off-farm sources of tree products are exhausted, there is economic incentive for farmers to increase tree cultivation on farm to have access to fuelwood, fodder and other products. Therefore, areas of low tree cover or high population density are logical places to target additional reforestation.

There is also evidence that farmers plant a variety of tree species on their farms. A full woody inventory carried out on 200 farms in four villages in western Kenya recorded a total of 190 tree species (Kindt and Lengkeek 1999). Even though average farm size was less than two hectares, a mean of 16 tree species per farm was observed. Scherr (1995) reported that trees were planted in Siaya and South Nyanza districts for building poles, fruit, green manure, shade, fencing, fuelwood, timber, ornamental, fodder and other uses. Although many of these tree species provide several products and services ("multipurpose trees"), on-farm products and services are typically sourced from several tree species. Having several species and varieties on one farm (with its limited space) providing a number of products and services at different times implies that farmers are applying a useful diversity concept comparable with that described in the crop diversity literature (e.g. Kindt and Lengkeek 1999). Arnold (1995) states that farmers plant trees in pursuit of their livelihood goals of income generation, risk management, household food security and optimum use of available land, labour and capital.

Most trees in Kindt and Lengkeek's (1999) survey were planted (78%) rather than natural regeneration (22%), indicating a strong tree-planting culture although the species of trees planted were dominated by species available in nurseries in the area (e.g. *Cupressus, Eucalyptus, Grevillea* and *Pinus*), not necessarily those that would be preferred by farmers (Kindt 1997). This suggests that there would be potential to increase the number of higher value species planted if material was available. Similarly, the genetic base of trees planted on farms appears to be narrow: 82% of the trees planted on farms in the area studied by Kindt and Lengkeek (1999) were sourced from the farmers own fields or the fields of neighbours and Weber *et al*. (1997) found that 75% of farm trees in Peru came from on-farm sources of germplasm.

We can conclude that there is great scope for improving those tree species currently planted through participatory domestication (Simons, 1997) as well as for introducing new species, particularly those that provide high value products. Unlike agricultural crops, most of these high value tree species are wild or near-wild and urgently require domestication to realise fully their benefits. Household surveys have shown that farmers seek to diversify their income but are often unaware of opportunities. This is due to unavailability of options and is also partly due to inadequate market information. In Cameroon, Ndoye (1995) found that 79% of farmers selling non-wood tree products in Cameroon were not aware of the prices that prevail in urban markets since a market information system does not exist (e.g. publishing/advertising prices).

Domestication of Agroforestry Trees

As trees come out of the forests and onto the farm, five main features have to be considered:

1. their function (fodder, timber, fruit, etc)
2. their value (economic, social, other)
3. their diversity (within and between species)
4. their number (as there is a finite number of planting holes per farm)
5. their niche on farm (boundary, contour, cropland, homegarden, woodlot, etc)

Taking these into account, intervention may be in one of four ways:

A. Replacement – when species A is harvested, replant with species A (improved or not)
B. Substitution – when species A is harvested, replant with species B
C. Expansion – increase number of planted trees on a farm (species A, Species B, etc)
D. Management – better manage existing trees on farm

Whilst much can be gained from experiences with industrial plantation species, agroforestry trees require different approaches, which involve social and political inputs as much as biological ones. To encourage tree planting amongst a diverse client group of resource-poor farmers requires better understanding of farmer's decision-making processes. The modest resources for tree domestication efforts have to be focused on priority species which have been determined following objective methodologies. Common to the domestication of all species is a need to accelerate the process to deliver appropriate improvement early on. The pro-active multiplication of germplasm is required to reduce the lag phase between identification and adoption of improved material.

Farmer-Driven Process

Perhaps the most important aspect in the domestication of agroforestry trees is that it must be done in a participatory way with farmers rather than as the provision of cultivars or germplasm developed on-station. Key questions which should be addressed before formal tree domestication commences include:

- is the research addressing farmers' problems?
- are farmers involved in all relevant aspects of the work?
- do farmers recognize the benefits of domestication?
- do farmers appreciate the benefits of domestication?
- are the approaches used sustainable?
- is the objective to increase production or maximize stability of production?
- are we skewing priorities with incentives or raising anticipation of markets which are by nature speculative?
- do we understand farmers' decision making processes?

Farmers' perceptions of the benefits of domestication affect greatly the strategy that should be developed. Consider a case of identifying an improved provenance of a priority fodder species. The biological threshold for improvement is fixed, whereby the best provenance may be say 45% more productive in terms of leaf biomass than the existing landrace material. The farmers' threshold for improvement is not fixed and can change. Farmers may not be able to perceive a 5% difference in leaf production but many may have a threshold for perceiving differences of above 20%. Since 45% is greater than 20% there is no problem and the new material may be actively promoted.

On the other hand, if the biological threshold for improving timber volume for say *Cordia africana* is 20% and the average farmers' threshold for improvement is 25%, then gains cannot be promoted as farmers will not perceive the superiority of the material. In this case, improvements will be hidden but nevertheless can still be important. The approach here would be to ensure that as far as possible only superior material was available in nurseries and seed stores since what is planted is what is available. The problem is that in most situations we are unaware of farmers' thresholds for improvement, and assume that new material can simply be promoted.

Which species to domesticate will depend on the objectives of domestication, and will differ if it is for income generation, germplasm conservation, forest conservation or farm diversification. It is important, however, that the limited resources available for tree domestication are directed towards priority species.

Species Prioritisation

Until recently research priorities among tree species were determined largely by researchers alone. Such subjectivity has led to sub-optimal use of resources although this does not mean that no successes have occurred (Simons 1996). Rigorous priority setting, however, requires understanding of user needs and preferences, technological opportunities and systematic methods for ranking species (Jaenicke *et al*. 1995). Published guidelines on species priority-setting represent a great advance in procedural methodology (Franzel *et al.* 1996). These methodologies have now been used in a number of ecoregions and in all these regions the lists of the top priority species for participatory domestication have contained mostly food or timber producing trees, or other cash-generating species (Jaenicke *et al*. 1995, Kindt 1997, Weber *et al*. 1997). The paradox is that a species may not be able to prove itself until its full intraspecific variation has been tested (Dunsdon and Simons 1996).

It should be emphasized that the number of priority species should not be restricted to only a handful of species. In priority-setting in the Peruvian Amazon where individual farmers were asked to name their top ten species, more than 200 species were recorded (ICRAF 1996). Clearly, what is a priority to one farmer may not be so for another. In the Sahelian zone of Niger, 470 farmers were polled for their priority trees and it emerged clearly that different sectors of the community had different priorities. Women were different from men in their preferences, whilst old men were different from younger men (ICRAF 1996).

Domestication Strategy

It is evident from the arguments presented above that tree domestication cannot be equated exactly with tree breeding. Whilst tree domestication also involves trials and selection, it is also about:

- species priority setting with farmers
- proactive seed multiplication
- best nursery practices
- tree management
- extension messages (especially on seed collection)
- germplasm delivery pathways
- processing and marketing
- policy interventions

The critical point is that tree domestication is not about single activities but a coordination of a wide range of activities. Perhaps previously researchers felt that evaluation of provenances on station was tree domestication. The problem is that NGOs may then ask for 4 tonnes of seed and if no consideration has been given to this the research may be wasted.

To significantly increase the numbers of high-value trees under cultivation, constraints such as inadequate information on cultivation and management, lack of planting materials, policy barriers, paucity of choice and poorly functioning markets need to be removed. In this regard, research on input markets (e.g. planting material) is as important as research on output markets in understanding smallholder investment in tree cultivation.

Encouraging a Tree Planting Culture

ICRAF and other organisations promoting sustainable natural resource management through the incorporation of trees into the agricultural landscape essentially have two client groups of small-scale farmers: those with a tree planting culture and those without one. For the first group, the current niches for tree planting may be nearly saturated or approaching this condition. However, saturation is relative and, as centrally planned economies move towards market-based economies against a background of trade liberalisation, the removal of agricultural subsidies and the opening up of new markets may make agroforestry more attractive.

To engender a tree planting culture amongst diverse groups of farmers that do not have it requires a good understanding of their prevailing economic, social and environmental situations. Poverty and food insecurity are two compelling influences on many of these farmers. Through the cultivation of high-value trees on farm there is the opportunity to contribute directly to food supply and nutritional well-being as well as providing income which can be used to purchase food or give protection to the agricultural base upon which food production depends. Global trade now exceeds $US3400 billion and even the most remote regions are being increasingly exposed to commerce. Whilst rural landscapes in the tropics should not become subordinated to the needs of the world's industrial marketplace, the entry point for many small-holder poor farmers to the marketplace may well be intensification through high-value trees (Sanchez and Leakey 1997; Sanchez *et al.* 1997).

The main functional uses of trees with a high economic value will be those providing high-grade timber, fruits and medicines. Here economic value refers to three aspects: (1) consumptive use value (value of products consumed directly without passing through the market e.g. fruits, firewood); (2) productive use value (value of products commercially exploited); and (3) and non-consumptive use value (indirect values of ecosystem functions, such as watershed protection, climate regulation, biodiversity preservation).

Timber Trees

The influence of international trade for timber is now very high and has been for some time. Yet, the consumption growth rates for forest products are highest in developing countries, and in Africa as a region (FAO 1997). Interestingly, of the 22 countries where wood products account for more than 10% of GDP, 18 of these are in Africa (FAO 1997). Even for a small industry such as woodcarving in Kenya, more than 60,000 carvers generate an annual return of US$20 million (Cunningham 1998). It is clear that in Africa, as elsewhere, decreased levels of timber harvesting from natural forests will ensue as increased access to markets, depleted stands and environmental concerns make it less attractive.

The opportunities to grow timber on farmland are great, especially of species with established markets such that on-farm plantings have the potential not only to supplement and but eventually to supplant supplies from natural forest. Mahogany (*Swietenia macrophylla*), one of most prized timbers in the world illustrates this point well. For centuries, the tallest and largest trees have been removed from the wild leaving few, if any, trees behind. This has caused local extinctions as well as dysgenic selection with remaining trees being small or of poor form. It has recently been placed on Appendix II of CITES, and Brazil, the country with the largest natural stocks, has put a moratorium on further logging). Although plantations have been established in several tropical countries over the past 50 years, when grown at any significant density it is attacked by the mahogany shoot borer (*Hypsipyla grandella*). In contrast, when trees are grown at low densities such as in agroforestry systems (Mexico, Brazil, Indonesia and Philippines) trees have a greater chance of escaping devastating attack.

Fruit Trees

Fruit trees are often extremely attractive options for farmers since they not only provide opportunities to generate income but can be consumed by the small holder's family. As with timber trees, the fruits do not have to be marketed internationally to generate significant income. One such example would be the Baobab tree (*Adansonia digitata*). Both leaves and fruit command high prices, as they are often the only available food sources during periods of drought. In Burkina Faso more than 40% of households use *A. digitata* leaves as a vegetable and 85% of what is used is bought in the market where it can fetch up to US$0.70 per kilo (Lamien *et al*. 1996). In Cameroon, Gockowski *et al.* (1997) found that indigenous fruits were ranked as number 1 among non-crop sources of revenue and that 51% of farmers in the humid forest zone were selling indigenous fruits. Ndoye (1997) concluded from a further study in Cameroon that structural adjustment policies and devaluation of the CFA franc have discouraged agricultural intensification and farmers have turned to tree products for income generation. This is in turn has placed enormous pressures on the wild genetic resources of fruit trees necessitating for many species their conservation through use on farm.

Woody Phytomedicinals

Medicinal products from trees can also either be sold or used directly by the farmer. An often understated benefit of growing medicinal trees is that if farmers are able to supply and treat themselves with locally grown medicines they are healthier and thus can work more productively on their food growing enterprises. In Cameroon, sixty percent of the population use tree products of traditional pharmacopeia to treat themselves (Leakey 1997). Many of these people as well as others in Africa and Europe use compounds in bark extracts of *Prunus africana* to treat prostate gland disorders. The pharmaceutical products derived from *P. africana* now fetch more than US$220 million annually (Dawson 1997). Several authors (e.g. Cunningham 1995, Dawson 1997) have pointed out the inadequacy of the natural populations to even meet current demands and the need to plant large numbers of trees, a fact reflected by its inclusion on Appendix II of CITES in 1995. A major bottleneck to on-farm cultivation is sufficient quantities of planting stock and difficulties in handling the recalcitrant seed. This shortage is reflected in the high rural price for seed (US$2 – 8 kg^{-1}) and seedlings (US$0.20 – $0.50 each).

Markets

Whichever tree species is grown on farm, the markets want tree products with a constant, uniform characteristics and elastic supply. Most tree products extracted from natural forests have a relatively inelastic supply whereas farmers can be more elastic in their supply and switch to new species/products. Encouragingly, industry (small-scale and large-scale) have expressed the desire to enter into collaboration to ensure stable and quality supplies of tree products (Leakey 1997).

Dewees and Scherr (1996) provided a comprehensive review of the extent and deficiencies of policy and market studies of tree products. They concluded that of greatest importance is that market information systems are adequate to enable domestication efforts to respond quickly to change. Greatest stability of income will accrue to farmers when a large number of species are cultivated. It is crucial that researchers find ways to ensure that a broad array of genetic diversity in trees is delivered to and maintained by farmers. Strategies for this are evolving (Simons 1996) recognizing that no single approach will suffice for the wide range of species and circumstances.

Agroforestry approaches to poverty alleviation, nutritional security and environmental rehabilitation will become increasingly reliant upon the presence of high-value trees in the system. Considerable scope exists to increase the number and type of these high-value trees in agroforestry systems. To increase the frequency of high-value trees under cultivation, constraints such as inadequate information on cultivation and management, lack of planting materials, paucity of choice and poorly functioning markets need to be removed. The development of tree products from new high-value tree species is a challenge to link tree domestication research with marketing to ensure income generation and food security. Research on input markets (*e.g.* planting material) is as important as research on output markets in understanding smallholder investment in tree cultivation (Koffa and Roshetko 1997).

Conclusion

Although large advances in the domestication and commercialisation processes of agroforestry trees are possible, some caution is required to ensure small-scale farmers benefit. The excessive commercialisation of agroforestry species could lead to outside capital investing in large-scale plantations at the expense of the small-scale farmer (Leakey and Izac 1996). In some situations, the pre-existence of large plantations of a certain species can ensure industries develop sufficiently to make it profitable for small-scale tree growing enterprises to emerge (Cossalter 1996). Attention will also need to be given to the weak bargaining power of many small-scale farmers who face monopolistic buying. This can be done by organisation of producers and primary traders in order to strengthen their positions.

The contributions of tree products grown on farm to local economies, livelihood security and dietary risk minimisation are great. Profitability, equity and sustainability are key advantages over products derived from natural forests or plantations. For these, and other, reasons the future of trees is on farm.

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Trees on Farms in Industrialised Countries: Silvicultural, Environmental and Economic Issues

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Abstract

In industrialised regions, there is at present a trend towards a reduction of the areas devoted to intensive agricultural landuse. Many farmers maintain trees on their properties, while others innovate, by updating traditional agroforestry techniques. One main difference between silvicultural management of small- or large-scale forestry and farm forestry is the presence of a farm (and tree) manager within the system, available for supervising and tending the trees, due to differences in time scales between agricultural and forestry components. Trees are often considered by the general public as a panacea for reducing the adverse effects of industrial development, and even in the scientific literature, the virtues of agroforestry are often described with little reliable scientific background. However a number of well documented scientific studies show the ability of trees to enhance the environmental value of an area. The contribution of trees and agroforestry systems to sustainable management of the natural resource base has been widely proven, in particular to combat widespread land degradation including salinity, soil erosion, soil acidification and soil structure degradation. Despite the difficulties faced when studying the economics of trees on farms, due to the self-consumption of woody products, and to the difficulty in studying the non-commercial value of environmental benefits, many farmers adopt agroforestry for motivations other than financial or direct environmental benefits, such as the social and cultural value of trees within a landscape.

Keywords: Farm forestry, Agroforestry, Sustainable management, Landscape, Multiple-use

Introduction

Although multiple use of land prevailed world-wide at prehistoric times, the expansion and intensification of agriculture since the Middle Ages has resulted in separating forests from fields. Both in the Old World and in the New World, land use has largely specialised, some areas being devoted to agriculture and others to forestry, with the exception of some agroforestry practices which were maintained despite the pressure of industry and mechanisation. However, even nowadays, many farmers still maintain trees on their properties, distributed over pasture land, within hedges or shelterbelts, or as small woodlots.

In many industrialised countries, economic and political pressure as well as environmental concern are now causing a reduction of the areas devoted to intensive agricultural land-use. Some policy-makers consider that the land set aside is now becoming available for small- or large-scale plantation forestry, thus maintaining the barrier between agriculture and forestry.

However, a strong message is being given by dynamic farmers who have started to innovate, by updating traditional agroforestry techniques in order to diversify production, reduce costs, and improve the environment. Farmers generally plant or retain trees on their land for multiple benefits. For example, agroforestry plantings can provide shelter to stock, potentially reducing stock mortality, and protection to crops in extreme wind conditions. These benefits are most relevant to cropping/grazing systems. Surveys carried out in different countries demonstrate that the main reasons for maintaining trees on farms are the following: shade and shelter, conservation and land protection, landscape and farm environment, and more generally reduction of agricultural overproduction, increased diversity of rural production, reduction of timber imports, maintenance of rural employment/rural infrastructure, increased environmental diversity (Anon 1995, Sibbald *in* Étienne 1996, Étienne and Rapey 1999).

In most industrialised countries, there is increasing recognition that many of the current agricultural systems are not sustainable in the long term. Moreover, there is a strong environmentalist pressure against timber extraction from native forests, as well as reforestation with exotic species. In Australia, the widespread clearing of native vegetation, resulting from the introduction of European agricultural systems, has led to widespread land degradation including soil erosion, soil acidification, salinity, and loss of biodiversity. These combined factors have led to an increasing interest in farm forestry and agroforestry systems.

Although the scope of this presentation is not to give a classification of "trees on farms", we will briefly cite a few practices. Traditional "farm forestry" may include small farmer woodlots, hedgerow management, and some aspects of community forestry. Traditional agroforestry includes forest grazing, "dehesa" or "montado" in the Iberian peninsula, wooded rangeland, and various mixtures of agricultural practices with orchards, including grazing and growing vegetable crops, such as central European "Streuobst". "Modernised agroforestry" includes tree plantations on pasture, tree plantations with crops, "timberbelts", alley cropping, "forest farming", riparian buffer planting, "contour plantings", windbreaks, "special products" such as Christmas trees or short rotation biomass production. Large scale afforestation of agricultural land will not be addressed here, as it has been widely studied in other circumstances (*i.e.* Savill *et al*. 1997) and is well documented within IUFRO. Trees which are mainly treated as agricultural crops (with annual harvests) will also be excluded, such as fruit orchards managed solely for fruit production. For further discussion on agroforestry systems and agroforestry practices, on community forestry, farm forestry, and social forestry, readers can refer to Nair (1993) and Sinclair (1999).

Despite the very wide range of practices, from conventional or newly planted farm woodlands through silvopastoral and hedgerow management to individual tree cultivation on pasture or arable land, a number of important issues are common to all types of "trees on farms". In this presentation we shall focus on the tree component of the systems considered, although this may be considered by our fellow-agroforesters as a heresy: it must be kept in mind that agroforestry and farm forestry systems are multiple-agent, multiple-use systems, and that interactions between components are their main characteristic.

Silvicultural Issues

Silviculture is the art and science of cultivating forest crops for all their diverse range of uses and objectives (Savill *et al*. 1997). These objectives may be production of timber or wood products, shade and shelter, protection of the natural resource base, or various other services. Silvicultural activities include site preparation, choice of species, plantation and restocking, weed control, fertiliser use, thinning and pruning and protection from biotic or abiotic damage. A number of questions concern the management of trees on farms. They concern not only silvicultural aspects, but more generally the entire farm or "agroforestry estate" management.

One first question to be raised concerns the type of ***land available for farm forestry***. More precisely, what type of land will become available for i) large scale afforestation, ii) farm forestry, iii) agroforestry? This point has been largely debated in various workshops (Bock and Rondeux 1990, Anon 1992, Welte *et al*. 1994). A statement commonly put forward is that forestry in industrialised countries is a marginal activity: good soils are reserved for agriculture, while forestry is confined to soils on which agriculture is impossible.

Jarvis and Sinclair (1990) stress that up to now good land has been reserved for agriculture, and forestry has been practised on poor land, deemed unsuitable for agriculture. In farm forestry we could therefore be concerned with tree production on good quality deep brown soils of moderate to high fertility. However, Lloyd (1990) argues that the type and location of land potentially "available" will mostly be that which would be designated as "SSSI" (Sites of Specific Scientific Interest), requiring special protection measures. Establishment of small woodlands on such sites would therefore be regarded as of very serious concern for nature conservation, whereas establishing coppice woodlands on land previously in use for cereal production would greatly benefit nature conservation. Bulfin (1990) reports that in Ireland forestry is more profitable, in the long term, than agriculture throughout extensive areas of marginal agricultural soils – particularly the wet mineral lowland soils. But certain areas are likely to be unproductive and possibly not worth planting, and where that land area is also marginal for agriculture, then serious consideration should be given to bringing about a change in land use. In Australia, there is a general perception that farmers will be/are unwilling to devote the most productive parts of their farming systems to agroforestry or farm forestry plantings. However, owing to the increasing emphasis on the potential multiple benefits of trees on farms there has been a considerable amount of research into evaluating the best place in the landscape to locate trees for a range of outcomes including improved water balance, shelter, and biodiversity benefits (Schofield and Bari 1991, Clarke *et al*. 1998).

At the urban – rural interface there is a high urban pressure for residential and/or recreational purposes. The price of land is generally higher when sold for development than maintained for forest or agricultural use. Agroforestry practised in these areas could relieve some of economic and ecological pressures placed on landowners (Nair 1994). This situation has given rise to the concept of "buffer-zone agroforestry systems", in addition to more conventional "urban forestry" or "community forestry". To summarise, marginal land? good quality land? - probably both, depending on the socio-economic context.

Many textbooks concerned with ***silviculture*** provide some indications on farm woodland management (see for example Savill *et al*. 1997). In addition, several handbooks are specifically devoted to farm woodland planning (Insley 1988, Abel *et al*. 1997), farm woodland practice (Hibberd 1988) or farmland afforestation (Bazin 1992), as well as urban forestry (Hodge 1995).

In many areas abandoned by agriculture spontaneous growth of trees leads to poor quality stands, overstocked, heterogeneous from a forester's point of view, but with poor biodiversity, with high fire hazard, and a "closed" landscape (Anon 1999). Introducing grazing — and a livestock farmer — can improve many of these aspects. In some state or community forests, farmers may use the forest for extensive grazing at some periods in the year. This requires a specific agroforestry management — management of the forest and management of the animals — with positive feedback i) to the farmer, as additional fodder, available at specific periods where it would otherwise be lacking, and ii) to the forest manager, for fire prevention, conservation and biodiversity, or landscape management. In rural, and especially upland areas, community forests are most often tended by the local population, mainly farmers, for firewood and possibly grazing, and/or amenity. (Decaix 1994, Bland and Auclair *in* Étienne 1996). Small farm woodlots, representative of most traditional farm woodlands, are very often managed by the farmer as conventional coppice with standards, producing firewood, posts and other services, and sometimes a small amount of timber. An important aspect of farm forestry is the fact that farmers generally do not consider trees as a merchantable crop (contrary to agricultural production), but maintain them for a large number of non-commercial aspects (Étienne and Rapey 1999, Nougarède *in* Cailliez and Lecomte 1999, see "economic issues"). Farm woodlands are very often managed as mixed, multi-purpose stands, generally as coppice-with-standards which offers a large flexibility. Jarvis and Sinclair (1990) propose single-stem coppice, as producing stems of larger diameter is likely to be a more important option today for the production of marketable industrial feedstock. Riparian forests can be managed also for annual non-timber products, such as fruits, nuts, ornamentals or latex (Robles Diaz de Leon and Kangas 1999).

In many newly planted, modern agrisilvicultural plots — "alley-cropping" in the US or "silvoarable" in the UK — trees can often be managed specifically for timber. This requires a high level of tending (i.e. form pruning), but in general in farm forestry, the ***presence of a farm (and tree) manager*** within the system is extremely favourable compared to conventional small- or large-scale forestry. In France in the 1960s a widespread forestry policy of afforestation of abandoned farmland led to a multiplication of "stamp-size" woodlots, (un-)managed by absentee owners. Nougarède (1994) states that afforestation "pulverised into a great number of small dispersed woodlots is irrational and leads to a hostile climate and an irreversible disorder which definitively compromises a balanced management of rural areas". As farm woodlands are very often managed as mixed, multi-purpose stands, this heterogeneity demands high levels of commitment, skill, research, and resources. These can be available in farm forestry, but rarely in the case of absentee owners. Gathy (1990) observed that the majority of species involved in small-scale forestry require pruning and thinning to be carried out rapidly and carefully, and that very often this is unfortunately not performed in conventional small-scale forestry, even in the case of species that tend to fork. Bazin and Guinaudeau (1990) noted that although it is possible to pay contractors it is better to induce farmers to plant trees themselves as it makes them feel responsible for them, and this turns out to be more efficient, and therefore more economical, as labour represents 70 to 80 percent of the total cost of a plantation.

It must be stressed that little is known concerning ***timber yields*** in farm forestry, mainly because forest growth models are generally based on measurements obtained from plots situated within homogeneous forest areas, in order to be representative of a given situation, and to avoid "border effects", which is rarely the case in farm woodlots. Most of the research on farm- and agroforestry is quite recent, and much of this contains data for relatively young growth. There is only limited information available about the long term impact of silvicultural treatments on growth rates (Cabanettes *et al*. 1999). It has been shown that with a "taungya"-type practice, as well as many agrisilvicultural situations, the agricultural crop often benefits the trees (Dupraz *in* Auclair and Dupraz 1999, Gavaland and Cabanettes 2000). This can be attributed to the specific care taken to cultivate the crop, with weed and/or pest control and fertilisation, which are not usually practised with the same intensity — if at all — in conventional forestry, and which spread beyond the crop to benefit the trees. The effect of grazing among trees is unclear, as contradictory results have been observed. Clason (1999) found that grazing improved timber production, but Cutter *et al.* (1999) observed neither improvement nor reduction of wood production.

The management of trees on farmland presents particular ***technical aspects***. The presence of livestock among the trees, in agroforestry, along hedgerows or on plot borders generally requires tree protection: individual "tree-shelters" or fences (Booth 1990). In agrisilvicultural situations individual tree-shelters can also be beneficial, as they serve as indicators of the exact place of the trees at the establishment phase, when they can be smaller than the surrounding crops, and they also protect the trees from mechanical damage due to machinery and from herbicide applications on the crop (Dupraz 1994). Arable land is always transversable by a tractor, unlike some forestry terrain, thus leading to a highly mechanised industry. The adaptation of farm machinery and the use of some agricultural methods, such as weed control, can greatly reduce establishment costs of trees, whether in agroforestry situations or as pure plantations. Agricultural machinery can be either used directly or adapted at a relatively low cost for tree management (Booth 1990). The ever-increasing size of farm machinery has led detractors of agrisilviculture to ban this practice from modern systems, however, it has been clearly shown that planting trees within agricultural crops is quite feasible with examples of silvoarable systems in the U.K., of "agroligniculture" in France, or of alley-cropping in the U.S. (Beaton *et al.* 1999, Dupraz and Newman 1997, Gordon and Newman 1997). Disposal of farm waste products, due to intensive livestock production, by spreading in wooded plots is possible. This is, however, debated, as forest managers are not eager to see their forests converted into landfills. Irrigation is never available in forests, but often on farms, and this can be of great benefit to trees in dry situations. Fertiliser combined with irrigation on the arable plot can spread out to the trees. Weed control is well developed in farming, and much less — and is exposed to great resistance from the public — in forestry. The trees can benefit from the weed control within the crop, however if herbicides are to be used, great caution must be taken not to damage the trees. In agrisilviculture or alley cropping, crop cultivation maintains weeds at a low level, thus benefiting the trees.

Due to large ***differences in the time-scale*** between agricultural and tree components of the system, ***labour*** can become available for tree tending at periods when the demand for agricultural labour decreases. There is more flexibility in tree tending operations than for animals or crops. Jarvis and Sinclair (1990) point out that one advantage that farm forestry may have over large scale afforestation is that it could be designed and managed to spread labour requirements more evenly and fit in more closely to existing annual cycles. Although farm woodlands can have a number of different objectives — shelter for grazing animals, firewood from coppice — the production of high quality timber can be expected, thanks to individual tree care, such as pest survey and management, or form-pruning.

In addition to the tending of trees, the presence of trees within a farm can modify some ***farm management*** techniques. Étienne *et al.* (1994) have pointed out several management constraints with forest grazing. Large forest areas must be grazed, because the forest provides little fodder, often of poor nutritional value. It is often necessary to plan for buffer areas in case of exceptional climatic events (drought, frost). The establishment of areas improved by cultivating, oversowing and fertilising is required to produce fodder of higher nutritional value, and thus allow a higher stocking rate. This entails a stronger grazing impact on the vegetation, which is necessary when grazing is practised with the aim of decreasing fire hazard. Grazing open, cultivated areas is also an alternative for obtaining higher quality fodder. More generally, pastoral management must be adapted to face multiple use as well as multiple users of the forest (Gillet and Gallandat *in* Étienne 1996).

The production of energy from ***biomass from short rotation tree crops*** is one of the promising solar based renewable energy sources currently available to replace the use of fossil fuels. Biomass can be converted into a range of energy forms, including electrical and heat energy, liquid and gas fuels, and charcoal. On a world scale the International Energy Agency estimates that biomass energy sources have the potential to meet 40% of all present energy consumption, and that already these sources are second only to hydro-electricity as a supplier of renewable energy to commercial users. There are already a significant number of projects which involve the utilisation of biomass for renewable energy and other products. In Sweden *Salix* sp. have been extensively planted on farmland as “energy forests”, producing an average yield of 10 to 12 t ha^{-1} yr^{-1} of dry matter in 3- to 5-year rotations (Christersson *et al.* 1993). However, such production can only be reached on soils with sufficient water and nutrient supply, not contaminated by heavy metals. But where energy forestry has been implemented, the farmers have obtained satisfactory results: recovery of the investment is possible in relatively short times, and if necessary it is very easy to return to agricultural or other land uses. A large number of biomass-energy projects include:

- The production of heat through ecologically acceptable wood-energy plants both at the homestead scale and at the community scale;
- The generation of electrical and heat energy by the combustion of biomass residues from sawmills and agricultural crops (co-generation and co-firing);
- The production of combustible gases which can be used to power small scale electrical generators (wood gasification);
- The production of ethanol and methanol for use as a solvent, or as a liquid fuel which can be added to petrol or diesel for use in conventional vehicles;
- The production of oils for use as a pharmaceutical product, and as an alternative to ozone depleting industrial solvents such as trichloroethane;
- The generation of electrical power in tandem with the production of high quality

charcoal for specialist smelting, and for use as a cooking fuel;

The production of activated carbon for use in the purification of water, air and oil, and for the extraction of gold in the mining industry.

Environmental Issues

Trees are often considered by the general public as a panacea for reducing the adverse effects of industrial development, and care should be taken by scientists not to overstate the positive effects of trees. Even in the scientific literature, the virtues of agroforestry are often described with little — or poor — reliable scientific background, with no consideration for the drawbacks. In this respect, Huxley's book (1999), although concerned mainly with tropical agroforestry, provides a large scope of reflection and of sound scientific data applicable world-wide. Given this restriction, a great number of scientific studies show the ability of trees to enhance the environmental value of an area. The contribution of trees and agroforestry systems to sustainable management of the natural resource base has been widely studied, in particular to combat widespread land degradation including salinity, soil erosion, soil acidification, soil structure degradation (Prinsley 1993, Auclair and Dupraz 1999, McAdam *et al*. 1999).

Since European settlement in Australia there has been widespread clearing of native vegetation. Large areas that were previously forested were converted to traditional European agricultural cropping and grazing systems. These shallow rooted cropping and pasture systems generally do not use as much water as the deep rooted native vegetation, resulting in significant increases in recharge to the groundwater system. An increase of recharge of up to two orders of magnitude is typical (Walker *et al*. 1998). This has resulted in a rise in the water-table of more than 1 metre per year in some dryland agricultural areas (Davis *et al*. 1999). This is in part because the patterns of seasonal water use of the introduced agricultural systems are considerably different from native vegetation. The problem is most pronounced in southern Australia which is characterised by a winter dominated rainfall regime. During the winter months when rainfall is greatest, and atmospheric demand is low, evapotranspiration rates are low. While this factor applies equally to native vegetation and agricultural crops and pastures, deep-rooted native vegetation is able to exploit the stored soil moisture. Shallow rooted cropping systems cannot fully exploit this stored soil moisture, resulting in increased rates of deep drainage and groundwater recharge. The introduction of trees into the landscape has been identified as one of the key ways to address this ***hydrological imbalance***. The difficulty, however, is determining where trees need to be placed in the landscape to have the maximum benefit and minimum cost from a sustainability and production perspective. If trees are planted over shallow saline water-tables they may not be sustainable in the long term because of salt accumulation in the root zone of the tree. Trees remove water from the soil leaving the salt behind in the root zone. If rainfall and/or irrigation are not sufficient to flush this salt away from the root zone, trees may eventually die. This process has been modelled in a 21-year-old eucalypt plantation in southern Australia, showing that increases in salt storage resulted in a decline in leaf area index (LAI) and stem growth. The work also demonstrated that in certain scenarios, if the plantation is harvested and the area is returned to pasture, there may be a severe reduction in pasture growth. In the scenario modelled, pasture growth was suppressed for eight years after plantation harvest (Davis *et al.*1999).

The establishment of trees in areas that were previously dominated by pasture is likely to have an effect on ***catchment runoff***. This is because trees generally have higher evapotranspiration rates than pastures owing to a number of factors, including more persistent and higher leaf area, greater rainfall interception and deeper rooting depth than pasture systems (Vertessy and Bessard 1999). The extent to which the introduction of farm forestry activities results in a decrease in catchment runoff is dependent on the proportion of the catchment planted to trees, and the location of these plantations. Upland high rainfall (>800 mm) areas are the most productive regions for the establishment of large scale farm forestry plantations. Reduction of runoff from these upland catchments is likely to result in decreased dilution of salt loads in rivers in the medium to low rainfall areas. ***Soil acidification*** is another significant problem in intensive agricultural systems, which causes significant annual losses of production. There is evidence that trees can help reduce soil acidification, and that some species appear to be more effective than others. However, it should be noted that a reduction of acidity in the soil surface layers results in an increase in acidity deeper in the soil profile (Noble and Randle 1999). ***Water quality*** issues arise from the concern about high levels of fertilisers, pesticides, and other agrochemicals getting into streams and groundwater. The enhancement of root density per unit volume of soil, and better stratification of rooting depths resulting from the species diversity of agroforestry systems provide greater capture and filtering of chemicals moving through the soil to groundwater (Nair 1994). Along riparian buffer zones, trees have proved efficient in reducing pollution of water courses, and particularly for nitrate control (Caubel-Forget and Grimaldi *in* Cailliez and Lecomte 1999). However, Puech *et al*. (*in* Cailliez and Lecomte 1999) have shown that a small number of woodlots scattered among intensive crops were poorly efficient for nitrate reduction, because of drainage systems which concentrate pollutants in streams. If afforestation does indeed reduce nitrates due to lower fertiliser requirements, the afforestation of marginal land not previously fertilised will have little impact. Similarly, arguments in favour of afforestation as a less intensive land-use than agriculture, with a longer cycle of establishment and harvesting, can be counterbalanced by the fact that there will be little impact if agriculture is maintained on the best agricultural land and marginal sites are brought into forest use (Lloyd 1990).

The widespread loss of ***biodiversity*** is a great concern for the general public. There is a strong impulse to improve wildlife habitat by the re-introduction of woody perennials into agricultural land in Europe. Balent *et al*. (*in* Cailliez and Lecomte 1999) have shown that the presence or absence of a roe deer, robin, chaffinch, and song thrush were highly correlated with forest fragmentation, each species exhibiting a favourite spatial distribution of forest patches. One advantage claimed by agroforestry is that it can bring into farmland some of the biodiversity benefits associated with woodland (Stamps and Linit 1998). In the U.K., Burgess (1999) has demonstrated that the development of silvopastoral agroforestry can increase the diversity of invertebrates and maybe birds in grassland systems, and that agrisilviculture can increase the diversity of airborne arthropods, small mammals and possibly birds within arable agriculture. Nevertheless, it must be kept in mind that an increase in diversity may also increase the number of organisms formerly designated as pests — phytophagous insects, slugs, small or large mammals which very often feed on trees or create various types of damage. It is also difficult to attach significant environmental benefits to an increase in common field margin bird species where this results from a loss of the more sensitive species dependent on extensive grazing and woodlands (Lloyd 1990). There remains an important lack of diversity criteria. At the time of writing this manuscript the IUFRO conference on “Criteria and Indicators for sustainable forest management” in Nancy has not yet been held (March 2000), but it is hoped that important results will emerge.

Trees are generally considered as important features of the landscape. Most people consider rural landscapes to be timeless, and resistance to any change is often very great. Forest management can arouse public antipathy, and in areas of great natural beauty can lead to outspoken criticism. Conversely, depending on how land-use management is carried out, there are many opportunities for enhancing the ***landscape value*** of woodlands. Sustainable management should therefore take into account the visual impact on the landscape. The European agricultural landscape is fundamentally an artificial mosaic of fields, wood and water of various sizes or shapes. Jarvis and Sinclair (1990) suggest that the introduction of new areas of woodlands provides considerable opportunity for manipulating the basic features of the landscape in relation to particular design criteria. On the other hand, some valleys in the French Vosges or Jura mountains have in the past been submerged by forests planted by non-resident (urban) landowners, greatly reducing aesthetics and diversity. By re-introducing cattle the extension of wooded areas has been stopped, and some woodlands have been re-spaced and opened up to grazing, resulting in a greater amenity value (Douchet *in* Anon 1999, Letzelter *in* Anon 1999).

It is often thought that trees have a positive effect on the global carbon balance, by means of ***carbon sequestration***. However, this is largely disputed as the carbon balance must be considered over the long term (Dupraz and Auclair 2000). Carbon fixation within timber is in fact only temporary, as furniture or housing lumber has a half-life estimated as 80-100 years, and paper products have a half-life of 1-6 years (Skog and Nicholson 1998). Tree plantations do indeed fix carbon according to their growth rate — usually the land is replanted to trees which fix carbon rapidly in the first years of growth — but when harvested (or at the end of their life) a large amount returns to the atmosphere by decomposition of leaves, litter, branches, roots or processing residues, and only the amount effectively used as wood products is fixed for a certain time. Firewood, paper, posts, and small packages do not fix carbon for very long (van Kooten *et al.* 1999). Carbon fixation within soils is considered more important than within the living biomass, with small amounts in cultivated crop fields, larger amounts in natural grasslands, and relatively large amounts under woodlands, which however lose most of the carbon when they are clear-cut. Van Kooten *et al.* (1999) consider that there is no difference in carbon storage between land-uses. Nevertheless, substituting wood for fossil fuels can greatly reduce the consumption of carbon-producing fuels. This is probably the best manner of reducing carbon emission to the atmosphere, but wood is not the only source of bio-energy, energy-rich annual crops can also contribute positively to the carbon balance.

Agroforestry is being increasingly practised in Mediterranean regions to help ***prevent wildfires***. In silvopastoral systems there are less trees, better managed — pruned, thinned, and generally tended by the farmer — than in natural forests. The lower vegetation, which is generally the site of birth of wildfires, is controlled either by weed control in arable crops, or grazed in silvopastoral systems, therefore is less prone to fires. However, shrub dominant species are more or less palatable according to the type of animal and grazing management — stocking rate, grazing season, supplementation, herding technique. Therefore grazing is not the only solution for maintaining effective fuelbreaks, it must be combined with at least one other fuel reduction technique (Étienne *et al. in* Étienne 1996).

To summarise, there is a general concern that industrialised regions will suffer profound environmental modifications in the near future, with a loss of agricultural and rural employment, a closure of landscapes, and an increase of various ecological imbalances. The integration of forest and agricultural activities can be a solution to help face the problems liable to appear in such a situation, by:

- reducing hydrological imbalance,
- reducing catchment runoff,
- reducing soil acidification and nitrate levels,
- improving water quality,
- increasing biodiversity,
- improving landscape value by diversification,
- improving the carbon balance by fossil fuel substitution,
- participating in fire prevention

However, it must be stressed that if the final objective concerns only one of these points, other, simpler systems may be better adapted. Complex systems such as agroforestry are able to contribute simultaneously to a number of aspects of interest to the environment, and can provide answers to a series of questions which may even appear contradictory.

Socio-economic Issues

The economics of trees on farms are extremely difficult to apprehend, for many reasons. ***Self-consumption*** of woody products, as firewood, posts and sometimes timber, rarely enters into agricultural statistics. Taking into account the ***non-commercial value*** of environmental benefits poses problems, and much remains to be investigated. In most industrialised countries, agricultural and forest production are driven by ***regulations and incentives*** or dis-incentives, which make it impossible to compare different productions on a purely economic basis. Several characteristics of agroforestry systems make them difficult to compare economically and financially with alternative enterprises. They are long term; they offer multiple benefits, many of which are difficult to quantify; and they involve many complex interactions between the tree and non tree components (Prinsley and Moore 1993). ***Legal aspects*** often render tree plantation or harvest, as well as the adoption of agroforestry practices, very difficult, if not impossible. Nougarède (1994) concludes that "in fact, it is impossible to determine the economics of any “agro-silvo-pastoral equilibrium”.

Nevertheless, economic calculations have been attempted in many different situations. Sibbald (*in* Étienne 1996) noted that economic results vary with authors and/or economic models, and Price (1995) concluded that agroforestry does not offer extraordinary benefits of the financial or non-financial kind at the farm scale, but there could however be differences at the community or regional scale. Thomas (1990) stated that on good grazing land agroforestry would not be an attractive option for farmers, but that on poorer quality land the situation alters dramatically. In an case study in Scotland, Sibbald (1990) concluded that the best economic option would be to reduce the original livestock farm area by 63 percent in favour of afforestation, and with 10% of the land improved the flock number could increase and annual income be maintained. In a case study in Australia, Campbell *et al*. (1999) showed that eight out of the ten farms studied can expect direct positive returns from their agroforestry enterprise. In three of the cases, the annualised value of income was 25% greater than that which would have resulted without tree planting. Analysing hedgerows, Bazin (1992) found that timber production in well managed hedgerows is far from insignificant in the economics of a farm as well as at a larger regional scale. Dupraz (1999) found that in some situations agroforestry can give greater economic benefits than monocrops, even with no biological benefits from the plant association. From an extensive study of agroforestry farms, he noted that some biologically successful agroforestry systems may be rejected, whereas some poorly efficient agroforestry systems are readily adopted by farmers. In a comparison between agricultural, agroforestry, and forestry practices, Gavaland and Cabanettes (2000) found that a pure agricultural crop produced in the short term higher financial benefit than the same crop in association with high quality timber, or in association with short rotation woody trees for energy, afforestation with high quality timber trees producing the lowest benefit. Robles Diaz de Leon and Kangas (1999) however noticed that non-timber products, such as fruits, nuts or ornamentals, can add some financial value to trees which would otherwise be of little value.

Economics are difficult to compare between different systems on an equality basis, without distortions by competing grants. For instance, various incentives often exist in favour of agricultural crops or farming, and in favour of forestry, but are non-existent for agroforestry. Sibbald (*in* Étienne 1996) noted that without subsidy for the forestry component, silvopastoral systems could generate returns at least equal to sheep-based farming systems, but according to the type of incentive, one can obtain either a small reduction in return from the silvopastoral compared to the purely agricultural system, or a higher return from the silvopastoral system than from pure farming.

Many economic analyses do not take into account the positive ***effect of trees on agricultural productivity*** due to water management, the provision of shelter and reductions in erosion. To account for this, in their case study concerning ten farms in Australia, Campbell *et al*. (1999) modelled a basic ‘degradation’ scenario, which assumed that, without trees, farm productivity would decrease with a 10% decline over the time of the project. When incorporated into the evaluation, the sustainability analysis showed that environmental benefits from the trees may translate to significant economic benefits that will be realised through increased agricultural production.

A major difficulty in comparing different management options concerns the ***time scale***. Most agricultural productions are apprehended on an annual basis, whereas the other economic characteristic of investment in trees is the long-term nature of the investment. The establishment costs, combined with cost of taking land out of annual agriculture, has a doubled effect on farm cashflow. Farm cashflow can be significantly reduced in the first few years, followed by sustained lower annual cash incomes until harvest. However, Mary *et al.* (1999) suggest that economic evaluations can be envisaged in the short- or medium-term, instead of long-term, because a farmer's decision is taken in a very uncertain context concerning the value of timber harvested at the end of the rotation.

Due to the difficulty of determining the economic benefits of farm- and agroforestry generically, the case study approach has been implemented by several authors (Étienne and Rapey 1999, Campbell *et al*. 1999). Their aims were to identify, describe and where possible, quantify the economic, environmental and social impacts of farm- and agroforestry on the farm family and business. They were based on descriptions of land-use, farm and livestock management, agroforestry and forestry techniques, valuation of agroforestry and forestry realisations, and farm, forest and household perspectives. Key decision criteria, priorities for forestry and agroforestry development actions and professional perspectives for the farmer were identified. The logic was that tree planting (and associated costs) indicates a conviction by the farmer that there are positive benefits to be gained from integrating trees into the farming system (Campbell *et al*. 1999).

A key factor determining the economic viability of trees is where they are placed in the landscape. This is often not dictated by the best soil type for growing trees. The opportunity cost of the investment (the land use displaced by farm forestry) drives the need to match farm enterprises to the land capability. Farmers that have planted trees on land with the lowest opportunity cost are getting the best economic performance from the farming system as a whole because they are endeavouring to match land capability with enterprises that maximise the per unit return on that land (Campbell *et al*. 1999).

In most cases, trees are actively employed to address economic and environmental issues simultaneously. In every case, both environmental and economic issues are considered. However, the final emphasis on environmental or economic motivation varies depending on the current physical and financial state of the farm, as well as individual perceptions of the challenges that face the farmer and the tools available to address these challenges (Campbell *et al.* 1999). When studying farmers' attitudes towards agroforestry, Étienne and Rapey (1999) observed many other motivations than financial or direct environmental benefits. Mid-term and long-term expectations not necessarily linked with forest production are generally combined, such as:

- a reduction of farm activity,
- a means of securing succession,
- timber capitalisation,
- preservation of the environment for future generations,
- creation of a diversified landscape and improved aesthetics for ecotourism,
- use of woodlots as shelter for grazing animals,
- wildlife management,
- reduction of the risk of crop loss through diversification
- reversibility of agroforestry, contrary to afforestation which is less "reversible" both biologically and legally.

The above case studies demonstrate that effective planning and ex-ante evaluation at the project and the whole farm level can prevent costly mistakes. Effective planning and basic economic evaluation can be used as tools to optimise the economic aspects of a plan with environmental objectives. A number of economic decision support tools have been developed in many countries, aiming at:

- reducing landholder uncertainty in relation to financial impacts of implementation of farm forestry or agroforestry on the farm business, and
- improving the ability of farmers and farm advisers to interpret complex biological, financial and legal information into information that can be used to support their decision making.

Several economic models are now used to support agroforestry decision making. Among others, we can cite FARMTREE, developed in Australia and "Agroforestry Estate Model"

(AEM), developed in New Zealand, which provide a sophisticated definition of the proposed planting program, silvicultural regime and integration of the forestry component with the existing agricultural land uses. Several forest stand growth models and simulation packages (STANDPAK, CAPSIS) have integrated modules which take agroforestry practices into account. Most models cover a comprehensive array of project outcomes with considerable scope for sensitivity analysis of results. However, for these models to be directly accessible to farmers or advisers, extensive training would be required. Spreadsheet based models such as ARBUSTRA (Dupraz and Liagre 1997), BEAM (University of Wales, Bangor, U.K.), BLUEBELTS or AGROFORESTRY CALCULATOR (Campbell *et al*. 1999) are more user friendly but less comprehensive. They provide economic evaluations of agroforestry in comparison with existing land uses, on the basis of predefined production cost and management information associated with agricultural and forestry enterprises. They do not directly simulate tree growth but rather draw heavily on the expertise of local advisers who can provide a "best bet" estimation of how trees will perform in a variety of conditions.

The above models provide economic evaluations, however, Étienne and Rapey (1999) noted that a strictly market-based assessment is largely insufficient, even if it takes into account patrimonial aspects and amenities, because farmers' decisions are often influenced by spatial organisation. They used a resource dynamics model (RDM) developed by Étienne and Herlant (1997) to predict the effects of agroforestry development on livestock and timber production as well as on labour organisation and amenities. It is based on observed and simulated changes in the farming layout, related to productive and non-productive resource dynamics. The simulation of various scenarios resulted in new questions being raised by the farmers, concerning for example the types of future landscapes and their conceivable dynamics, or the efforts required for management of the new woodlands. With the increasing value given to environmental and aesthetic objectives, there is still a need to develop new adapted indices such as biodiversity, wildlife management and valuation, landscape beauty and living conditions quality. This work has been pursued further by applying landscape visualisation and design software to the farmers' projects (Auclair *et al*. 2000). The effects of various scenarios on the visual aspect of the landscape provide a basis for discussion between partners concerning spatial organisation, such as the layout of forest and agricultural plots.

The ***social and cultural value*** of trees within a landscape is often very important (Herzog 1998), if not always explicitly described. There is a positive social impact at the personal and family level. The most common community impact comes through increased involvement with the community, but in some cases agroforestry produces positive economic benefits to the community as well (Campbell *et al*. 1999). Nougarède (*in* Cailliez and Lecomte 1999) observed that farmers manage their woodlands as they grow older (>50), whilst the young generation devotes itself to agriculture and breeding. In the context of rural decline, one of the advantages of agroforestry is the fact that the trees remain within the farm management system, contrary to afforestation: the farmer therefore benefits from annual income from the farm as well as the other expectations from the trees. Maintaining rural employment is a key issue within industrialised countries.

Gillet and Gallandat (*in* Étienne 1996) point out that the social and cultural value of trees has a global impact on a great number of multiple "users". From an economic point of view, the main users of wooded pasture are agricultural businesses, even though in some regions the revenue generated by trees is quite significant. But a wide variety of occasional users are appearing in growing numbers and importance: walkers, skiers, horse riders, cyclists, picnickers, hunters, gatherers, etc. The tourist attraction of wooded pastures is considerable, although difficult to measure. The sometimes divergent interests of these different types of users generate conflicts which are often difficult to reconcile.

Legal aspects concerning trees on farms, and particularly agroforestry, can vary greatly not only between countries, but also between small regions within a country. For instance in the US agroforestry implementation is very much linked with natural resources conservation

(Buck 1995). In Europe, up to recent times, a very conservative position has been maintained by the pressure of both forestry and farming interest groups, but innovative farmers are progressively leading the way towards the adoption of better adapted regulations (Dupraz 1994).

Discussion and Conclusion

At the conference on "Agroforestry and land-use change in industrialised nations" in Berlin, P.K. Nair (1994) underlined the rather rigid focus of land-use institutions on long-established conventional agriculture and forestry disciplines. At that time it was considered impossible to revamp the existing strong and influential infrastructures for agriculture and forestry, and, while great strides were being made in the developing world, institutions in industrialised countries were unable to direct agroforestry program development.

Nevertheless, research programmes have been implemented in several countries in collaboration between governments, industry, and research organisations (Auclair and Cailliez 1994), to address some of the barriers to commercial farm forestry development. An Australian national strategy framework for agroforestry (RIRDC 1996) identified four groups of impediments:

lack of farm forestry culture,

economic uncertainties,

public policy issues,

distorted markets.

The strength of these new research and development strategies in Australia has been the close working relationship that has been developing between researchers, advisers and policy makers, local government and processors, educational institutions, landholders, farmers and industry at the national and regional levels.

Forest scientists are now facing new issues, with new types of land available, new types of silviculture — or more precisely, of farm- and agroforestry management. As Jarvis and Sinclair (1990) pointed out, there is now a range of interesting species and silvicultural options not previously practical, and for which there is little or no background knowledge. We are facing not one single system, but many (silvi)cultural options according to the objectives — immediate income, capital building, amenity, conservation. Using a single piece of land for multiple objectives increases management complexity, but allows continued flexibility with regard to the balance of tree and agricultural production in the future. This complexity is another challenge to research, which was until now very mono-disciplinary. Foresters, and forest scientists, will have to consider not only trees and tree stands, but also farmers, whose objectives will mould the most suitable set of designs and management regimes for farm trees in each particular situation. Forest scientists will need to open up to multidisciplinarity. As Nougarède (1994) stated, biological and technical research must produce applicable models, new management objectives must be socially — and economically— acceptable, if new regulations and incentives are implemented they must not hinder classical agricultural and forest activities.

Confronted to these new challenges, we not only join T. Simons in stating that ***the future of trees is on farms***, but also that ***the future of forestry research is on farms***.

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Timber Production in Tropical Agroforestry Systems of Central America

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Abstract

Two of the most important changes in the agroforestry research agenda over the last 20 years have been with respect to the attention given to perennial rather than just annual crops, and the commercial productivity of trees in addition to their service functions. Interest in the potential of timber trees on tropical farms has increased, and in the humid tropics more emphasis is now given to agroforestry systems with perennial crops. Partially as a result of this shift of focus, agroforestry is now widely studied and promoted for diversifying and sustaining productivity of high quality agricultural land in addition to the previous emphasis on the recovery of degraded land or making productive use of marginal land. Interest in alley cropping systems has been reduced drastically, especially in the dry tropics, while there is an increasing recognition of the existing role and potential of silvopastoral systems and agrisilvicultural timber plantations, both for diversified production (in order to improve cash flow and reduce risk) as well as a means to improve site conditions; i.e., the potential contributions of trees to both ecological and economical sustainability of Central American farms has been recognized. In this paper, three examples of tropical agroforestry systems, which produce timber products, are discussed: multistrata agroforestry systems with perennial crops (e.g., coffee, cocoa); small woodlots on private farms, established with the Taungya systems; and silvopastoral systems which include a timber component. After presenting data from case studies, emphasizing the regional importance of timber productivity from these systems, some of the lessons learned from these medium-long term experiences are discussed. These include research methods (both experimental and survey approaches) and the selection of components and systems. The integration of socioeconomic and biophysical research, and of the results obtained at different scale levels, is also discussed.

Keywords: *Cordia alliodora*, Research methodologies, Selection criteria, Shade trees, Silvopastoral systems, Taungya

Introduction

Tropical timber production statistics usually only refer to the productivity of pure tree plantations and natural forests (FAO 1999) and texts on silviculture concentrate on plantations (e.g., Evans 1992) or natural forest management (e.g., Dawkins and Philip 1998). Nevertheless, in the case of some valuable timber species, such as *Cordia alliodora* in Latin America, a high percentage of the harvested volume comes from farms, usually from agroforestry systems such as associations with pastures (silvopastoral systems) (Souza de Abreu *et al*. 2000, Berti 1999) or with perennial crops (agrosilvicultural systems; e.g., with coffee (*Coffea* spp.) or cacao (*Theobroma cacao*)) (Somarriba and Beer 1987). Furthermore, the establishment of small timber plantations (woodlots) on farm may be carried out with crop association during the establishment phase; i.e., the Taungya system (Jordan *et al*. 1992). Due to continuing deforestation of the natural forests in the region, these systems are increasing in importance (Current and Scherr 1995). The potential of agroforestry systems for sustainable land use has long been recognised (Young 1989) but their potential to produce commercial timber has only been reported in a small percentage of the agroforestry literature (e.g., articles in the journal *Agroforestry Systems*). This paper provides an overview of the principal agroforestry systems that contribute to timber production in Central America, their productivity and some of the considerations involved in their successful adoption, such as germplasm selection criteria (socioeconomic and biophysical) that take into account crop characteristics and management.

Agroforestry Systems with Perennial Crops

In the lowland and mid-elevation humid tropics of Latin America, perennial crops such as cacao (*Theobroma cacao*) and coffee (*Coffea* spp.) are of huge economic and ecological importance because of their contributions to export earnings and employment, as well as their service functions (e.g., C sequestering, biodiversity conservation, water yields) (Beer *et al*. 1998). Timber, fruit and/or "service" (do not provide commercial products; managed only for the benefit of the crop) shade trees are included in the majority of these plantations (Perfecto *et al*. 1996). In the five principal coffee producing countries of Central America, coffee plantations cover 857,000 ha of land (Galloway and Beer 1997) and if they were all to produce an average commercial timber yield of 4 m^3 ha^{-1} yr^{-1} from the shade trees (Beer *et al*. 1998), the potential production would be close to 3.5 million m^3 ha^{-1} yr^{-1} of valuable cabinet timbers such as *C. alliodora* and *Cedrela odorata* (Table 1). This estimate may be exaggerated since most of the available data on timber production in coffee plantations comes from the more humid lower (hence hotter) zones, where growth rates are presumably higher. Moreover, in optimal coffee zones (generally >1000 masl) farmers use less or no shade in their plantations. On the other hand, much higher timber productivity from shaded coffee plantations has been recorded (Beer *et al*. 1998), and since the service functions of coffee agroforestry systems (for society) are becoming recognized and financially rewarded, the farmers' motivation to retain or increase the tree (and hence timber) component of their coffee plantations is increasing. This is especially apparent in Costa Rica, once the regional leader in the conversion of shaded to unshaded coffee (Perfecto *et al*. 1996), but now a leader in planting timber species in coffee (Tavares *et al*. 1999, Viera *et al*. 1999). A second example can be found in El Salvador, where a World Bank supported project is promoting environmentally friendly coffee production, particularly to benefit migratory birds (Wille 1994). The coffee produced in this way will be certified and will receive a premium price in North America.

The widespread occurrence of farmers protecting and managing naturally regenerated timber trees in pastures, perennial crop, and even in sugar cane plantations (Somarriba and Beer 1987), demonstrates that they do recognize the value of trees in their farming systems; e.g., to diversify their farms and hence reduce financial risk (Ramirez *et al*. 2000). The indigenous Ngöbe people of Panama successfully adopted the technology of inter-planting *C. alliodora* in semi-abandonned cacao once they recognized that this timber species could be managed as another crop (Neri *et al*. 2000). One reason for this success is that growth rates of *C. alliodora* can be exceptionally high in the optimal conditions provided in perennial crop plantations (drainage, weed control and fertilization plus wide tree spacing), especially in the lowland alluvial soils in humid areas which are often used for cacao production; e.g., in cacao-plantain (*Musa* AAP) systems in Bocas del Toro, Panama, average *C. alliodora* dimensions of 36.6 cm and 25.6 m have been recorded after eight years (Somarriba *et al*. 2000b).

Factors which mitigate against timber production in perennial crop plantations include tree felling damage to underlying crops; e.g., in Costa Rica, the net income from the timber was reduced by \$10 – 17 m^{-3}, depending on the coffee productivity and its price, to compensate for coffee damage due to tree felling and extraction (Somarriba 1992). Coffee or cocoa yield reductions, due to competition from trees (light, water, nutrients; Beer *et al*. 1998), limits the number of mature timber trees to less than 100 ha^{-1}, even for small crowned species such as *C. alliodora* (Beer 1992). On the other hand, real timber prices are likely to increase in the future while crop prices are gradually declining (Gomez 1995, Ramirez *et al*. 2000), and there are many options to minimize tree felling damage in these systems (Somarriba 1997).

Woodlots Established with Annual Crop Interplanting (Taungya)

The intercropping of tree plantations with annual crop species is still an exotic agroforestry system in Latin America, in contrast to Asia where the system became widespread in the 19th century, or Africa where it was introduced by the British colonial governments during the last century, in both cases to transform natural forests into timber plantations.

The involvement of farmers, who practised shifting cultivation, in the management of state plantations, stabilized migration and increased the livelihood of many rural landless households, although the creation of dependence of landless farmers on these systems was strongly criticized (Jordan *et al*. 1992). In the new world, most of the experience with intercropped tree plantations has been on-station or in on-farm trials. These have focused on tree establishment in association with annual crops in order to achieve early financial returns and provide incentives for reforestation without completely losing the agricultural productivity of the reforested land of small or medium sized farms (e.g., von Platen 1996). However, the system has also been used on larger commercial private farms; e.g., the field workers of a 250 ha farm in San Carlos, Costa Rica were allowed to cultivate annual crops in forest plantations during the establishment phase and sell the products. Compared to pure reforestation, this practice lowered soil preparation, weeding, pest and fire control costs by 51 to 68% (Rodriguez 1998). During the last 20 years about 10,000 ha yr^{-1} were reforested with incentives in Central America (Godoy 1997). Growth rates have been estimated at 10 to 30 m^3 ha^{-1} yr^{-1}, depending on site quality, tree species and plantation management (Volkart and Cano 1982, Vásquez and Ugalde 1995) and hence the potential timber production from these plantations can be estimated at 2,000,000 - 6,000,000 m^3 yr^{-1} (Table 1).

Timber species such as *Acacia mangium, Alnus acuminata, C. odorata, C. alliodora, Eucalyptus camaldulensis, Eucalyptus deglupta, Eucalyptus grandis, Gmelina arborea, Pinus caribaea, Swietenia macrophylla, Tectona grandis* and *Terminalia ivorensis* adapted well to association with annual crops such as *Colocasia esculenta,* Cucurbitaceae, *Dioscorea alata*, *Manihot esculenta, Oryza sativa, Phaseolus vulgaris, Xanthosoma sagittifolia, Zea mays* or *Zingiber officinale*; i.e., compared to pure tree plantations, tree survival after transplanting and early growth were only slightly reduced or even were improved by association with crops. Positive effects were due to partial shade for facultative pioneers and an improvement of soil humidity, structure (result of soil tillage for crops) or fertility (result of crop fertilization and/or crop legumes) (Somarriba *et al*. 2000b).

Table 1. Potential timber production from three agroforestry systems in Central America.[1]

	Coffee plantations[2]	Taungya	Silvopastoral systems
Area (ha)	857,000	200,000[3]	9,200,000
Average productivity (m^3 ha^{-1} yr^{-1})	4	10 – 30	2
Potential productivity (m^3 yr^{-1})	3,428,000	2,000,000 - 6,000,000	18,400,000

[1]Commercial saw log volume only
[2]Costa Rica, Nicaragua, Honduras, Guatemala and El Salvador only
[3]Total area of tree plantations established in Central America with reforestation incentives (average of 10,000 ha yr^{-1} during the last 20 years; Godoy 1997)

The initial densities of pure and mixed timber plantations were often the same (2.5 x 2.5 to 3 x 3 m), although initial tree spacings of 3 x 6 m extend the cropping period and can rapidly produce saw logs of good quality (stem diameter and stem form) (Kapp and Beer 1995). The optimal tree-crop distance depends on the competitive behaviour of the tree and crop species; e.g., with *Z. mays*, a 1 m separation gave good results for *C. alliodora* seedlings but *E. deglupta* competed successfully with only a 40 cm separation. However, when combined with *M. esculenta,* a minimal tree-crop spacing of 120 cm was needed for both tree species (Schlönvoigt and Beer 2000).

C. alliodora is a species that responds well to improved soil conditions, especially to drainage and soil fertility (Schlönvoigt and Schlönvoigt 2000); i.e., benefits that can obtained directly from association with crops if competition for light is correctly managed. Five-year-old *C. alliodora* on alluvial soils in the humid lowlands of Costa Rica, which had been interplanted with three *Z. mays* crops, followed by one *Z. officinale* crop and finally interplanted with the fruit shrub *Eugenia stipitata*, compared to a pure *C. alliodora* stand, had stand densities and total stem volumes of 258 and 465 trees ha^{-1}, and 96 and 65 m^3 ha^{-1}, respectively (Kapp and Beer 1995). Timber yield increases from crop association may be lower for species adapted to poor soil conditions because their response to soil improvement is poor; e.g., *A. mangium* on the same site only produced 65 *vs.* 62 m^3 ha^{-1} in Taungya and pure plantations, respectively. High productivity, short rotation systems of species with a high resprouting potential (reduced reforestation costs) have high adoption rates by farmers (Nascimento de Almeida *et al*. 1999).

In Central America, the productivity of woodlots associated with annual crops has been studied mostly for short rotation firewood species. The association of *A. acuminata, Eucalyptus globulus* and *Casuarina equisetifolia* with annual crops, in the Achiguate watershed, Guatemala, produced 152, 362 and 125 m^3 ha^{-1} of firewood, respectively, after five years (Leiva 1993). Even when firewood production was similar or slightly higher in pure plantations (135, 366 and 125 m^3 ha^{-1}, respectively) the best financial return was achieved with the Taungya and the pure agricultural systems compared to pure forest plantations. Nevertheless, when the environmental services of trees in watersheds are considered, then the Taungya system is the most attractive land use system.

Silvopastoral Systems

In Latin America, more than 90 million hectares of land is under pasture, mostly as a result of forest conversion to cattle ranching (FAO 1999). Nevertheless, valuable timber species, such as *C. odorata*, *C. alliodora*, *Pithecellobium saman* and *Albiza* spp., retained at low tree densities (4 to 15 trees ha^{-1}), are common in the tropical lowland pastures (Camargo *et al*. 2000, Souza *et al*. 2000) and in the highland regions, where intensive dairying is practised, there are good examples of planted and natural regeneration of *A. acuminata* in pastures (Russo 1990) and *Cupressus lusitanica* wind breaks (Harvey and Haber 1999). Livestock farmers in the region recognize the potential of valuable timber trees in their pastures to generate income to buffer low animal product prices on the national and international markets (Pomareda 2000). Profitability of small Costa Rican dairy farms is increased, especially when labour costs increase, by diversification with high valued timber species such as *C. alliodora* (2,188 *vs.* 1,478 US$ $farm^{-1}yr^{-1}$ for farms with and without the trees) (Holmann *et al*. 1992). Small cattle farms may be more dependent on timber resources to generate income; e.g., timber extraction per unit area in Esparza, Costa Rica was higher on small cattle farms (1.35 m^3 ha^{-1} yr^{-1}) compared to medium (0.55) and large (0.13) farms (C. Viera and C. Barrios, pers. comm. 1998). Small and medium cattle farmers in Matiguas, Nicaragua, can use their timber stock as a guarantee to obtain credits to improve pastures and to plant more timber trees (Barrios, pers comm. 1999).

Silvopastoral systems have an estimated commercial timber productivity of 2.0 m^3 ha^{-1} yr^{-1} (Holmann *et al*. 1992, Camargo *et al*. 2000) and hence the estimated 9.2 million ha of pasture land in Central America (Kaimowitz 1996) have the potential to produce 18.4 million m^3 yr^{-1} (Table 1). These estimates were based on the fact that about 50% of these pastures are found in the drier areas where timber productivity was assumed to be 40% lower than that of the humid sites (Stewart *et al*. 1992). However, timber production potential may have been overestimated because a high percentage of these pastures are on degraded land. For example, the productivity of *C. alliodora* in pastures is low due to the low stocking rates and in some cases infertile compacted soils (0.6 to 2.0 m^3 ha^{-1} yr^{-1}) (Lopez *et al*. 1999, Camargo *et al*. 2000).

The recent interest of developing countries to purchase carbon sequestered in forest and agroforestry ecosystems may provide tropical farmers with further incentives to adopt silvopastoral technologies. Traditional silvopastoral systems in San Carlos, Costa Rica, have about 50 tons carbon ha^{-1} stored in the commercial timber which could generate an additional US$400 income if the price for sequestered carbon was $8 ton^{-1}. Trees also provide other ecological services in pastures including a reduction of heat stress of animals and nutrient cycling. Milk yields of dairy cows with access to tree shade were 20% higher compared to yields obtained from cows without shade (Souza *et al*. 1999).

Cattle farmers may select timber species with small crowns (e.g., *C. alliodora*, *C. odorata*, *Albizia* spp. and *Platymiscium pleiostachyum*) to reduce competition with grasses for light and to sustain high yields of animal products (Harvey and Haber 1999, Souza *et al*. 2000). Nicaraguan and Costa Rican cattle farmers may protect timber tree seedlings in pastures (C. Barrios, pers. comm. 1999) but in one study in Costa Rica, more than 60% of the damage observed on young timber trees was due to indiscriminate chopping and herbicide use (Camargo *et al*. 2000). In Cuba, the exotic timber species *Khaya nyasica* and *Khaya senegelensis* grew moderately well in mixtures with *Panicum maximum* grass, with mean tree height and breast height stem diameter of 8.5 m and 11.9 cm, respectively, at age nine years, but sheep grazing resulted in debarking of trees (Renda *et al.* 1999). Studies conducted in the Chaco region of Argentina also showed that grazing management is crucial to promote natural regeneration of valuable timber species (*Geoffroea decortican, Schinopsis balansae* and *Prosopis nigra*) in pastures. The percentage of tree damage decreased from 65 to 48% when pasture availability increased from 3.1 to 5.0 ton DM ha^{-1}, though some tree species were more tolerant of grazing (Simon *et al*. 1998). Direct seeding in cow dung instead of in the soil resulted in less browsing (0.4 *vs.* 6.5%, respectively) and trampling (17 *vs.* 56%, respectively) damage of *P. saman* in grazed pastures (Barrios *et al*. 1999). Establishment of timber species with improved exotic grass species, such as the Brachiarias that are being promoted in Latin America, may not be successful because these grasses are very competitive. For example, in the acid soils of Caqueta, Colombia, *Enterlobium cyclocarpum* had lower growth rates in mixtures with *Brachiaria decumbens* (0.4 m yr^{-1}) compared to combinations with native grasses (0.7 m yr^{-1}) (Cipaguauta *et al*. 1999).

Evaluation of Timber Productivity in Agroforestry Systems

Traditional experimental designs and approaches, used for agricultural and forestry research, are frequently inadequate for the study of timber production in agroforestry systems (Somarriba *et al*. 2000a), especially since the majority of the studies have to be carried out on-farm. Major limitations are:

1. Wide tree spacing (8 m) results in large plots and experiments (0.25 and 2.25 ha, respectively, for only three complete blocks of three species). This is not feasible on most farms, or an inadequate number of core plot trees per plot (<16) is used if plot size is reduced.
2. Most small-medium farms require spatially variable management of irregularly sloping and inhomogeneous sites where the underlying assumptions of traditional designs are not fulfilled (e.g., variances may not be homogeneous; variance intra-plot > intra-block > inter-block).
3. In the case of medium-long term tree species trials in agroforestry systems, it is usually impossible to maintain all factors (except species) constant because the permanence of the system will depend on adapting pruning and thinning, as well as other management activities (e.g., weeding), to the characteristics of each tree

and the needs of the underlying crop or pasture. Hence trials become contrasts of systems, in which many factors vary, rather than species comparisons (e.g., Boulay *et al*. 2000).

4. The time frame required to establish and evaluate a complete harvest cycle for timber trees (usually >10 years; often >20 years) is unacceptable for the clients of the results, such as development programmes and farmers' groups.

The alternative is to use survey rather than experimental approaches (Coe 1999), where one attempts to describe and quantify site and management factors, in addition to tree productivity, and hence infer conclusions such as identifying the optimal growth conditions for each tree species and/or the effect of key factors on tree productivity, such as the nature and management of associated crops/pastures. The risk that confounding factors compromise the reliability of results, and the need for a large number of samples, is obvious. Valuable information can be obtained by quantifying tree volumes during commercial harvesting if there is reliable information on tree ages (e.g., Somarriba and Beer 1987). Permanent plot studies can be used to complement and check data obtained during logging but again the heterogeneity and small size of tropical fields limits extrapolation of the results (Somarriba *et al*. 2000b).

The socioeconomic factors (laws, traditions, regulations, incentives, etc.) that influence the removal or establishment of timber trees on resource poor tropical farms (Kaimowitz 1996, Berti 1999) are inadequately understood even though they are probably the main barrier to adoption of improved land use. This is one research area where scaling issues, and integration of information from different scales (farm, community, national) must be considered.

Selection of Agroforestry Systems and Timber Species for Specific Biophysical and Socioeconomic Conditions

In the case of small farmers, the criteria to select on-farm sites and methods to plant timber trees may be completely different to the traditional approach to reforestation; e.g., instead of using the worst land available for high density tree plantations, the small farmer will often prefer a rapid, less risky timber production from permanent low tree density agroforestry combinations on better agricultural land (Current and Scherr 1995). The failure of alley cropping, at least in the seasonally dry tropics (Carter 1995), clearly demonstrated the need to pay more attention to matching agroforestry systems to local conditions. Even within the same ecological zone, the interaction of biophysical and socioeconomic factors leads to clear differences in the way a particular agroforestry system is managed; e.g., the shade structure of coffee plantations (Llanderal and Somarriba 1999). Within a farm and even plantation, micro-site differences are important for species selection; e.g., *C. alliodora* mortality in one line planting trial varied from 0-100% per plot due to minor differences in the water table (Kapp *et al*. 1997). Finally, farmers in the tropics often take advantage of heterogeneity within their fields (e.g., to mix species in home gardens; Mendez *et al*. 2000) while modern intensive farming and research methods are usually designed to eliminate heterogeneity within a field (Guharay *et al*. 2000). The selection of on-farm sites, where timber trees could be incorporated with crops/pastures, also has to take into account neighbouring land use; e.g., timber species, such as *E. deglupta* and *Terminalia ivorensis* in boundary lines, can reach 20 m height in as little as five years (Kapp *et al*. 1997) resulting in significant shade, and maybe root competition, for the same horizontal distance (Akbar *et al*. 1990). If an adjacent farm is used for cacao or coffee, the possibility that tree-crop competition will provoke future conflict between neighbours will be much less than when shade sensitive annual crops are planted.

Although species-site matching (biophysical characteristics) is a basic concept for any reforestation activity, the decisions are much more complicated in agroforestry programmes, especially those dealing with small-medium tropical farms where the socioeconomic factors can lead to very different decisions on adjacent farms. For example, many coffee farmers in Costa Rica replaced traditional "service" shade trees with *E. deglupta* in the late 1990's, apparently because this reduced management costs (pruning of the "service" shade trees) rather than because of the timber value of the fast growing *E. deglupta* (Tavares *et al*. 1999). In silvopastoral systems, the ability of a species like *A. mangium* or *T. grandis* to tolerate physical damage (e.g., animals rubbing against tree trunks), browsing and compacted soils (Kapp *et al*. 1997, Bolivar *et al*. 1999) are important criteria if early grazing amongst the trees will occur.

Compared to pure forestry operations, in agroforestry systems there are additional criteria for timber species selection due to crop needs (e.g., allowable shade levels) and/or as a result of agricultural management (e.g., intensity and timing of grazing). Again different scales need to be considered. "Organic" certification will usually be at the farm rather than crop (plantation) level and hence on "organic" farms, tree selection criteria will include potential to sustain associated crop production in the absence of inorganic fertilizers as well as tolerance/resistance to pest/disease problems that would require agrochemical protection (e.g., leaf cutter ant [*Atta* spp.] damage of *E. deglupta*). In the tropical lowlands, where there are rice, banana and other agroindustrial crop plantations, aerial spraying limits the planting of any tall trees on surrounding farms.

Agricultural practices can modify site conditions to favour certain timber species. Planting *C. odorata* or *S. macrophylla* in pure plantations or open grown conditions (e.g., in pastures) invariably fails because of attack by the shoot borer *Hypsipylla grandella* (Newton *et al*. 1993, Rodgers *et al*. 1995). In contrast, merchantable trees of these species are often found in multi-strata agroforestry systems such as coffee or cacao plantations. Again, in contrast to pure timber plantations, where the potential to modify site conditions such as soil chemical and physical properties as well as weed management is very limited, in agroforestry associations it is possible to significantly improve site index (quality); e.g., for *C. alliodora* at age five years in Talamanca, Costa Rica, from 14.1 to 17.5 m (Kapp and Beer 1995). This has led to the suggestion that valuable tropical timber species, such as *C. odorata* and *S. macrophylla,* should be planted in agroforestry associations rather than in pure plantations because success depends upon intensive management which can only be provided in an agricultural context (Leakey, pers. comm.).

In genetic improvement programmes of timber species for agroforestry systems, as well as for species-site matching, tree species selection criteria should include: local preferences; timber value; low competitivity (with the crop); wind firmness and resistance to stem breakage in open grown situations; narrow crowns to reduce competition for light, wind fall and breakage risk (lower wind resistance) as well as underlying crop damage during harvesting or wind fall; and, in the case of silvopastoral systems, tolerance of soil compaction/water logging (Boshier and Beer 1997). Most timber trees in agroforestry systems are open grown; i.e., tree crown interactions are insignificant. Hence, selection for traits such as stem form, degree of stem taper and canopy characteristics become even more important than for pure forestry plantations since the silvicultural interventions of selective thinning and using competition from neighbouring trees are not options. Furthermore, considerations of acceptable wood density under conditions of maximum diameter increment will be of increased importance. Below-ground characteristics, which indicate which tree species are likely to compete more with associated crops (e.g., rooting depth and fine root density) are important considerations in agroforestry systems since the farmer will usually give priority to crop over timber production. When associated agricultural land use involves tillage, especially the inclusion of root crops in Taungya systems, below ground characteristics such as rooting depth and susceptibility to root diseases (e.g., *Terminalia ivorensis* [Kapp *et al*. 1997]) increase in importance. Many other characteristics are used to select shade tree species for coffee and cacao plantations (Beer 1987), illustrating the complexity of choosing appropriate timber species (or germplasm) for agroforestry systems. The importance of agroforestry systems to produce timber in Latin America is increasing and should be promoted at all levels from international markets down to individual farms.

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The Importance of Forest Patches, Isolated Trees and Agricultural Windbreaks for Local and Regional Biodiversity: the Case of Monteverde, Costa Rica

by
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Abstract

In Central America, most landscapes consist of a mosaic of pastures, agricultural fields, and forest fragments interspersed with residential and urban areas. Although these landscapes are highly fragmented and altered, they often retain a remarkable diversity of tree species within forest patches, isolated trees, and planted windbreaks. The forest patches, isolated trees and windbreaks are important for conserving both local and regional biodiversity because they provide important food sources, nesting sites and habitat for a variety of animal species (particularly birds), and may serve as stepping stones or corridors that facilitate animal movement across the agricultural landscape. They also help conserve plant diversity, both because the trees themselves often represent forest species that would otherwise be absent from the landscape and because the trees serve as hosts for numerous epiphytic plants. By acting as foci for seed dispersal and seedling establishment, the trees also facilitate the regeneration of forest plant species within the agricultural landscape. We present a case study of the importance of forest fragments, isolated trees and agricultural windbreaks for the conservation of both local and regional biodiversity in Monteverde, Costa Rica, summarizing and synthesizing the work of more than 20 years of ecological research in the region.

Keywords: Altitudinal migrations, Biodiversity, Forest patches, Isolated trees, Windbreaks

Introduction

One of greatest challenges currently facing land managers is how to maintain and conserve biodiversity within fragmented, human-dominated landscapes (Bennett 1999). In Central America, as in many other parts of the world, natural landscapes are increasingly being converted into complex mosaics of pastures, agricultural fields, forest fragments, and residential areas, threatening the status of many plant and animal species (Forman and Godron 1986, Forman 1995). Because deforestation is rarely complete, most landscapes retain scattered forest fragments, isolated trees or other fragments of natural vegetation. In addition, agricultural lands often include windbreaks, fence rows or borderline plantings that were planted by farmers. Although these landscape elements are usually overlooked in conservation strategies, they may play critical roles in maintaining and conserving both local and regional biodiversity by providing habitats and resources that are otherwise lacking within the agricultural landscape (Crome *et al.* 1994, Forman 1995, Corbit *et al.* 1999). In some cases, they may also serve as stepping stones or corridors that facilitate animal movement across agricultural lands (Bennett *et al.* 1994, Haas 1995, Guevara *et al.* 1998).

While there is growing recognition of the potential importance of forest fragments, isolated trees, and agricultural windbreaks in the conservation of biodiversity within fragmented landscapes, there are few studies that have examined their role in conserving biodiversity at both a local and regional level. We present a case study of the importance of forest patches, isolated trees and windbreaks in the agricultural landscapes surrounding the Monteverde reserve complex in north-western Costa Rica, for the conservation of both local and regional biodiversity. We focus primarily on the Pacific slope of the Monteverde region, both because this is where the most research has been conducted and because the Pacific slope has been heavily deforested and influenced by agricultural activities. In addition, we briefly discuss the value of the forest fragments, isolated trees and windbreaks for local farmers in order to highlight their agricultural and economic importance.

The Monteverde Landscape

The Monteverde region lies within the Tilarán mountain range, a north-south volcanic mountain chain in central, northern Costa Rica (10 18'N, 84 48'W; Holdridge 1967), and encompasses an elevational gradient from 200 m to almost 1800 m. The communities of Monteverde and Santa Elena occur between 1250-1500 m. The region has a mild, montane climate (annual temperature 18.5°C, annual rainfall 2500 mm), with a dry season from November to May (Haber *et al.* 1996). At the lower elevations, temperatures are slightly warmer and the dry season is more pronounced (Clark *et al.* 2000).

At the top of the mountain range, there is a complex of reserves (hereafter referred to as the Monteverde reserve complex) that straddles the continental divide and encompasses roughly 28,000 ha, primarily on the Atlantic slope. This complex is composed of the Monteverde Cloud Forest Biological Preserve (10,500 ha), the Bosque Eterno de los Niños (BEN, 17,000 ha), and the Santa Elena Reserve (310 ha), of which all but the Santa Elena reserve are privately owned and operated (Haber *et al.* 1996). Two important isolated protected forests exist on the Pacific slope: Bajo del Tigre (30 ha) and the San Luis Biological Research Station (239 ha), administered by the Monteverde Conservation League and the Tropical Science Center respectively. On the Atlantic slope, the reserve complex is contiguous with the Arenal National Park (12,123 ha; Garcia 1996).

Outside of the reserve complex, most of the land has been converted to pasture for dairy farming or developed for ecotourism, and the landscape is a mosaic of pastures, coffee fields, sugarcane fields, small forest patches and residential areas. In the area immediately adjacent (3-10 km) to the reserve on the Pacific slope, dairy farming is the principal economic activity (with the exception of ecotourism activities generated by the reserve complex). It is estimated that roughly 60% of the area occurs as pasture, 15% exists as coffee or sugarcane fields and forests cover the remaining 25% (Harvey and Haber 1999). Most of the dairy farms in the region are small (mean=16.5 ha, range=5-40 ha), family-owned, and intensively managed with fertilizer inputs, exotic grasses (primarily *Cynodon nlemfuensis*) and a rotational grazing system (Harvey and Haber 1999). At lower elevations, cattle raising is the principal source of income and farms tend to be much larger and less intensively used.

Importance of Monteverde for Conserving Regional Biodiversity

The Monteverde region is crucial for conserving regional biodiversity because it contains one of the few intact, protected high-elevation forests in Central America (LaBastille 1978). Due to its rough topography and steep environmental gradients, the Monteverde region has seven different life zones (tropical wet forest, tropical moist forest, premontane wet forest, premontane moist forest, premontane rain forest, lower montane wet forest, and lower montane rain forest) within a relatively small area of roughly 250 km^2 (Bolaños and Watson 1993). Like other montane forests, it includes a high diversity of both plant and animal species, many of which are endemic to cloud forest habitats (Balslev 1993). The Monteverde Cloud Forest Preserve alone includes >100 species of mammals, 400 species of birds, 120 species of amphibians and reptiles, >3000 plants (including >700 trees, >870 epiphytes, >500 orchids, and >300 ferns) and >500 species of butterflies (Lawton and Dryer 1980, Wheelwright 1986, Haber *et al.* 1996, Haber 2000).

Many of the species present in the Monteverde area occur only in cloud forest habitats of Central America and a significant number of species are endemic to the Tilarán mountain range (Wheelwright 2000). A ten-year study of the flora of Monteverde found a total of 166 plant species new to science, about half of which are endemic to the Monteverde region (Haber *et al.* 1996, Haber 2000). A few tree species (e.g., *Ilex haberi*, *Pleurothyrium guindoni*, *Ocotea monteverdensis*) have only been identified from a few specific sites and have extremely small populations. The Monteverde flora and fauna also includes a considerable number of species that are endangered or threatened, both nationally and/or regionally. For example, Young and colleagues (1998) found 19 resident and three long-distance migrant bird species in the Monteverde region that are considered threatened regionally.

Within the Monteverde region, the diversity of plants and animals changes rapidly over the elevational gradient, and species turnover between life zones (even those located in narrow bands occurring over short distances) is high, indicating the importance of conserving forest along the entire elevational gradient (Wheelwright 2000). Among trees, the proportion of tree species shared among two adjacent life zones is estimated to be roughly 20% of the number of species that occurs in either life zone separately (Haber *et al.* 1996). There is similarly a high turnover across life zones among animal species. In various studies of the Monteverde avifauna, a total of 235 bird species were found in the five upper life zones, yet the number of species in each individual life zone ranged from 72 to 126 species and the Jaccard similarity indices for adjacent life zones were low, ranging from 0.30 to 0.47 (Young *et al.* 1998).

Importance of Forest Fragments, Isolated Trees and Windbreaks for the Conservation of Biodiversity

Although the current reserve complex protects roughly 28,000 ha of forest, it is unable to conserve the diversity or plant and animal life present in the region because it protects only a fraction of the elevational gradient on the Pacific slope, extending only down to 1500 m, and also includes a very limited area (<2000 ha total; Powell and Bjork 1995). Of the seven Holdridge zones that occur in the region, only three life zones (lower montane rainforest, premontane rainforest, tropical wet forest) are protected by more than 600 ha in the reserve complex (Powell and Bjork 1995). Two additional life zones (lower montane wet forest and premontane wet forest) are poorly represented, and two (premontane moist forest, tropical moist forest) are not represented at all (Powell and Bjork 1995, Haber pers. obs.). As a result, numerous species of plant and animals that only occur in the lower-elevation forest remnants of the Pacific slope are not represented within the reserve complex's limits. Conservation of many of Monteverde's migrating species is also not assured since the survival of these species depends not only on the protection of the reserve complex, but also on the protection of their seasonal habitats and travel paths within the fragmented landscape outside of the reserve boundaries (Powell and Bjork 1995).

The maintenance of forest patches, windbreaks, and isolated trees within the agricultural landscape may be critical for protecting the diversity of plant and animal life within the Monteverde region as these elements provide resources, habitats, nesting and roosting sites that may enable some (though clearly not all) forest species to persist within the fragmented landscape. In the lower regions of the Pacific slope, where there are no large contiguous tracts of forest remaining, the forest fragments, windbreaks and isolated trees represent the main habitat available to forest species. The presence of isolated trees, windbreaks and forest patches may also considerably enhance the connectivity of the landscape (reducing the distances that animals must travel between forested areas) and act as stepping stones or corridors that facilitate animal movement. For migrating species, the presence of trees, whether in forest patches, dispersed in pastures, or planted in windbreaks, may also provide critical resting and foraging sites on their migrations from the highlands to the lowlands, or from the Atlantic to the Pacific slopes.

Forest Patches and the Conservation of Biodiversity

One of the most important landscape features for the conservation of biodiversity outside of the reserve are the small forest patches scattered throughout the agricultural landscape. Most of the forest patches in the Monteverde region occur along streams or on steep slopes that are unsuitable for farming (Guindon 1997). Although their shape, size and location vary considerably, a survey of 30 patches on the Pacific slope, at an elevation of 1000-1500 m, found that forest patches ranged in size from 0.2 to 7.9 ha, with an average of 2.4 ha (Guindon 1997). Often, the patches have been degraded by selected removal of timber species, or by grazing, trampling and physical damage by cattle (Guindon 1997).

Forest Patches and Plants

Despite their disturbed nature and small size, the forest fragments on the Pacific slope are important for the conservation of biodiversity because they host a high diversity of plant life and often contain species that do not occur in the existing protected areas. In a survey of trees of 30 forest fragments on the Pacific slope, a total of 225 tree species representing 130 genera and 59 families were found (Guindon 1997). Tree species diversity within individual forest patches ranged from 14-100 species, with trees in the Lauraceae family being dominant (Guindon 1997). A significant portion of the species found in forest fragments do not extend their ranges into the reserve complex: a total of eighteen tree families, 64 genera and 138 tree species found in the Pacific slope forest fragments (Guindon 1997) were not found in a one-ha sample within the contiguous forest in the Monteverde Cloud Forest Biological Preserve (Nadkarni *et al.* 1995).

Forest fragments are also important for conservation because many of the tree species that occur within the fragments in the seasonally evergreen forest (premontane wet forest and premontane moist forest) on the Pacific slope adjacent to the reserve are endemic and undescribed species that do not occur within the reserve complex. Over the past 15 years, a total of 35 tree species new to science have been discovered in the Pacific slope fragments adjacent to the reserve, of which none occur within the protected area (Haber 2000). To date, 12 of these have been described and 23 still await the publication of scientific names (Haber pers. comm.).

Species turnover between forest fragments is high, indicating that it is important to conserve forest fragments along an elevational gradient. For example, two forest fragments that differed by only 200 m in elevation and were separated by a physical distance of less than 2 km, shared only 12 of 105 identified tree species and had no lauraceous species in common (Guindon 1997).

Forest Patches and Birds

In addition to serving as important habitats for forest plants, the forest fragments provide key habitats and resources for animal species. Although the fragments are thought to be important for a variety of animal species (such as howler monkeys, white-faced monkeys, sloths, coatimundis, agoutis, margays, olingos, kinkajous and many species of bats), most of the research in the Monteverde region has focused on their importance for both resident and migrating birds.

Avian diversity within the Pacific slope forest patches is considerable. In a mist-netting survey of 13 Pacific slope fragments (including 1120 mist-net hours), a total of 62 bird species were found (Hamilton DeRosier unpublished data). This represents >10% of all the bird species within the Monteverde region (DeRosier 1995). The diversity of birds within forest fragments depends, among other factors, on the availability of fruit resources, the degree of connectivity of the forest fragment with the intact reserve or other forest patches, the size of the forest fragment, as well as the individual requirements, dispersal abilities and behavior of each bird species (Guindon 1988, 1997, DeRosier 1995, Hamilton DeRosier and Nielsen in prep.).

In addition to serving as habitat for resident bird species, the forest fragments are also critical habitats for bird species that migrate seasonally out of the reserve down to lower elevations in search of food or nesting areas. Bird species that are known to migrate seasonally and to depend, at least to some degree, on the protection of the forest fragments include resplendent quetzals, three-wattled bellbirds, keel-billed toucans, black guans, emerald toucanets, mountain robins and some species of hummingbirds (Guindon 1988, 1997, Powell and Bjork 1995). Of these migrations, the two best-documented seasonal migrations are those of the resplendent quetzal and the three-wattled bellbird. Both of these species nest in the cloud forest between January-June, and then undertake seasonal migrations to both the Pacific and Atlantic slopes following the temporal availability of fruit, especially of Lauraceae trees (Guindon 1988, Powell and Bjork 1995). By July, most individuals of both species have moved into the Pacific forest patches and isolated trees of adjacent farms. Because these forest fragments occur at lower elevations and experience warmer temperatures, they host different tree species from the reserve and have different fruiting phenology, providing fruits at a time when fruits within the reserve are limiting (Guindon 1997). During the several months that the bellbirds and quetzals visit the forest fragments, large congregations of birds within small forest patches are common. Powell and his collaborators, using Jolly-Seber mark-recapture formulas (Nichols *et al.* 1981) estimate that as many as 300 bellbirds may depend on several Pacific slope fragments that total less than 20 ha in size during this period (Hamilton DeRosier pers. comm.).

Forest Patches and Butterflies

The forest patches scattered over the Pacific slope buffer zone of the Monteverde reserve complex also hold considerable importance for the conservation of butterfly diversity. In an intensive, three-year census of butterflies in the Monteverde region, Haber and his colleagues recorded 645 butterfly species on the Pacific slope in the Monteverde area between the Pacific coast and the Continental Divide (ranging from 70 to 1600 m), of which 625 species were found outside of the reserve complex. A total of 150 species were recorded within the Monteverde Cloud Forest Preserve (above 1500 m), but only 20 of these species were found only within the Preserve (Haber in prep.). About 50 of the butterfly species found within the forest fragments on both the Atlantic and Pacific slopes are classed as rare (DeVries 1987, 1997). In addition, seven species of undescribed hairstreaks have been collected from the Monteverde region, of which three were collected within the reserve complex and four were found only outside the reserve (Haber pers. comm.). While the conservation status of these species is poorly known at present, it appears likely that the forest fragments are critical for their persistence in the region.

In addition to the many resident butterflies occurring within the forest fragments, a large number of butterflies pass through the fragments each season during altitudinal and cross-country migrations (Haber 1993). The migrating butterflies spend part of the year in the lowlands of western Guanacaste and northern Puntarenas Provinces, where the habitat consists primarily of tropical semi-deciduous forest. During the dry season (November-May), these forests lose anywhere from 0 to 90% of their leaves, and many of the butterflies leave the area and migrate to less seasonal (cooler and moister) habitats in the nearby Tilarán mountains or over the Continental Divide to the Atlantic slope. It is estimated that roughly 75% of the butterfly species found in the Monteverde region migrate seasonally in response to seasonal changes in climate and plant phenology (Haber in prep.). The eastward migration from the Pacific to the Atlantic peaks from October to January (transition from wet season to dry season), whereas westward migration is concentrated in April and May (transition from dry to wet season) (Haber 1993). Especially during eastward migration, many of these species depend on the forest fragments for food resources and intermittent protection from the storms and strong winds of the early dry season. The prevalence of butterfly migration illustrates the importance of protecting habitat along the migration route, as well as at both ends of the migration path.

Isolated Trees and the Conservation of Biodiversity

Another common feature at Monteverde that may play an important role in the conservation of biodiversity within the agricultural landscape are the isolated or dispersed trees that occur within the pastures, agricultural fields and road banks. Although often overlooked in conservation strategies, isolated trees provide key habitats and resources for both plant and animal species and serve as stepping stones that facilitate animal movement within the agricultural landscape (Guevara *et al.* 1992, 1998, Guevara and Laborde 1993, Harvey and Haber 1999). Within the Monteverde landscape, the density and diversity of isolated trees varies considerably among different farms and between the higher and lower elevations of the Pacific slope. In the dairy farms adjacent to the reserve complex on the Pacific slope, isolated trees are a common and conspicuous element of pastures: a survey of pastures on 24 farms (400 ha total) found that pastures had an average of 25 isolated trees ha^{-1} (range: 5-80 trees ha^{-1}; Harvey and Haber 1999). At lower elevations, where the main activity is cattle ranching for meat production, casual observations and aerial photos suggest that the tree component is much less abundant (Guindon pers. obs.). Historically the grasses on these farms were burnt on an annual basis at the end of each dry season, to stimulate the production of new grass with the first rains and clear the pastures of shrubs and trees (Guindon pers. obs.).

Isolated Trees and Plants

The isolated trees represent a high species diversity and significantly increase the plant diversity within the agricultural landscape. In a survey of >5,500 trees occurring in pastures of 24 dairy farms on the Pacific slope, a total of 190 tree species were found, of which 57% were primary forest species (Harvey and Haber 1999). This represents roughly 60% of all the approximately 320 tree species occurring within the study area (Harvey and Haber 1999). The most common families represented in pastures included Lauraceae (28 spp.), Myrtaceae (17 spp.), Fabaceae (15 spp.). Meliaceae (7 spp.), Solanaceae (7 spp.), Euphorbiaceae (6 spp.) and Moraceae (6 spp.) - all of which are families commonly found in intact, adjacent forests (Harvey and Haber 1999).

Many of the isolated trees in pastures, particularly those that are relicts of the original forest, maintain rich communities of epiphytic plants, including woody shrubs, tank bromeliads, herbaceous epiphytes and mistletoes, thereby further increasing the diversity of plant species present within the pastures (Nadkarni and Matelson 1989, pers. obs.). These epiphytes, in turn, provide important foraging resources (fruits, nectar, invertebrates, and water) and nesting materials for forest birds and other animals (Nadkarni and Matelson 1989, Hietz-Seifert *et al.* 1995).

Isolated trees may also help conserve plant diversity by serving as foci for seedling recruitment and regeneration in pastures, both by providing local sources of propagules and also by attracting seed-dispersing birds and bats into agricultural areas (Guevara *et al.* 1986, Guevara and Laborde 1993, Harvey 1999). In a recently abandoned pasture in Monteverde, for example, recruitment of tree seedlings and saplings was greater beneath remnant trees than in open sites within the same pasture but without overhanging vegetation (Murray *et al.* unpublished data). Mean species richness was also much greater beneath remnant trees (6.4 ± 2.12 species vs. 0.7 ± 0.94 species; Murray unpublished data). Recruits included both pioneer and primary forest species, many of which were represented in the surrounding forest but not as reproductive individuals within the pasture. This finding parallels those in other locations (e.g., Guevara *et al.* 1986, 1994, Uhl *et al.* 1991, Guevara and Laborde 1993) and reinforces the emerging consensus that remnant pasture trees greatly enhance the rate of forest regeneration on abandoned pastures. In active pastures, isolated trees similarly serve as foci for regeneration, however few of the regenerating trees actually survive and establish within the pastures because cow grazing, trampling and manual weeding by farmers destroy most of the regenerating seedlings (Harvey and Haber 1999).

Isolated Trees and Birds

In addition to enhancing the floral diversity of pastures, isolated trees also help maintain faunal biodiversity within the fragmented landscape by providing fruits, leaves, and nesting, roosting and perching sites to birds, bats and other animals (Lynch 1989, Saab and Petit 1992, Estrada *et al.* 1993a, 1993b, Perfecto *et al.* 1996). Of the isolated trees surveyed in the pastures of 24 Monteverde farms, more than 94% of all trees are known to provide fruits for frugivorous species (Harvey and Haber 1999), and some of the most common isolated trees (*Acnistus arborescens*, *Citharexylum costaricensis*, *Ficus pertusa*, *Hampea appendiculata* and *Sapium glandulosum*) provide fruits for more than 20 bird species each, thereby constituting an important food resource within the landscape (Wheelwright *et al.* 1984). Dead isolated trees may also serve as nesting sites for birds such as masked tityras, emerald toucanets, woodpeckers, parrots and quetzals (Hamilton DeRosier pers. obs.)

Casual observations of birds in isolated trees and studies of individual bird species suggest that fruiting isolated trees in pastures are visited by a large number of bird species, particularly when fruit availability within the reserve is low (Murray pers. comm., DeRosier pers. comm.). Studies of isolated trees in pastures, coffee fields and agricultural lands in other areas of Central America have similarly noted the importance of isolated trees as habitats and food resources for bird species (Powell *et al.* 1989, Robbins *et al.* 1989, Perfecto *et al.* 1996, Greenberg *et al.* 1997). During the months of June-September, when food resources within the Monteverde complex reserve are limiting, it is common to see clusters of birds within isolated, fruiting trees: as many as eight quetzals have been observed in a single Lauraceae tree (*Ocotea monteverdensis*) and as many as five bellbirds have been seen simultaneously in a single isolated pasture tree during this period (Hamilton DeRosier pers. comm.). Similarly, in a bird survey in July 1997, 18 of the counted 23 quetzals were found in three remnant trees (Hamilton DeRosier pers. comm.).

The importance of isolated trees depends on their fruiting status, as well as their distance from the nearest forest patch. In many cases, the isolated trees act as 'stepping stones' that facilitate bird and animal movement across the agricultural landscape; however species that are unable to cross the distances between the forest and the isolated trees cannot benefit from their presence. Studies in other areas have shown that the presence of isolated trees effectively enhances landscape connectivity, thereby making it easier for some bird species to move between forest patches (Guevara *et al.* 1998).

Agricultural Windbreaks and the Conservation of Biodiversity

Like forest patches and isolated trees, the agricultural windbreaks in the Monteverde landscape may play a critical role in the maintenance of biodiversity by providing habitats, resources and serving as corridors for animal movement. Although there are some 'natural' windbreaks consisting of strips of forest that were left for wind protection when the original forests were cleared, most of the windbreaks in the region are recent additions to the landscape, planted as part of a reforestation effort led by the Monteverde Conservation League between 1989-1995. The windbreaks were planted primarily to protect the cattle from physical stress by the trade winds and prevent grass desiccation, however they also serve to reforest a previously bare landscape. The windbreaks consist primarily of four species (*Montanoa guatemalensis*, *Cupressus lusitanica*, *Croton niveus* and *Casuarina equisetifolia*, of which only *Montanoa* is native to the region), are generally 2-4 rows wide (mean width=5 m; Harvey 1999) and are planted perpendicular to the strong NE trade winds that hit the area from November to April (Clark *et al.* 2000). An estimated 186 km of windbreaks were established in the Monteverde region during this period, turning a previously very open pastoral landscape into one criss-crossed by lines of trees (Varela pers. comm.) Especially at the lower elevations, the windbreaks represent some of the only wooded areas present in the landscape and serve as important refuges for forest regeneration and as critical links that facilitate the movement of some bird species across the landscape.

Windbreaks as Habitats for Forest Trees

The agricultural windbreaks are narrow, relatively young habitats (consisting of mainly of exotic tree species) that differ greatly from intact forest in species composition, structure and microclimate, yet they nevertheless provide important habitats for forest tree recruitment within the agricultural landscape. This is accomplished in part because the microclimate within the windbreaks is more favorable to plant species and in part because they represent some of the few fenced areas where cattle cannot enter and destroy regenerating seedlings (Harvey 1999). Birds visiting the windbreaks or using them as corridors to cross the pastures often defecate seeds, which may later germinate and establish as seedlings. An intensive one-year study of seed dispersal within the agricultural windbreaks and adjacent pastures in Monteverde found that windbreaks received more than 40 times as many tree seeds and more than twice as many species of tree seeds as adjacent pastures, indicating the importance of these windbreaks as foci for forest regeneration (Harvey 2000). Surveys of the understories of established windbreaks revealed that a wide variety of forest tree species are colonizing and establishing within the windbreaks. A total of 91 tree species (including both primary and secondary forest species) were found as seedlings within the windbreaks, just 5-6 years after they were established (Harvey in press). The mean density of seedlings was 2.14 per m^2. Although it is not clear how many of these tree species will survive and become reproductive individuals, at least there is a strong potential for the windbreaks to serve as conservation tools for forest tree species.

Interestingly, the position of the windbreak within the landscape appeared to have an important effect on tree recruitment patterns. Windbreaks that were directly connected to forests had significantly higher densities and diversity of forest tree seedlings in their understories than windbreaks that were separated from forests by 20-50 m (Harvey 1999, in press). These differences reflect the greater activity of frugivorous birds within connected windbreaks and the presumably higher input of forest tree seeds.

Windbreaks and Birds

In addition to providing sites for forest regeneration, the planted windbreaks may help maintain animal species within the fragmented landscape. The windbreaks are frequently visited by birds and other animals because they provide perches, shelter from predators, foraging sites for insects and nectar, and serve as corridors that enable forest animals to cross the otherwise open, agricultural landscape. In addition, the natural windbreaks (but not the planted windbreaks, which consist of exotic species) also provide fruits for frugivorous species. A three-year mist-netting study of birds using both planted and natural windbreaks found a total of 84 bird species using windbreaks, of which 64 species were found in natural windbreaks and 74 were found in the planted windbreaks consisting of *Montanoa guatemalensis* and *Cupressus lusitanica* (Hamilton DeRosier and Nielsen unpublished data). Although the overall species diversity of birds was similar in natural and planted windbreaks, natural windbreaks appeared to serve as habitat for bird species whereas the planted windbreaks appeared to be only transient foraging sites or travel paths. In natural windbreaks, several nests were found and several bird individuals were repeatedly captured, suggesting that these birds actually reside within the windbreaks. In contrast, no nests of any birds were found within the planted windbreaks (even though the windbreaks were sampled during the primary breeding season of the local bird species) and recaptures of individual birds within the same windbreak were rare (Hamilton DeRosier and Nielsen unpublished data).

Because many of the windbreaks are joined to forest fragments (on one or both ends), they greatly enhance the overall connectivity of the landscape and can potentially serve as corridors for some animal species. Mist-netting and mark-recapture studies suggest that some bird species use the windbreaks as corridors to travel from one forest patch to the next (DeRosier 1995). Windbreaks that were connected to forest patches contained a higher percent of forest-dwelling birds and frugivorous birds than those windbreaks that were isolated from forest patches (Hamilton DeRosier and Nielsen, unpublished data). In addition, bird capture rates within windbreaks were positively correlated with distance to the nearest forest fragment and many individuals were recaptured moving through the windbreaks, indicating that the windbreaks serve as passageways for birds moving between forest patches. Perhaps the strongest indication of the corridor usage by birds was that capture rates remained high over the five consecutive days within each windbreak, suggesting that the birds being captured were new arrivals rather than residents.

Aside from birds, a variety of other animals have been observed in windbreaks including sloths, monkeys, mice, kinkajous, opossums, squirrels and snakes (Hamilton DeRosier pers. obs, Harvey pers. obs.). Some of these animals may forage in the leaf litter, branches of the windbreak trees or in the windbreak/pasture edges, while others may simply pass through the windbreak on their way to other habitats.

The Importance of Forest Patches, Isolated Trees and Windbreaks to Farmers

While it is clear that the forest patches, isolated trees and agricultural windbreaks play critical roles in the conservation of plant and animal diversity in the Monteverde landscape, at both local and regional scales, it is also important to consider their roles within the farm context because ultimately the retention and management of forest patches, isolated trees and windbreaks depends on the land use decisions of the local landowners who own them. Decisions to retain or remove trees from the landscape are likely to be closely linked to agricultural considerations and differences in the abundance of forest fragments, trees and windbreaks among farms reflect personal differences in the perceived value of these elements.

In general, local landowners in Monteverde are well aware of the benefits of retaining trees (whether as dispersed individuals, forest patches or in planted windbreaks) within their farms, and value them not only for the agricultural functions they provide but also for their roles as habitat for wildlife. In a survey of 40 landowners on the Pacific slope outside of the Monteverde reserve, Guindon (1988) found that farmers retained forest patches for both utilitarian reasons (provision of timber, firewood, and fence posts; protection of water springs; wind protection), as well as non-utilitarian reasons (wildlife protection and personal enjoyment). Sixty percent of the farmers considered their forest land to be more valuable than pasture or land under other uses and many had taken steps to protect their forest patches or increase the size of the forested land: >77% of the farmers interviewed had invested in fences to protect their forests and 42.5% had planted trees to increase or protect their forested areas (Guindon 1988). Because of the perceived high value of forests, most landowners planed to leave their forested land for the next five years; only 12.5% planned on reducing their forest area (Guindon 1988).

Landowners are also conscious of the agricultural and ecological benefits of retaining trees within their dairy pastures. A survey of 22 dairy farmers found that farmers leave trees primarily to provide shade for their cattle, thereby preventing heat stress in the dry season that can significantly reduce milk yields (Harvey and Haber 1999). Farmers also leave isolated trees as a potential sources of timber, firewood and fence posts and to ensure that the grass stays green in the dry season (due to lower temperatures and higher humidity below tree crowns). Perhaps of most conservation interest, 64% of the farmers surveyed mentioned that they often retain isolated trees in pastures because they provide fruits for birds and wildlife (Harvey and Haber 1999). Although farmers recognize the importance of having isolated trees in their pastures, if the density of trees within a pasture is high, they will selectively remove some trees to prevent the grass from being overshaded (Harvey and Haber 1999). In addition, most farmers harvest a few trees each year for timber or fence posts (Harvey and Haber 1999). This selective removal of trees, combined with the poor regeneration of trees in pastures that are active, is likely to decrease the remnant tree component in future years, unless active management is taken to facilitate tree regeneration within the pastures.

While there have been no formal studies documenting the importance of planted windbreaks to farmers in Monteverde, casual conversations with farmers suggest that the windbreaks play a valuable economic role in dairy farm production (Harvey unpublished data). Windbreak establishment in the region has greatly improved milk yields, both by reducing the physical stress to animals and by keeping the grass greener for a greater proportion of the dry season (Harvey unpublished data). The proliferation of windbreaks within the landscape (windbreaks now occur on >90% of all dairy farms in the area) and the high interest of farmers in establishing additional windbreaks to further protect their animals, also attest to their perceived importance. Interestingly, farmers are now eager to use native tree species within windbreaks. If native species are indeed incorporated into existing or future windbreaks, the ability of the windbreak to support animal species is likely to be greatly enhanced (Capel 1988).

Conclusions

By providing habitats, resources and habitat corridors that are otherwise lacking in the agricultural landscape, the forest patches, isolated trees and windbreaks play a critical role in conserving both local and regional biodiversity within the Monteverde region. Although the forest fragments are generally small and isolated, they nevertheless retain a high diversity of plant species and provide habitat and refuges for many animal species, including many altitudinal migrants that are currently threatened. The isolated trees - whether relicts of the original forest canopy, newly regenerated individuals or planted by farmers - also provide critical habitat and resources within the agricultural landscape for both plant and animal species. Perhaps most interestingly, the agricultural windbreaks, despite being composed of primarily exotic species, also appear to enhance local biodiversity by serving as foci for seed dispersal and forest tree regeneration, and by functioning as corridors that facilitate bird movement across agricultural areas. While the forest patches, isolated trees and windbreaks are unlikely to conserve all of the biodiversity present in the region, they appear to help maintain a significant portion thereof. Since all three of these landscape features also serve important agronomic functions and are highly valued by farmers, there is a unique opportunity to integrate conservation goals with farm management and to manage tree cover within the landscape to both conserve local and regional biodiversity, while maintaining farm productivity.

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Sub-Plenary Session: D2

Cultural Diversity in Forest Management:

Forests in Sustainable Mountain Development

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Why are Mountain Forests Important for Sustainable Development?

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Abstract

Mountains and uplands occupy a quarter of the Earth's land surface. About one tenth of humankind lives in them, and they affect the lives of over half the world's population. The global significance of mountain forests is recognised by the inclusion of a specific chapter in "Agenda 21", endorsed at the 1992 Earth Summit. The values of mountain forests to mountain people, those living downstream, and much of the remainder of humanity, including their roles as centres of biodiversity; the storage and supply of water; the provision of fuelwood and many other wood and non-wood products; essential complements to agriculture; sites for recreation; and protection against natural hazards and soil erosion. These values are underlined in documents resulting from regional meetings around the world, and emphasised in many recent and ongoing projects. They are the focus of the Task Force on Forests in Sustainable Mountain Development of the International Union of Forestry Research Organizations (IUFRO), which has prepared a state-of-knowledge report for the XXI IUFRO Congress.

Keywords: Mountains, Forests, Sustainable development, IUFRO.

Introduction

Mountains occupy approximately a quarter of the Earth's land surface (Kapos et al., 2000). About one tenth of humankind lives in them, and they affect the lives of more than half of the world's population (Ives, 1992). Building on a number of initiatives over the past three decades (Ives and Messerli, 1990; Stone, 1992), their global significance was specifically recognised at the UN Conference on Environment and Development (UNCED), or 'Earth Summit', in Rio de Janeiro in June 1992 by the inclusion of a chapter in "Agenda 21", a plan for action into the 21st century which was endorsed by the heads of state or governments from most of the world's countries. The inclusion of Chapter 13 of "Agenda 21" - "Managing Fragile Ecosystems: Sustainable Mountain Development" – places mountain regions on an equal footing with climate change, tropical deforestation, desertification, and similar issues of global change (Turner et al., 1990) in the global debate on environment and development. Chapter 13 includes two 'programme areas':

A) generating and strengthening knowledge about the ecology and sustainable development of mountain ecosystems;
B) promoting integrated watershed development and alternative livelihood opportunities.

In September 1993, the UN Inter-Agency Committee of Sustainable Development gave the Food and Agriculture Organization of the United Nations (FAO) responsibility for acting as Task Manager for Chapter 13. In this role, FAO has fostered a number of global and regional initiatives; and many countries have also taken steps towards implementing various elements of Chapter 13 (Chipeta and Michaelsen, 1995; Sène and McGuire, 1997; Price, 1999; Sène, 2000). In 1998, the United Nations General Assembly declared that the year 2002 would be the International Year of Mountains, further underlining the global significance of mountain areas. FAO has also been designated as the lead agency for this.

The concept of sustainable mountain development has been defined as "a regionally-specific process of sustainable development that concerns both mountain regions and populations living downstream or otherwise dependent on these regions in various ways" (Price and Kim, 1999). This paper discusses the values of forests in relation to the major areas through which forests are linked to sustainable mountain development, and reviews initiatives that have taken place since 1992.

The Values of Mountain Forests

Chapter 13 begins "Mountains are an important source of water, energy, and biological diversity." Forests play crucial roles in fulfilling all of these functions. Recent work by the World Conservation Monitoring Centre (WCMC), in which mountains were objectively defined according to rules relating to altitude, slope, and relative relief using a global database with a spatial resolution of 1 km, has shown that they cover 24% (35,813,437 sq. km) of the Earth's land surface. This map was then overlain on an existing global database of forests prepared by WCMC. Putting these two databases together, the result is that 28% (5,179,248 sq. km) of the world's forests are mountain forests (Kapos et al., 2000).

In any mountain range, the diversity of ecosystems reflects the range of altitudes, slopes, aspects, geological substrates, and soils; as well as the effects of human activities. All of the centres of greatest vascular plant species diversity are in, or include, mountains: Costa Rica, the tropical eastern Andes, the Atlantic forest of Brazil, the eastern Himalayan-Yunnan region, northern Borneo, and Papua New Guinea. Secondary centres are found in Mediterranean and arid mountains, the Rocky Mountains, and Central Asia (Barthlott et al., 1996). In Europe, a very high proportion of centres of plant diversity is in mountains (Davis et al., 1994). Species diversity typically decreases with altitude; thus, forests generally have greater diversity than the non-forested zones above (Jenik, 1997). An overview of issues relating to the biological diversity of mountain forests has recently been published by Grabherr (2000)..

Mountains are of vital importance to the globe as sources of water, typically having higher rates of precipitation than surrounding lowlands. Forests play a number of important roles in the water cycle (Liniger and Weingartner, 2000). These include the capture of atmospheric moisture, particularly by cloud forests, which are widespread but of particular importance in tropical areas (Hamilton et al., 1994); storage of snow and water in and beneath canopies; and release to watercourses, which is strongly affected by the degree of disturbance by natural and human forces (Hamilton and Bruijnzeel, 1997). In semi-arid and arid regions, over 90 percent of river flow comes from the mountains. Even in temperate Europe, the importance of the Alps is shown by the fact that, while the Alps occupy only 11 percent of the area of the Rhine basin, they supply 31 percent of the annual flow – and more than 50 percent in summer (Mountain Agenda, 1998). Much of the water flowing through and from the mountains is used to produce hydro-electric power. This is largely used on the plains below; though water power has also long been important in mountain economies, especially for grinding grain.

Wood is the primary source of fuel for those living in the mountains of the developing world (Schweizer and Preiser, 1997), and also many industrialised countries, where it has only been supplanted by electricity and fossil fuels in recent decades, if at all. Mountain forests are also the primary sources of fuel for nearby settlements in the foothills and plains, so that the collection of wood for fuel or the production of charcoal is a major factor in deforestation in many regions where mountain and nearby populations – both rural and urban – are increasing. Globally, more than half of estimated wood consumption is for fuelwood and charcoal, largely in developing countries (FAO, 1992). However, there are relatively few regional assessments of the use of wood energy resources; one exception is for the Himalaya-Hindu Kush (Rijal, 2000). The highest rate of deforestation in any biome is for tropical upland forests: 1.1 percent per year. Rates of clearing are particularly high in Central America, East and Central Africa, Southeast Asia, and the Andes (FAO, 1993a).

The second sentence of Chapter 13 notes that mountains are also a source of forest products, agricultural products, and recreation. Mountain forests are important sources of timber in many countries, though the costs of harvesting are typically higher than on low-angle land (Gregersen, 2000; Sekot, 2000). However, in many parts of the world, such land, even if once forested, provides a greater economic yield for agriculture or settlement; a process of conversion that took place centuries ago in Europe and has spread to many tropical countries in recent decades. Thus, the pressures on mountain forests increase. Until recently, the concept of sustained yield from forests focussed primarily on the production of wood for industrial and other uses. New models of sustainable forest management (e.g., FAO, 1993b; Maser, 1994) give greater emphasis to the need to manage forests as ecosystems, rather than 'mines' of exploitable resources. One critical element of this is to ensure sustainable yields of non-wood forest products - valuable for food, nutrition, medicine, construction materials, and household and cultural uses - which contribute to the subsistence and market economies of mountain people; and, in some cases, national economies (Arnold and Perez, 2000; Shrestha and Pokharel, 2000). Such products are vital for many in developing countries, but also provide supplementary sources of food and income in industrialized countries (Hansis, 1996; Richards and Creasy, 1996), and have recently been of increasing importance in the uncertain conditions being experienced in the former communist countries of Central and Eastern Europe.

In many mountain regions of the world, it is inappropriate to speak of 'foresters' and 'farmers' (Price and Thompson, 1997). Agriculture and forestry are inseparable activities within a complex mountain landscape, with forests providing essential resources to ensure the viability of agriculture. These resources depend greatly on local ecological and social conditions. In many parts of the world, grazing animals rely on forage within forests, fodder brought from them, and the shade they provide during hot summer days. The expansion of grazing land by clearing and/or burning at the upper timberline has led to its depression in many mountains, by as much as 300 m in the Alps (Langenegger, 1984). Restoration of forests in this dynamic zone is often difficult or impossible because of changes in microclimate and soil conditions following clearing.

In many tropical countries, slash-and-burn agriculture represents a successful means of utilising forested ecosystems when human population densities are low and government policies do not limit movement. However, settlement and/or high population densities often lead to a level of degradation from which forests cannot recover; and clearance in order to grow illegal crops has affected forests in many less-accessible mountain regions. Agroforestry - through planting, natural regeneration, or controlled use of remnant forests, often combined with intercropping of food crops - can often permit continued use of land by large human populations (Atta-Krah and Tang, 2000). However, this requires that those who make the necessary investments of time and labour have security of tenure and, in many cases, that extension services and other organisations provide new tree or crop species in addition to those of local origin in order to provide the desirable mixture of food security, income generation, and slope stability (McDonald et al., 2000; Singhal et al., 2000).

The longest-established uses of forests for recreation are for hunting and fishing for pleasure: activities that also remain important for subsistence in many regions. The more widespread use of forests for recreation derives from a series of linked factors; particularly, increases in accessibility, leisure time, and income in both industrialised, but also many developing, countries (McCool and LaChapelle, 2000; Pröbstl, 2000; Nepal, 2000). This phenomenon began in the early 19th century in western Europe and spread to the mountains of South Asia, eastern North America, and Latin America over the next century (Price, 1992). However, until after the Second World War, it was limited to relatively few locations. Mass recreation now takes place in mountain forests around the world, with a vast range of activities: both active (e.g., skiing, mountain-biking, hunting, walking) and passive (e.g., bird-watching, painting, sightseeing). A critical issue is how to manage such rapidly-growing activities to minimise environmental and societal impacts, and to maximise benefits to local communities (Price et al., 1997; Godde et al., 2000).

Following the mention of the vital resources provided by mountains - notably, as discussed above, by their forests - the first paragraph of Chapter 13 notes the rapid changes that are taking place in mountains: soil erosion, landslides, and rapid loss of habitat and genetic diversity. The loss of diversity can result from many of the processes discussed above, such as deforestation, excessive harvesting of forest products, hunting, and recreation. The protective function of forests, in stabilizing slopes and limiting damage from extreme events, such as avalanches and floods, has long been known by mountain people with, for instance, local regulation in the Swiss Alps since the 13th century, and national legislation from the late 19th century (Price, 1990). Nevertheless, it should be recognised that this legislation followed major floods after decades of unheeded warnings of the risks of excessive utilisation of the forests. A more recent example is in Thailand, where landslides and floods followed widespread replacement of forests by agriculture and plantations (Hamilton, 1992). The major issue for minimising risks from 'natural hazards' is therefore how to develop and implement policies to ensure stable forest cover (Ottitsch and Weiss, 2000), particularly when this has been lost through human action, extreme events, or a complex mixture of these.

Actions Towards Sustainable Mountain Development

The fact that forests are implicated in the majority of the issues addressed in the introductory paragraph of Chapter 13 underlines their central importance to sustainable mountain development. Forests are also specifically mentioned in a number of the sub-paragraphs describing activities that governments are encouraged to implement within the two programme areas of Chapter 13:

> 13.6(f) "integrate all forest, rangeland and wildlife activities in such a way that specific mountain ecosystems are maintained";
>
> 13.7(b) "build an inventory of different forms of soils, forests, water use, and crop, plant, and animal genetic resources, giving priority to those under threat of extinction. Genetic resources should be protected in situ ...";
>
> 13.10 "Strengthen scientific research and technological development programmes, including diffusion through national and regional institutions, particularly in meteorology, hydrology, forestry, soil sciences and plant sciences";
>
> 13.16(b) "establish task forces or watershed development committees, complementing existing institutions, to coordinate integrated services to support local initiatives in animal husbandry, forestry, horticulture and rural development at all administrative levels".

Under programme area B (paragraphs 13.13-22), there are also a number of sub-paragraphs that propose activities related more generally to various aspects of forests: pilot projects combining environmental protection, development and environmental management practices/systems (13.21a); participatory generation of technology for watershed management (13.21b); technology, training, and dissemination of knowledge relating to agroforestry and other aspects of land and water management (13.21c, 22a); and national centres for watershed management (13.23).

The importance of forests is also underlined in the documents resulting from the regional inter-governmental consultations on sustainable mountain development which have taken place since UNCED, in Africa (ILRI, 1997), Asia (Banskota and Karki, 1995), Europe (Backmeroff et al., 1997), and Latin America (Mujica and Rueda, 1996). All of these documents, endorsed by representatives of a total of 62 countries and the European Union, stress three major issues of direct relevance to forests. First, integrated approaches to land use, involving all stakeholders, are necessary, but require investment. Second, land use practices should be appropriate to land capability and community needs and capabilities. Third, there are strong linkages between land management and the conservation of both water and biodiversity; mechanisms to ensure the security of these important values of forests include the protection of areas with minimum human impacts and the development of ecological corridors and transboundary protected areas.

Many of these cross-cutting issues can be identified in activities which have begun in different countries since UNCED. However, it is rarely possible to say that such activities result directly from Chapter 13. Even when they are specifically in the context of a national plan or strategy for Agenda 21, conservation, or biodiversity (as, for example, in Bulgaria, Japan, Pakistan, Papua New Guinea, or Philippines), such activities may have been planned or underway before 1992

(Price, 1999). The following paragraphs illustrate a few of these activities, recognising that similar examples could probably be cited for other countries. However, few national governments specifically identified such activities in the 'country statements' submitted to the fifth session of the UN Commission on Sustainable Development in April 1997.

In Japan, the Council of Ministers for Global Environmental Conservation approved the National Action Plan for Agenda 21 in December 1993. Chapter 13 of this plan places a very strong emphasis on the management of forests for protection, production, recreation, and conservation. The links between the latter two 'outputs' and economic development is clearly identified in relation to the development of eco-tourism. Nevertheless, while the maintenance and encouragement of mountain economies is a clear goal of the chapter and a law passed in the same year, this is within the constraints imposed by the need to minimise health and environmental impacts. The Basic Plan for Forest Resources, passed in 1996, emphasizes five main functions of forests: 1) conservation of water resources; 2) disaster prevention; 3) environmental conservation; 4) timber production; and 5) health and cultural activities.

One activity that clearly notes its antecedence in Chapter 13 is the Inter-regional Project for Participatory Upland Conservation and Development, which the FAO/Italy Cooperative Programme began in 1992 in Bolivia, Burundi, Nepal, Pakistan, and Tunisia (d'Ostiani, 2000). Its aim is to identify and field test "strategies, methods and techniques for the promotion and consolidation of people's participation in the conservation and development of upland watersheds" (d'Ostiani and Warren, 1996: 11). A number of preliminary conclusions have emerged. First, the inter-regional institutional framework and the flexibility in planning and implementation are both important. Second, participatory methods are necessary but not sufficient; teams must also address technical elements of watershed management and underlying environmental, socio-economic and organisational issues. Third, participatory integrated watershed management involves both process-based activities and physical interventions. Finally, while limited resources can be very valuable for catalysing development investments, most actions take longer than anticipated.

Many of the projects funded by the World Bank and the Global Environment Facility (GEF) in recent years also emphasize participatory approaches and multi-functional economies (Global Environment Facility, 1996; World Bank Environment Department, 1996). Examples of World Bank projects include those in Bhutan, Indonesia, Pakistan, Tunisia, Turkey, and Yemen, which focus on watershed management, improving and restoring forest productivity, and institutional strengthening. Many GEF projects, which focus on conserving biodiversity in national parks and other protected areas, also emphasize cooperative forest management within these areas and in their buffer zones, recognising the importance of ensuring sustainable livelihoods and joint decision-making as necessary elements of biodiversity conservation. These include projects in Bolivia, Cameroon, China, Costa Rica, Ecuador, Indonesia, Mexico, Nepal, and Uganda, as well as Slovakia and Ukraine; thus, such approaches are valid not only in developing but also industrialised countries, as recognised by the Pan-European Biological and Landscape Diversity Strategy, endorsed by Ministers of Environment from 55 European states in 1995 (Council of Europe/UNEP/ECNC, 1996).

In June 1997, the UN General Assembly held a Special Session (UNGASS) to review the implementation of all of "Agenda 21". The final document of this meeting specifically mentions mountains in relation to four issues:

- continued deterioration of mountain ecosystems, resulting in diminishing biological diversity (para. 9);
- the need to formulate and implement policies and programmes for integrated watershed management (para. 34);
- the need for ecosystem approaches to combat or reverse soil degradation, recognising the multiple functions of agriculture (para. 62);

the need for national policy development and implementation to ensure sustainable patterns of consumption and production in tourism (para 68).

These concerns relate very closely to many of the values of mountain regions explored in the first section of this paper. According to the UNGASS final document, all countries are expected to have prepared national strategies for sustainable development by 2002 – since declared as the International Year of Mountains – involving all interested parties and integrating economic, social, and environmental objectives. There is considerable scope, and need, for the large number of countries with mountain forests to consider how these should be considered in such strategies.

The Role of IUFRO

In recent decades and years, there has been a widespread shift in the science and practice of forestry, from emphasis on the production of wood towards management based on recognition that forests serve multiple functions and produce a wide range of outputs (Price and Butt, 2000). This multifunctionality has long been present in most mountain forests, even when they have primarily been managed for sustained harvests of timber, but is now increasingly recognised as the basic concept which should underpin mountain forestry around the world (Buttoud, 1998, 2000).

Recognising the general shifts in forestry, as well as the changing expectations of populations around the world regarding mountain forests, and the rapid rates of change in the cover and uses of forest ecosystems, in 1995 the International Union of Forestry Research Organisations (IUFRO) established a Task Force on Forests in Sustainable Mountain Development for the period 1996-2000. The Task Force has two main purposes with respect to the roles of forests in the sustainable development of mountain areas:

to provide a framework for developing and strengthening linkages within IUFRO and between IUFRO members and other relevant organisations and initiatives;

to prepare an assessment of major issues for mountain forests at the beginning of the 21st century.

It is recognised that trends in the cover and/or density of mountain forests in different parts of the world are different, with two broad types which will often have to be considered separately in the assessment. The first is in the temperate zone (industrialised countries), where cover and/or density are generally stabilised or increasing, from land abandonment and re- or afforestation (e.g., Piussi, 2000). In certain regions, significant impacts of tourism and air pollution occur. The second is in tropical, semi-arid, and arid countries, where there are significant decreases in cover and/or density, especially through clearance for agriculture. Serious erosion and desertification, exacerbated by human activities, are often major problems. However, the causes of change in forest cover interact and in many complex ways (Scherr and Templeton, 2000).

A number of means have been used to fulfil the purposes of the Task Force. An early activity was the creation of a 'mountain forests network' on the IUFRO website, listing active individuals and organisations both within and outside IUFRO. Linkages have been developed with other relevant initiatives at different scales, notably regional (e.g., European Cooperation in the Field of Scientific and Technical Research [COST] Action E3, FAO/European Forestry Commission Working Party on Management of Mountain Watersheds; European Observatory of Mountain Forests; FAO Latin American Technical Cooperation Network) and global (e.g., Inter-governmental Forum on Forests, the Mountain Forum). A side meeting was held at the World Forestry Congress in Antalya, Turkey, in October 1997, in order to begin to define further work. In addition to the issues raised throughout this paper, the participants suggested that the Task Force should work on the following areas:

advocacy of the commonalities of mountain regions, including the promotion of North-South dialogue;

valuation of the benefits of mountain forests, which requires the close involvement of social scientists from diverse disciplines, with a focus on the service-related functions of mountain forests;

contributions of science to awareness-raising and policy-making, through strong linkages between social and natural scientists, practitioners, and decision-makers.

The IUFRO Inter-divisional Conference on Forest Ecosystem and Land Use in Mountainous Areas in Seoul, Korea, October 1998 (Korean Forestry Society, 1998) was a further key event in the activities of the Task Force. Subsequently, its major activity has been the preparation of a state-of-knowledge report on forests in sustainable mountain development, with 90 contributions from 124 authors around the world, to be published in time for the XXI IUFRO Congress (Price and Butt, 2000). The report includes a small number of comprehensive overviews at a global scale, some overviews at regional or country scales, and many case studies illustrating topics at local to national scales. The overall conclusion from the report is that we have many snapshots, but not enough consistent data sets – especially with regard to economic data, for both market and non-market goods and services – or analyses or syntheses which are sufficiently broad in both space and time and bring together insights from a sufficiently diverse range of perspectives. Such broad analyses and syntheses are becoming ever more essential in an era of rapid economic, political, and ecological change and are necessary to provide the foundations of integrated policies which recognise the key roles of mountain forests for many sectors of society.

Around the world, within and outside IUFRO member organisations, research in mountain forests is being undertaken by scientists from a wide range of natural and social scientific as well as technical disciplines; and also by local people who, though they often have little if any training in the 'scientific method', can provide vital complements to the results generated through this 'objective' process. To bring together and integrate these different worldviews, new technologies such as geographic information systems can be of great value; in general, better means of communication, using all appropriate media, are essential (Pandey, 2000). Research is an essential element in defining the future of mountain forests. Yet, for the benefit of both mountain people and all those who depend on and enjoy the environments they manage, the results of research must be effectively disseminated to all those concerned, in mountain villages, forestry companies, government agencies, academic institutions, non-governmental organisations, parliaments, regional policy-making bodies, and global organisations. Such issues will be discussed in the concluding business meeting of the Task Force at the IUFRO Congress, with a view to defining IUFRO's activities to contribute to sustainable mountain development in the period up to, during, and beyond the International Year of Mountains, 2002.

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Resistance and Elasticity: Useful Concepts in the Sustainable Management of Mountain Forest Ecosystems

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Abstract

Ecological stability properties are attributes characterising the dynamics of an ecosystem. They include the concepts of resistance (staying essentially unchanged despite the presence of disturbance agents) and elasticity (speed of return to reference states or dynamics after a temporary disturbance). In the management of mountain forests that protect against natural hazards such as snow avalanches, resistance and elasticity are already intuitively used. However, traditional silvicultural approaches have focused on stand dynamics and considered the forest as a "stable" system. This is insufficient in the long-term since driving factors, be they external to the forest ecosystem such as atmospheric inputs, or internal such as browsing, have the potential to affect stand dynamics and thus effective protection, especially since they may exhibit long-term trends. Potential changes in, for example, chemical soil properties, need to be considered in forest management, and an ecosystem-based view adopted. Ecological stability properties that are crucial for long-term effective protection need to be identified, monitored with suitable indicators, and integrated into the sustainable management of these forests. The concept of ecological stability properties is so flexible that is not only a promising conceptual tool to sustainably manage protection forests, but also forests delivering other products and services.

Keywords: Sustainable forest management, Natural hazards, Mountain forests, Resilience, Resistance.

Introduction

The concept of "ecological stability" has been appealing to many ecologists for many decades (MacArthur 1955, Lewontin 1969, Holling 1973, Pimm 1984, Rapport 1998 p. 27). However, applications of the concept to specific ecological problems based on real data have been sparse (Larsen 1995, Grimm 1999). One of the problems with "ecological stability" is the fuzziness of the concept. In a comprehensive review, Grimm and Wissel (1997) conclude that the term has caused so much confusion that it should be avoided. They advocate subdividing the concept into several "ecological stability properties", including resistance (staying essentially unchanged despite the presence of disturbance agents) and resilience (returning to the reference state or dynamics after a temporary disturbance). They also provide a rigorous terminological framework that is applicable in a variety of situations, and present a checklist to precisely characterise an ecological situation, which enables meaningful stability statements to be made.

Ecological stability properties have not only been used in a purely ecological context. Some stability properties have also intuitively been used in forest management. In the case of protection forests, i.e., forests on steep slopes that protect people and assets against natural hazards such as snow avalanches and rockfall, resistance and resilience are of particular interest (Brang, submitted). Sustainable management of these forests means containing forest dynamics in a way that unacceptable impact of natural hazards is avoided (Brang et al. 2000). As the occurrence of natural hazards is bound to specific stand structures, the limit between acceptable and unacceptable impact can be described in terms of stand structural variables. For protection forests in the Swiss Alps, such minimum conditions for effective protection have been defined and are now used in silvicultural decision-making (Wasser and Frehner 1996). The rationale for trying to achieve minimum, and not optimum conditions is that most silvicultural operations on these slopes are so costly that expenses exceed revenues. Consequently, subsidies are needed as an incentive for the forest owner to carry out silvicultural operations aimed at ensuring effective protection. Spending subsidies in a cost-effective way means subsidising only operations that are absolutely necessary to achieve acceptable, and thus minimum levels of protection.

In an earlier paper (Brang, submitted), I have explored benefits of applying resistance and elasticity to the sustainable management of protection forests. This contributes to a comprehensive analysis, characterisation, and evaluation of disturbances and slow changes in protection forests. Resistance and elasticity can equally be applied to all dynamic ecosystem processes, e.g., stand dynamics, regeneration dynamics, and changes in soil chemistry (Brang, submitted). Resistance and elasticity can also be quantified using suitable variables. Reference conditions (or dynamics) can be selected based on purely ecological considerations, or on ecological services (Cairns 1995) a forest is expected to provide. The concepts are also linked to the risk analysis framework (Risk Assessment Forum 1996): high resistance to changes can be expressed as low likelihood (and potential damaging impact) of these changes, and high elasticity means short time periods with potential damaging impact.

However, many questions remain to be answered. Managing protection forests, in the face of multiple disturbances, for specific minimum levels of resistance and elasticity of relevant ecosystem properties is challenging in several ways. First, a silvicultural operation itself is usually a disturbance (Geils et al. 1995) with potential side-effects, which may trigger further unplanned disturbances. Second, the disturbance regimes in mountain forests are currently changing. New types of disturbing influences emerge, and old types gain in strength. Mountain forest ecosystems in Switzerland are currently subject to unprecedented impacts of atmospheric pollutants (causing soil acidification, eutrophication, and nutrient imbalances, Flückiger and Braun 1998, Kurz et al. 1998a), global climate change (Price and Barry 1997), and browsing by ungulates (Brändli 1995). These influences have the potential to impair effective protection, and thus to impede the sustainable management of these forests. The question is therefore how silviculture is going to cope with these challenges. Third, there may be trade-offs between resistance and elasticity. If this is the case, forest management should not maximise one at the cost of the other, but find an optimum.

In this paper, I am going to conceptually address these questions. I will illustrate the ideas with examples, and provide scientific evidence where available.

Ecological Stability Properties: an Old Concept Gains Momentum

This section is for the reader who is unfamiliar with the concept of ecological stability properties. Grimm and Wissel (1997) define three basic concepts that are part of ecological stability properties: 1) ”constancy” (= staying essentially unchanged), 2) ”resilience” (= returning to the referential state or dynamics after a disturbance), and 3) ”persistence” (= the persistence through time of an ecosystem). ”Constancy” includes the property ”resistance” (= constancy despite the presence of disturbing agents). ”Resilience” includes the property ”elasticity” (= speed of return to the reference state or dynamics).

A "disturbing agent" is a factor that has the potential to abruptly and substantially change ecosystem characteristics. This change may occur on various temporal and spatial scales. Its effect on an ecosystem is called a "disturbance", as "any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment" (White and Pickett 1985). In this paper, I subsume "events" caused by continuously acting agents such as acid deposition that lead to slow changes in the ecosystem also under the notion "disturbance" (but see Jax 1998/1999).

Statements about an ecological stability property are only meaningful if the ecological situation is clearly defined (Grimm and Wissel 1997). A stability statement such as ”this forest is more resistant than that one” is so vague to be almost meaningless. Does the statement refer to the resistance of the landscape to changes in forest patch patterns, or to the resistance of an ant to a leaf falling to the ground? Grimm and Wissel (1997) advocate defining the ecological situation using six characteristics which are applied to forests in Table 1. In the context of sustainable management of protection forests, the ecological situation is given by the scale of the natural hazards involved, the nature of the protective effect of the forest, and the disturbances that have the potential to impair effective protection. Stability statements in this paper refer, unless otherwise stated, to the following situation: The level of description is the population level; the variables of interest are variables describing the spatial structure of the stand; the reference values of the variables of interest are values at which the stand offers effective protection against snow avalanches and rockfall (Wasser and Frehner 1996); the disturbances are caused by wind or bark beetles; the spatial scale is the stand scale; and the time scale is 500 years. Examples of meaningful stability statements are "this stand (area 5 ha) will recover from a complete windthrow disturbance to a stem density of 400 ha^{-1} (dbh   8 cm) within 40 years", and "the soil on 50% of this area of 1 ha will resist changes in pH to values below 3.0 in any soil layer within the next 200 years, given annual acidic inputs of 4 keq yr^{-1} ha^{-1}." For managing protection forests of the European Alps, the most relevant stability properties are resistance and elasticity (Brang, submitted). In terms of stand structure, the ideal protection forest is highly resistant to natural disturbances that have the potential to impair effective protection; it has moderate resistance to natural disturbances that do not impair effective protection, but enable renewal of the tree layer, and can easily be replaced with anthropogenic disturbances (silvicultural operations); and it is highly elastic, i.e., regeneration rapidly fills any gaps.

Natural and Anthropogenic Dynamics of Mountain Forest Ecosystems as Related to Natural Hazards

Managing a protection forest is different from managing a forest for timber volume, timber value, aesthetics, recreation, species diversity, or habitat for specific threatened species. Managing a protection forest means primarily managing stand structure because only a specific structure ensures effective protection. The protective effect of a protection forest is mainly the result of an interaction between natural hazards, trees, gaps, soil surface roughness, slope, and weather conditions. Trees prevent, by snow interception and release, and by differential snow melt, a homogeneous snow layer from building up (Imbeck and Ott 1987). Trees' stems, stumps and nurse logs stabilise the snow pack, by providing an anchoring system and a rough surface. In a protection forest, disturbances affecting trees on an area exceeding a certain minimum area have the potential to impair effective protection. Gaps exceeding 30-50 m perpendicular, and 100 m parallel to the contour line should be avoided in order to prevent snow avalanches from releasing (Wasser and Frehner 1996). This means that small-scale disturbance regimes are preferred.

Fortunately, small-scale disturbance regimes, with gap areas below 0.1 ha, prevail in the Swiss Alps (Zukrigl 1991, Brang et al. 2000) although specific data are missing, and quantifying these disturbance regimes (e.g., gap size distribution, disturbance frequency) would be a highly rewarding task. Large-scale disturbances only exceptionally occur, mostly as a result of wind and bark beetles, and rarely from fires and snow break. Moreover, there is evidence that Swiss mountain forests would be more resistant to large-scale disturbances if they were in a more natural condition. Extensive human disturbance that started in the Middle Ages has probably reduced the forests' resistance to such disturbances. As an example, stand structures are currently more homogeneous than they were in old-growth forests (Brang, submitted). This means that improvements of current stand structures to increase a stand's resistance against disturbances are possible. Current management practices in Swiss protection forests are aimed at speeding up this change towards more heterogeneous stand structures. In some cases, managers even try to implement anthropogenic small-scale disturbance regimes in cases where large-scale disturbances would be prominent in natural stand dynamics, e.g., in montane *Picea abies* forests *(Korpel' 1995*). It is unclear, however, to which extent this is possible in the long-term.

Table 1. Checklist for ecological stability properties (Grimm and Wissel 1997), applied to the management of protection forests. The table describes how the ecological situation can be defined to make measingful ecological stability statements.

Characteristics of the ecological situation	Question to be answered	Possible answers in the context of protection forests
Level of description	On which hierarchical level of an ecosystem are we describing stability?	Individual organism to landscape, depending on the desired protective effect. In the frequent cases where this effect directly depends on trees, the population level is used.
Variable of interest	Which (measurable) state variables are we referring to?	Indices of the spatial distribution of trees, distribution of the diameter at breast height, distribution of gap sizes and orientations, volume increment, estimated nutrient cycling rates
Reference state or dynamics of the variable of interest	What is the state variables "acceptable[$]" behavior?	"Acceptable" values of state variables depend on knowledge about the dynamics of protection forests and their relation to effective protection, and on the risk acceptable to the people needing protection.
Disturbing agents and disturbances	Which disturbing agents are affecting systems behaviour, and to what extent?[¶]	Disturbing agents that can cause the unwanted death of trees (storm, snow load, bark beetles), or that have the potential to alter tree species composition, and growth and mortality patterns (pathogenic fungi, extreme climatic events, bad management practices, soil acidification, browsing ungulates); frequency and intensity of the disturbances.
Spatial scale	To which spatial scale does the stability statement refer?	Tree to landscape level (0.001 ha – 100 ha). The spatial scale is given by starting and run-out zones of natural hazards.
Time scale	To which time scale does the stability statement refer?	Years to several centuries.

[$] Grimm and Wissel. (1997) focus on "normal" reference states or dynamics without external influences. This seems inappropriate in the context of an ecosystem managed for specific purposes. The notion of "acceptable" behaviour is more precise.

[¶] Grimm and Wissel. (1997) define disturbance as the result of dynamics exceeding reference dynamics. In the context of forest management, reference dynamics are dynamics where acceptable levels of disturbance are not exceeded. Management usually aims at replacing part of the highly variable natural disturbances by more predictable human disturbances.

Do Current Silvicultural Operations Enhance Forest Resistance and Elasticity?

Many traditional silvicultural operations involve the sudden removal of trees. More smooth changes can be achieved, e.g., by girdling (Guariguata 1999); however, such

methods are not widely practiced. One reason for this is that in *Picea abies* stands, girdling may trigger bark beetle attacks. In protection forests, cuttings are at present restricted to single trees or small stand patches the size of which is limited by the natural hazards involved (Wasser and Frehner 1996). Do these silvicultural operations increase or reduce a stand's resistance in the face of natural disturbing agents such as wind or bark beetles? In the last paragraph, we have already seen that this has not always been the case in the past (Brang, submitted). When addressing this question, we have to take into account that many of the relations mentioned below, although plausible and common knowledge of practicing foresters, remain to be demonstrated using rigorous scientific methods.

The ideal stand in a protection forest consists of trees or tree clusters that are mutually independent and resistant on their own, with their crowns being separated and reaching to the ground (Ott et al. 1997 p. 21, Brang et al. 1998). In such cases, removing a tree or a tree cluster has little influence on the stand's resistance, apart from a certain increase in canopy surface roughness. However, many stands are currently far from this ideal stand structure, with high stem density, the trees being mutually dependent and short-crowned with slender stems, and with internal stand edges being sparse. In these stands, thinnings may reduce inter-tree competition and increase the individual resistance of the trees to wind in the long-term (Slodicák 1995). However, in the short-term, removing a tree often means breaking up a fragile balance, and exposing trees to loads that they are not adapted to. Will they resist storms that, before the operation, hit their neighbour trees? Deciding whether the potential beneficial long-term effect (stabilisation) of such an operation will outweigh its short-term risks (destabilisation) is difficult. The potential destabilising effect can be minimised, by leaving the trees and tree clusters that seem most stable (low coefficient of slenderness, long crowns, no signs of root or stem rot, Wasser and Frehner 1996), and by leaving internal stand edges intact, but it cannot be entirely avoided. An operation that is aimed at stabilising a stand can therefore trigger further unplanned disturbances. The solution is often to concentrate management efforts on other stands with higher chances of success (Ott et al. 1997 p. 82, Brang et al. 2000), especially if the revenues from such an operation do not cover its costs, and if the operation must therefore be seen as an investment with uncertain return. This is frequently the case in Swiss protection forests.

Similar questions as with operations aimed at increasing resistance arise with operations that should enhance elasticity by promoting regeneration. In protection forests, regeneration is supposed to take place in small gaps, or under a light canopy. This is also often the case in old-growth forests on similar sites *(Korpel', 1995).* Elasticity increases with increasing seed rain, increasing share of microsites (Clarke 1992, Chambers and MacMahon 1994) that are favourable for successful seedling emergence and establishment, higher density and better condition of pre-established seedlings and saplings (seedling and sapling bank, Morin and Laprise 1997), and with faster growth that enables the recruitment to offer effective protection against natural hazards sooner. Seedling mortality, e.g., as a result of browsing (Eiberle 1989) should be low. In protection forests of the Swiss Alps, there are no long-term observations of silvicultural operations aimed at promoting elasticity by promoting regeneration, apart from planting which can be successfully done (Schönenberger et al. 1990, Ott et al. 1997 p. 96, Brang et al. 1998). The short-term evidence that is currently available suggests that creating small gaps, shelterwood-type and single-tree selection cuttings can be successful (Imbeck and Ott 1987, Ott et al. 1997, Brang 1998). The obstacles that are often encountered are browsing, unavailability of suitable microsites, and high seedling mortality.

The silvicultural technology to increase a stand's resistance and elasticity is available. The cases where the outcome of silvicultural operations is highly uncertain are identified (Ott et al. 1997 pp. 90, 93). The question remains if, using this traditional technology, protection forests can be successfully managed in the long-term.

Enlarging the Scope of Management of Protection Forests

Traditional silviculture in protection forests has tried to influence stand dynamics by replacing natural disturbance regimes with anthropogenic disturbance regimes (Fig. 1, arrow 1) which are more predictable. Increasing the resistance and elasticity of managed stands has been an implicit goal. This is understandable since stand dynamics determine how effective the protection against natural hazards is (Fig. 1, arrow 2). However, stand dynamics depend on many other dynamic factors and processes (Fig. 1, arrows 3). They depend on populations of browsing, fraying, and seed-dispersing animals that may promote specific tree species, and reduce the share of others. They depend on soil fauna and mycorrhizal fungi, on invasive plant species that have the potential to hinder tree regeneration, on new fungal, bacterial and viral diseases affecting trees and other organisms. They depend on changes in atmospheric inputs (Fig. 1, arrows 4 and 5) which alter soil chemistry, and on climate. They depend on soil physical properties. The dynamics of most of these ecosystem components and external forcing factors have usually been neglected in the management of protection forests. This was possible because these components were usually present in "acceptable" levels, with their variability only exceptionally causing any (recognised) unwanted changes to the tree layer. Action was not primarily taken in a preventive, but rather in a curative manner, after a specific damage such as windfall had occurred. Moreover, silvicultural operations have influenced some of the mentioned crucial ecosystem components (Fig. 1, arrow 6). In some cases, unwanted side-effects of silvicultural operations are known. Examples include the build-up of deep organic layers after replacing broad-leaves with coniferous trees on acidic soils (Fiedler 1980), or nutrient depletion or soil compaction as a result of heavy machinery used for timber harvesting (Zabowski et al. 1994, Jurgensen et al. 1997).

The challenge for silviculture is not only to integrate interactions of various ecosystem components and external environmental factors with stand dynamics and silvicultural operations (Fig. 1), thus enlarging the traditional view of forests as tree assemblies. The challenge is also that forest ecosystems are not systems in balance since some of the forcing factors (especially climate and atmospheric deposition) are not stable, but show trends. These trends are likely to finally exceed the resistance of current stands and thus cause *permanent* changes in stand dynamics (Huntley and Birks 1983, Bauerochse and Katenhusen 1997), be it by influencing tree establishment, growth and mortality directly, or indirectly by changes in ecosystem components that are crucial for trees. Forest ecosystems are slowly moving towards unknown new reference conditions of state variables (or of dynamics), which complicates also the application of ecological stability properties. The development of old stands (e.g., in *Picea abies*, stands exceeding 250 years in age) is particularly uncertain since such stands are very rare today. First evidence for such changes is the increase in tree growth (Spiecker et al. 1996) in central Europe. Other changes can be anticipated; e.g., selective browsing by ungulates is likely to change tree species composition (Eichenseer 1997, Kienast et al. 1999), stand structure (Kienast et al. 1999) and the internal stand climate, and atmospheric deposition is causing soil acidification that can affect fine root dynamics, and eventually tree nutrition (Dettwiler 1986, Kratz et al. 1996).

Is it now necessary to revise traditional silvicultural practices in protection forests in order to take other ecosystem components and states into account, and to adapt to environmental trends? Some of the mentioned ecosystem components (such as browsing animals) and states (such as soil physical properties) can be influenced by silvicultural operations, while other driving factors (such as climate change and atmospheric inputs, Fig. 1) are driven by processes out of reach of a forest manager. I do not see any general principle applicable to enhancing a forest's resistance, although the general diversity (or complexity)-stability relationship as proposed by MacArthur (1955) is increasingly supported by more realistic foodweb models (McCann et al.

1998). However, empirical evidence for this is still sparse (Johnson et al. 1996). It seems more promising to hypothesise a general diversity (or complexity)-elasticity relationship. This would suggest creating or maintaining diverse stand structures and species compositions in a forest ecosystem. In the absence of clear empirical evidence, adopting this approach is an application of the precautionary principle.

Integrating crucial ecosystem components and states into the management of protection forests does not mean rejecting traditional silvicultural systems. Traditional stand variables such as the stand density, the dbh distribution, gap size, shape, and orientation, and the cover and species composition of the regeneration are still relevant for silvicultural decision-making, and need to be assessed. However, other ecosystem components that are crucial for stand dynamics and sensitive to change need also to be monitored, if feasible on site, if not on adjacent intensive monitoring sites. These components need to be identified, and suitable indicators selected for monitoring. Their resistance to change, and their elasticity can equally be described using the framework of ecological stability properties. The selection of indicators needs to be site-specific. An already acidic soil may be sensitive to acidification from atmospheric inputs, while this is no issue on a site with ample nutrient supply.

The primary issues deserving our attention in protection forests in the Swiss Alps are soil acidification by atmospheric inputs that exceed critical loads and levels (Braun et al. 1996, Kurz et al. 1998b), which may cause nutrient imbalances and losses in the composition of the mycorrhizal fungi, browsing (Brändli 1995), dense ground vegetation and lack of nurse logs (Ott et al. 1997 pp. 29, 54), all impeding regeneration, loss of biodiversity at the level of species richness, and diseases of trees and seedlings. Those current silvicultural practices that have unwanted side-effects with respect to these issues need revision.

Do Resistance and Elasticity Compete or Support Each Other?

To explore the relation between resistance and elasticity (Webster et al. 1975), they should be applied to the same ecological situation. The highly resistant and resilient stand is a dream, as in this example: In many cases, a closed stand without gaps will be more resistant to wind than a stand with gaps. On the other hand, a closed stand without gaps will have fewer microsites suitable for regeneration, and thus lower elasticity, than a stand with gaps. I hypothesise that this competition-type relationship holds for populations where adults and juveniles are competing for the same resources. It seems to hold also for the case of browsed seedlings: Species that are not so often browsed, and thus resistant to browsing, like *Picea abies*, have more difficulty to recover from browsing than seedlings of broad-leaves like *Sorbus aucuparia* that are preferably browsed. However, already in this case there are species that show both low resistance and elasticity to browsing, like *Abies alba*. It is therefore not clear in which cases resistance and elasticity are competitive, and in which supportive.

At a stand scale, the silvicultural question whether resistance or elasticity should be promoted is often asked. In which situations and to which extent should a stand’s resistance be sacrificed in favour of its elasticity by promoting regeneration? With ideal stand structures, this question is easy to answer. As individual trees and tree clusters are mutually independent, whole clusters can be removed for promoting regeneration, without impairing the stand's resistance to disturbing agents such as wind. But how do managers decide in homogeneously structured stands? As the current stand's resistance is required for effective protection now and in the near future, while promoting regeneration will ensure effective protection only after several decades, and may even lead to gaps exceeding the maximum size for effective protection, the decision is very often taken in favour of current needs, i.e., resistance. An additional reason to favour resistance over elasticity is that regeneration can be introduced by planting, and is even growing faster than natural regeneration in many cases (Kahls

1973). This suggests proceeding with stabilising thinnings only, with insufficient light conditions for regeneration, and accepting natural disturbances as starting points for stand renewal.

Conclusions

If properly applied, ecological stability properties (Grimm and Wissel 1997) are a rigorous scientific concept to describe ecosystem dynamics. Some of the challenges that the use of this concept in forest management presents have been addressed in this paper and illustrated with the example of forests protecting against natural hazards. In such protection forests, the requirements for a continuous effect of the forest are especially high. Management aims at maintaining or creating specific stand structures which ensure high resistance and elasticity of the forest in the face of multiple disturbing agents.

When striving for a balance between resistance and elasticity in protection forests, a traditional silvicultural approach is insufficient. An ecosystem-based view (Schlaepfer 1997) of the forest needs to be adopted, and trends in driving factors such as climate change and atmospheric inputs recognised and anticipated in forest management.

The concept of ecological stability properties is not yet operational for field applications although some of its facets are already implicitly used in traditional silvicultural approaches towards the management of protection forests. It seems possible, however, to progress in implementing the concept, and first attempts for achieving this have been made (Brang, submitted). Tools for indicator development are available (Fisher 1998, Jackson et al. 1999, Prabhu et al. 1999).

The concept of ecological stability properties seems to be generally applicable to forest management, no matter which management goals are pursued. Integrating ecological stability properties such as resistance and elasticity has the potential to make the outputs of forests more predictable. The concept deserves further attention in sustainable forest management.

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Indigenous Agroforestry Technologies for Sustainable Himachal Himalayan Development

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Abstract

The traditional agroforestry systems in the Himachal Himalayas have shown that the local farmer is aware of the benefits of mixed cultures and grows at least three to six types of trees in and around his fields. The overall prevalence of trees under traditional agroforestry concept at each farmer's field showed an increase from 47% in the lower hills to 67% in the middle hills. In general, 35-60% of farmers' fields have trees in traditional agroforestry, ranging from 35 to 46 different species from the lower hills to the middle hills. In the lower hills, the focus was on timber and horticulture trees whereas in the middle hills the prime aim was to integrate fuelwood and fodder trees in the system. Keeping in view the indigenous knowledge of the architectural shape of the tree in which the farmer manages a particular type of species, various tree prototype models were developed and tested. These canopy architecture prototype models depict the type of the tree for lopping practice, the extent, and the zone of the canopy management done by the farmers. In this work, the human perception in adoption of a particular prototype of an agroforestry tree in a system was highlighted. The concept of conserving the biodiversity increased from the lower to the middle hills. The indigenous practice of coppicing, lopping, and pollarding the trees for crop compatibility with respect to the size of the field was traditionally adopted by farmers because it both improves the productivity of land in terms of fuel and fodder and reduces the stress on village forests.

Keywords: Agroforesty, Indigenous technology, Prototype, Tree Architecture

Introduction

The Himalayas constitute one of the well-defined phyto-geographical regions of the Indian sub-continent. Farming is by far the most important and widespread occupation in the region. About two-thirds of the rural people follow diversified farming which includes animal husbandry, agriculture and fruit farming as major components. Farming in the Himalayas still continues to be largely at the subsistence level. Adoption of trees in agroforestry is not a new concept in Himachal Himalayas but has been practiced traditionally since time immemorial. Agricultural innovations have concentrated heavily on developing high-yielding crop varieties. As a consequence, the role of trees in meeting subsistence needs and providing conservation and protective functions have been overlooked, as have traditional management practices and technologies. This has resulted in the disappearance of some species traditionally used and maintained by farmers. Though a number of studies on Himalayan agroforestry systems are available (Toky et al., 1989, Punam 1990, Gilmour and Nurse 1991, Nair and Dagar 1991, Ralhan et al., 1991, Atul, et al., 1994, Sundriyal et al., 1994, Atul et. al., 1995, Dagar 1995, Sharma et al.,1995, Thapa et al., 1995, Atul and Punam1996, Semwal and Maikhuri 1996, Singh et. al., 1997), information on the indigenous knowledge and species management by the farmers in the traditional agroforestry system within the ecosystem, which has great diversity in composition, structure and function, is fragmentary. Integration of indigenous knowledge and experience in promoting agroforestry remains a prerequisite to ensure its social acceptability and sustainability. Understanding local tree-use practices, then, is necessary for formulating adoptable agroforestry systems.

This study aimed to analyze the farmers' perception in adoption of a particular prototype of an agroforestry tree and to explore the indigenous knowledge before interaction strategies are formulated for the sustainable development of the Himachal Himalayas.

Materials and Methods

Study area

The study was undertaken in Kangra Valley, which encompasses the sub-montane low hill subtropical and middle-hill sub-humid zones of the Himachal Himalayas. The Shivaliks and Dhauladhar Himalayas traverse the Kangra district from northwest to southeast. It is the most populated and biggest agricultural district of Himachal Pradesh, 5,063 sq. km in area. The pattern of land utilization has largely remained unaltered over the last decade. Forests occupy more than 39% of the area. The net area shown is only 21.1%: a decline of 7.78%. The agricultural economy of the district is predominantly small-holding oriented. About 64% of the total holdings are less than one hectare in size, but these account for only 14.91% of the total cultivated area. The holding size group of 1-2 hectares accounts for 18.17% and 2-5 hectares for 13.18% of the total holdings. Holdings above 5 hectares comprise 4.6% of the total holdings in the district and cover more than 44% of the total cultivation area. Out of the 134,560 holdings enumerated in the valley, 101,160 individual holdings cover 67.67% of the total area of the holdings. More than 84% of the individual holdings have less than 2 hectares of land, occupying nearly 35% of the total area owned by the group, while more than 60% of the joint families have less than 2 hectares of land and occupy less than 25% of the transitional Palampur area. In the Kangra valley, farmers integrate trees, crops and grasses on a small piece of land to meet their basic needs of food, fuel and fodder under the umbrella of agroforestry.

Method of Study

Data was collected on various traditionally prevalent agroforestry practices in the Kangra valley from different zones starting from Kangra (lower-hill: 800m), Palampur (transition between lower and mid-hill), Mandi (mid-hill: 1900m). The average rainfall of Kangra, Palampur and Mandi is 1702, 2515 and 1800 mm annually. The soils of these sites vary from clay to loam or loamy soils. Thirty-six villages in these areas were selected from the revenue record numbers using the random number table with three replicates in each cluster. The method employed for sample selection was as described by Mehl (1990). The data were analyzed statistically using ANOVA (CRD design) (Zar 1974). The number and name of the villages was the same as given by the revenue department. The data encompassed the mapping of the fields in the selected village fields to know the stratified distribution of various prevalent arboreal components in the village ecosystem. For calculating the prevalence of agroforestry, a minimum of 30 fields with trees were selected. Each field was evaluated in terms of the number of trees, type of trees, the existing prototype of the tree, tree position, tree dimensions, practice of the associated agriculture system etc.

In addition to pre-formulated questionnaires (6,475 respondents), group discussions were held to identify farmers' tree objectives. The method followed was that given by Chuntanaparb and Ranganathan (1990), with location-specific modifications. Among the more noteworthy modifications were those related to participatory mapping. A visual image of village layout, shown in a phyto-geographical map mosaic, helped locate specific visual features and identify village land-use patterns, which were physically surveyed during the study. This permitted the project research group to analyze land-use practices and discuss specific issues related to tree management.

After introducing line drawing examples of stem form and canopy shape, local persons were invited to sketch drawings representing their own ideas about the management of agroforestry trees on their fields. The prototypes emerged through iterative changes based on participants' comments (Fig 1) as followed by group discussion on undesirable tree characteristics. Finally, refining the local participants' sketches developed the tree prototypes. The line drawings developed through this process helped not only in identifying the tree (prototype) but also in understanding the management practices (Table 1) that were applied to species selected for different agroforestry systems.

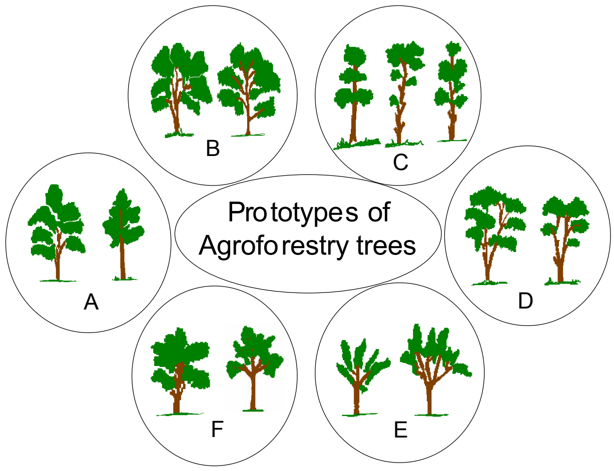

Fig. 1 Different prototypes of agroforestry trees prevalent in the traditional agroforestry systems

Results and Discussion

The study on the traditional agroforestry fields helped to reveal the distribution of various prevalent systems in the village ecosystem. The areas studied were significantly different in the prevalence of the traditional agroforestry systems (Table 2). It was found that the mean prevalence of traditional agroforestry systems in the village fields was lowest (47%) in the lower hills, 52% in the transition zone of the low and mid-hills, and 67% in mid-hills. The range of adoption of agroforestry was quite different from mean values, ranging from 31.96 to 62.97% in the lower hills and from 42.78 to 70.31% in the mid-hills. The mid-hill areas presented a unique picture in that there were pockets with more than 90% prevalence of trees in the farmers' fields; of 36 pockets sampled, the lowest value was 40.9%. Thus, it can be inferred that at the higher altitude, there were trees on almost each farm, which supports the postulate that the farmers have cleared the forests for agriculture and the trees on each field are the remains of those cut forests (Bishop 1983).

The number of species prevalent in different zones presented an inverse relationship with the precentage value of the adoption of agroforestry i.e., there was a significant decrease in the number of species with both increasing altitude and agroforestry adoption. Maximum values of farmers' field length and width did not vary significantly between the zones, whereas the minimum dimensions varied significantly (Table 2). The lowest values were observed in the transition zone. This is because, in the transition zone, the tea gardens and the unused lands were transformed to the agricultural fields through the intervention of the local population. The data analysis unveiled the minor features of the traditional agroforestry system and the prevalence of different prototypes on the farmers' fields. The manner in which farmers grow and maintain trees and perennial shrubs in a single production system with other components, such as agricultural crops and animals, is often determined by a number of external governance and inter-household characteristics. Changes in the overall economy and agriculture have overriding effects in farmers' agroforestry decisions. Household decisions influence species selection also. It was found that, in the lower hills, the farmers' preference was mainly to grow *Dalbergia sisoo* (Tali), followed by *Celtis australis* (Khirk), *Grewia optiva* (Beul) and *Salix* sp. (Beuns). In the mid-hills, the strong dominance of *Grewia optiva* (Beul) was clearly seen and other additional tree species were *Ficus* sp., *Morus alba* (Toot) and *Bauhinia variegata* (Kachnar). In the transitional zone, the farmers' preference was *Pyrus lannata* (Kainth), *Grewia optiva* (Beul), *Salix* sp. (Beuns) and *Albizia stipulata* (Ohi) in descending order of adoption.

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Table 1: Classification criteria of different prototypes of agroforestry trees

	Criteria	Prototype					
1	**Periodicity of management**	A	B	C	D	E	F
	Lopped every year			+	+	+	
	Lopped with yearly gap period						
	Lopped with gap of two or more years		+				+
	Not lopped at all	+					
2	**Extent of lopping**						
	Heavy lopping			+		+	
	Moderate			+			
	Partial		+		+		+
	No lopping	+					
3	**Purpose of tree management**						
	Fodder		+	+	+	+	+
	Fuel wood		+	+	+	+	+
	Fruit	+					
	Timber	+					+
	Animal bed			+	+	+	+
4	**Objectivity**						
	To increase leaf yield		+	+	+	+	
	To increase branching		+	+		+	
	To increase height of tree						+
	Others	+					+
5	**Canopy management**						
	Top					+	
	Middle		+	+			
	Lower		+	+			
	Mixed			+	+		+
	Nil	+					
6	**Lopping mechanism**						
	Only leaving top			+			
	Only side branches		+		+		+
	Only alternate canopies			+			
	Completely					+	
	Nil	+					
7	**Size of tree**						
	Small					+	
	Medium	+	+		+	+	+
	Tall		+	+	+		+
	Very tall			+			
8	**Managed at what unit**						
	Base	+	+		+		
	Side branching		+	+	+		+
	Top branching					+	
	Apex			+			
9	**Bole structure**						
	Single	+		+		+	+
	Double forked		+		+		
	Multiple forked		+		+		
10	**Stem management**						
	Primary stem	+				+	
	Secondary branching		+	+	+		+
	Primary and secondary		+	+	+		

Table 2 : Prevalence of different agroforestry tree prototypes preference in different hill zone of Himachal Himalayas

Species	Order of preference	Hill Zones	Prototypes of agroforestry trees (%)									Total trees
			A	B	C	D	E	F	G	H	I	**Number**
Grewia optiva	1	Lower hills	6	11	15	17	17	34	0	0	0	
	1	Transition	9	14	16	20	11	24	2	1	3	53
	1	Mid hills	8.8	26	15	19	6	21	2	0	1	93
	2	Lower hills	8	21	11	17	17	23	0	0	4	534
	2	Transition	4	8	18	14	20	24	0	0	14	84
	2	Mid hills	3.6	36	32	7	11	11	0	0	0	51
	3	Lower hills	6	19	6	6	13	50	0	0	0	28
	3	Transition	9	18	27	9	18	18	0	0	0	16
	3	Mid hills	7.7	7.7	0	15	0	69	0	0	0	11
Salix species	1	Lower hills	12	35	4	4	0	46	0	0	0	13
	1	Transition	0	13	12	7	38	29	0	0	1	26
	1	Mid hills	0	0	0	0	0	0	0	0	0	84
	2	Lower hills	29	71	0	0	0	0	0	0	0	0
	2	Transition	0	25	0	7	25	18	0	0	25	7
	2	Mid hills	14	14	0	29	0	43	0	0	0	28
	3	Lower hills	0	17	0	50	0	17	0	0	17	7
	3	Transition	6	19	25	6	19	19	6	0	0	6
	3	Mid hills	0	0	0	0	0	0	0	0	0	16
Ficus species	1	Lower hills	0	0	0	0	0	0	0	0	0	0
	1	Transition	0	0	0	0	0	0	0	0	0	0
	1	Mid hills	12	42	16	9	3	12	1	0	5	0
	2	Lower hills	0	0	0	0	0	0	0	0	0	119
	2	Transition	0	0	0	0	0	0	0	0	0	0
	2	Mid hills	5.3	37	16	16	16	11	0	0	0	0
	3	Lower hills	0	0	0	0	0	0	0	0	0	19
	3	Transition	0	36	9	36	9	9	0	0	0	0
	3	Mid hills	14	26	26	11	3	20	0	0	0	11
Hamiltonia suaveolens	1	Lower hills	0	0	50	0	13	38	0	0	0	35
	1	Transition	0	0	0	0	0	0	0	0	0	8
	1	Mid hills	0	0	0	0	0	0	0	0	0	0
	2	Lower hills	0	0	0	0	0	0	0	0	0	0
	2	Transition	0	6	29	21	24	21	0	0	0	0
	2	Mid hills	0	0	0	0	0	0	0	0	0	34
	3	Lower hills	0	0	0	0	0	0	0	0	0	0
	3	Transition	4	4	18	11	18	29	0	4	14	0
	3	Mid hills	0	0	0	0	0	0	0	0	0	28
Syzygium cumunii	1	Lower hills	0	0	0	0	72	28	0	0	0	0
	1	Transition	0	13	22	3	28	28	0	0	6	25
	1	Mid hills	0	0	0	0	0	0	0	0	0	32
	2	Lower hills	50	0	0	50	0	0	0	0	0	0
	2	Transition	10	24	18	10	14	18	0	0	6	6
	2	Mid hills	0	0	0	0	0	0	0	0	0	50
	3	Lower hills	0	0	0	0	0	0	0	0	0	0
	3	Transition	0	0	44	22	0	33	0	0	0	0
	3	Mid hills	0	0	0	0	0	0	0	0	0	9
Bauhinia variegata	1	Lower hills	0	0	63	5	11	21	0	0	0	0
	1	Transition	20	33	0	13	13	20	0	0	0	19
	1	Mid hills	2.9	11	9	6	23	31	14	0	3	15
	2	Lower hills	40	0	20	40	0	0	0	0	0	35
	2	Transition	4	4	11	21	39	18	0	0	4	5
	2	Mid hills	0	14	23	18	9	36	0	0	0	28

	3	Lower hills	0	0	50	25	13	0	0	0	13	22
	3	Transition	0	36	9	9	27	9	0	0	9	16
	3	Mid hills	6.3	38	25	0	0	19	6	0	6	11
Pyrus lanata	1	Lower hills	0	0	0	0	0	0	0	0	0	16
	1	Transition	4	14	25	12	29	11	1	4	1	0
	1	Mid hills	0	0	0	0	0	0	0	0	0	130
	2	Lower hills	0	0	3	0	69	28	0	0	0	0
	2	Transition	0	21	9	3	27	39	0	0	0	29
	2	Mid hills	0	6.3	53	9	13	16	3	0	0	33
	3	Lower hills	0	0	15	8	46	23	8	0	0	32
	3	Transition	6	11	11	17	22	33	0	0	0	13
	3	Mid hills	7.7	7.7	15	8	46	15	0	0	0	18
Celtis australis	1	Lower hills	5	17	29	7	21	17	0	0	3	13
	1	Transition	1	18	13	19	15	24	1	0	9	58
	1	Mid hills	0	0	0	0	0	0	0	0	0	79
	2	Lower hills	0	11	71	0	14	0	0	0	4	0
	2	Transition	3	6	32	16	19	23	0	0	0	28
	2	Mid hills	15	10	11	22	8	29	5	0	0	31
	3	Lower hills	0	8	25	0	42	25	0	0	0	110
	3	Transition	2	17	21	25	19	8	0	0	9	12
	3	Mid hills	15	19	15	12	8	4	8	4	15	53
Mangifera indica	1	Lower hills	0	0	0	0	0	0	0	0	0	26
	1	Transition	0	0	0	0	0	0	0	0	0	0
	1	Mid hills	0	0	0	0	0	0	0	0	0	0
	2	Lower hills	14	86	0	0	0	0	0	0	0	0
	2	Transition	0	0	0	0	0	0	0	0	0	22
	2	Mid hills	0	0	0	0	0	0	0	0	0	0
	3	Lower hills	15	54	4	27	0	0	0	0	0	0
	3	Transition	0	0	0	0	0	0	0	0	0	26
	3	Mid hills	0	0	0	0	0	0	0	0	0	0
Morus alba	1	Lower hills	0	61	22	6	0	6	0	0	6	0
	1	Transition	0	0	0	0	0	0	0	0	0	18
	1	Mid hills	28	19	9	11	0	9	0	0	24	0
	2	Lower hills	0	44	22	0	0	33	0	0	0	54
	2	Transition	0	0	0	0	0	0	0	0	0	9
	2	Mid hills	14	20	20	20	3	14	3	0	6	0
	3	Lower hills	6	39	9	0	18	3	0	0	24	35
	3	Transition	17	0	0	33	17	17	0	0	17	33
	3	Mid hills	9.1	32	14	23	9	14	0	0	0	6
Albizia stipulata	1	Lower hills	0	0	0	0	0	0	0	0	0	22
	1	Transition	5	25	20	40	0	10	0	0	0	0
	1	Mid hills	9.1	14	32	41	0	5	0	0	0	20
	2	Lower hills	29	57	0	14	0	0	0	0	0	22
	2	Transition	0	12	0	65	18	6	0	0	0	7
	2	Mid hills	2	27	8	37	2	22	2	0	0	17
	3	Lower hills	6	25	13	13	19	25	0	0	0	51
	3	Transition	0	13	0	78	4	4	0	0	0	16
	3	Mid hills	0	15	23	15	19	15	12	0	0	23
Dalbergia sisoo	1	Lower hills	11	29	30	5	10	14	0	0	0	26
	1	Transition	0	50	10	40	0	0	0	0	0	213
	1	Mid hills	0	0	0	0	0	0	0	0	0	10
	2	Lower hills	0	0	38	0	38	25	0	0	0	0
	2	Transition	0	50	33	17	0	0	0	0	0	8
	2	Mid hills	0	0	0	0	0	0	0	0	0	6
	3	Lower hills	9	17	9	39	9	9	0	0	9	0
	3	Transition	0	0	0	0	0	0	0	0	0	23
	3	Mid hills	0	0	0	0	0	0	0	0	0	0

The species-specific adoption by the farmers of the Kangra valley showed a different picture when cumulative data were analyzed. *Grewia optiva* emerged as the most adopted species (94.1%) followed by *Dalbergia sisoo (*63.1%) and *Celtis australis (*36.6%). This suggested that most farmers were adopting the silviculture components in traditional agroforestry, whereas when seen in terms of micro-zonal variation, the picture was different. *Grewia optiva* was found to be the main component / tree in the agro-ecosystem of the mid-hills as, of the cumulative figure of 94.1%, 59.5% was in the mid hills. *Grewia optiva* was completely missing in the fields of the lower hills, where it was replaced by *Dalbergia sisoo* as the most important agroforestry tree. Thus, adoption of a particular tree in a specific area can be attributed to micro-environmental variations in the ecological habitat of that species. An interesting finding was that, in general, the preference of farmers changed from cash crops like timber and horticulture in the lower hills to fodder trees in the mid-hills, fodder being the major constraint.

Based on the information gathered on farmers' perceptions, preferred location and disliked characteristics of the trees were identified. Farmers select species for specific locations according to their experience in tending and maintaining trees (Table 3). Prototypes identified by farmers for specific niches express concern over space requirements. Environmental conditions and the farmers' knowledge of crop requirements also influence them. The growth or biomass production of a specific species in a particular area was the result of appropriate environmental parameters including crop-environment interactions. The interactive function of atmospheric energy and soil moisture are key environmental conditions determining potential growth performance (Wickramasinghe 1990). Farmers were unable to grow straight- and long-stemmed species on sloping land with wind exposure. If they do, the stems grow crooked at about 2-3 m above the ground. This emerged to be an important factor for farmers not having single-stemmed species on their farmlands. Thus, for the sustainable development of such areas, it is critical to introduce species capable of withstanding high-velocity wind.

Participatory sketching of tree prototypes helped in understanding farmers' tree-management objectives, and how these objectives differed depending on a tree's ecological niche and the agroforestry production system. Broadly, users' perspectives vary not only with regard to tree products, but also with regard to species characteristics. In maintaining and growing trees within a limited land area, a farm family's decisions are influenced by a number of key issues related to their needs and experience. Thus, tree-use practices vary across regions, agro-ecological zones, and households.

Table 3: Analysis of variance of different parameters (mean values) of the farmers field for agroforestry adoption

Zones	Adoption	Prevalent species	Farmers field dimensions				
	%	Number	Area (sq. m)	Min length (m)	Max length (m)	Min width (m)	Max width (m)
Lower hills	46.94	13.55	54.80	6.52	17.41	2.30	6.88
Transition	52.71	12.25	46.80	5.59	16.77	1.92	6.26
Mid hills	67.34	8.55	62.06	6.72	17.31	2.70	7.28
CD (0.05)	5.31	0.91	7.60	0.93	NS	0.20	NS

This research, which gives priority to farmers' expressed needs and views, can facilitate formulating a farmer-oriented approach to promote tree species in agriculture, grasslands and wastelands i.e., agroforestry. Village agroforestry systems in Kangra Valley are associated with age-old tree-use practices that have evolved through farmers' experience to meet survival needs. Tree products - food, fuelwood, fodder, timber and mulch - contribute directly to household survival. Benefits of village agroforestry systems are diverse, but food products are of outstanding importance among them. The ability of *Morus, Grewia* and *Celtis* to ensure fuel and fodder security during the dry season and to provide familiar, traditionally used fodder products throughout the year are reasons why these species are found widely in the studied villages (Table 3). Another important factor is their ability to adapt to a limited space on limited land and still yield fodder during the scarcity period.

For *Grewia optiva*, irrespective of the order of preference and variation in the hill zone, the tree was managed in a specific prototype i.e. F and B (Fig 1) in which only side branches were partially lopped to meet the fodder and fuelwood requirement and to restrict the height of the plant to a medium level with a single or double forked bole structure. In the *Salix* species, the prototype ranged in five different types from B to F i.e., managing and lopping the tree depending upon the fuel, fodder, timber or any other requirement of the farmer (Table 3). In the mid-hills, the *Ficus* species was predominant and its architectural shape was maintained in B type only indicating the indigenous practice of partial lopping of primary and secondary branches, not at regular intervals. The presence and management of the indigenous forest tree species like *Hamiltonia suaveolens* showed that when abandoned tea orchards or unused lands were brought into agricultural use, farmers managed those trees which are secondary fodder and fuel wood sources. It was interesting to note that the multipurpose tree species (nitrogen fixing, source of fodder and fuelwood etc.) like *Bauhinia variegata* were managed under different prototypes, shapes indicating their relationship with their multi functional roles. Thus, it can be concluded that in the traditional systems, the shape or kind of prototype of an agroforestry tree is a direct function of its role in the system as well as the tree management practice adopted by the farmer to meet his purpose.

These findings about the traditional agroforestry systems and the use of indigenous knowledge about their management have to be taken seriously before intervention strategies are formulated. Efforts to promote agroforestry systems among small-scale farmers through introduction of improved varieties must recognize farmers' practices and expressed needs regarding tree products and characteristics. On this basis, priority species in the study area requiring improvement efforts were found to be *Grewia optiva* and *Celtis australis* irrespective of the location of the village, whereas fruit trees like *Mangifera indica*, and *Syzygium cumunii* and fodder tree *Bauhinia verigata* are of second priority. It can be inferred that the proximity of the city might have influenced the farmers towards fruit trees, the immediate source of cash.

Dependence on tree (being grown by their earlier generation) products for food and fruit is high among the people, who are unable to generate an adequate off-farm income to support a family or produce other commodities to meet the family's food needs. Apart from these factors, the culture of tree-use practices and local food habits have important effects on farmers' species decisions.

Conclusions

Traditional agroforestry systems based largely on indigenous knowledge and species are parts of the cultural patterns of the community. The gap between these indigenous systems and modern innovations is wide, despite attempts to replicate traditional systems with external support. While non-scientists have maintained the indigenous agroforestry systems of Himachal Himalayas, scientists can contribute in many ways to promote greater productivity, diversity, and enhanced returns to the family. Scientists can learn many lessons from farmers and, in turn, collaborate with them in developing techniques and new varieties that can be integrated into their farms. Transforming these findings into operational intervention programs will be complex, but is necessary to promote adaptable tree-use practices. This information related to tree-use practices can be interpreted in various ways according to one's objectives, but the major points are as follows:

1. Farmers' priorities for tree species vary according to the primary needs of the farmer's family.
2. Dependence on tree (being grown by their earlier generation) products for food and fruit is high among the people, who are unable to generate an adequate off-farm income to support a family or produce other commodities to meet the family's food needs. Therefore, farmers' needs and choices should be considered when promoting trees.
3. The best-suited tree characteristics cannot be determined by considering either the tree species or its products in isolation.
4. An attempt must be made to obtain the best germplasm from the local gene pools for further improvement. This would enable geneticists to apply genetic improvement to promote important local species. This is also essential in gaining farmers' reliance on the materials promoted by scientists.
5. Tree management practice is an important tool in the successful adoption of any agroforestry system. Ecological compatibility in terms of management has to be worked out before recommending any new innovation in the system.

Thus, though agroforestry is thought to be the best land management system, this is not accepted by all, particularly the smallholders. If by making use of indigenous knowledge gathered from traditional systems, we can make them ecologically as well as economically viable, only then we can think of sustainable Himalayan development.

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Forest and Mountain Development in Taiwan

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Abstract

Taiwan, with a total area of 35,915 km^2 and a population of 23 million is rich in forest resources; 58.5% of Taiwan is covered by forest, which plays an important role in soil and water conservation, timber production, and recreation. From 1914 to 1945, mountain development was concentrated on forest exploitation, railway and forest road construction. From 1946 to 1975, timber production, agriculture, and horticultural practices became the main scheme of mountain development. In 1976, the government passed the Forestry Management Innovation Act. Mountain development shifted from timber production to recreation and horticultural production for increasing the income of mountain communities. In 1989, timber harvesting was banned in natural cypress stands of national forests. In 1992, cutting was completely banned in natural forests. Since then, forest management has concentrated on sustainable forest ecosystem management. Culture and recreation have become the main thrust of mountain development. In recent years, the cultivation of crops has caused serious soil erosion disasters. Integrated forest management has great potential to ensure stability and sustainability in timber production and to provide ecological and economic security to mountain development.

Keywords: Forest, Environment, Mountain development, sustainability

Introduction

Taiwan lies off the southeast coast of mainland China. It is mostly mountainous, with an average annual rainfall of 2,510 mm and average annual temperature of 23°C. There are more than 200 important tree species of economic value, and includes species such as Taiwan red cypress, Taiwan yellow cypress, Taiwan red pine, Taiwan spruce, Taiwan hemlock, Chinese fir, camphor tree, machilus, and green bamboo. The forests play important roles in soil and water conservation, timber production, and recreation.

The role of forestry in Taiwan was to stimulate economic growth in the early development of the mountains. With socio-economic and population growth, pressure on forest and mountain development grew unevenly. The competition for land, inadequate management, and pollution have resulted in forest depletion and environmental degradation. Abuse of forest land has created great environmental impacts (Young 1994). The trade-off between economic growth and environmental quality as well as social function is one of the main issues of forest development policies in Taiwan. Forest and mountain development is not an objective per se but rather an instrument in the process of achieving national economic development (Adamowicz et al. 1993).

Forest ecosystems are an important part of the global environment. Forest conservation and sustainable management may be buffers to developmental impacts. As a nation in the global community, Taiwan strives very hard to foster conservation and sustainable forest management in order to ensure economic stability and environmental security. This paper presents an overview of Taiwan's experience in forest and mountain development.

Forest Resources

Taiwan, located in the sub-tropics, with a total area of 35,915 km^2 and a population of 23 million is rich in forest resources. About 58.5% of the land, nearly 2.1 million ha, is covered by forests: 1,120,400 ha (31.2%) of hardwoods; 438,500 ha (12.2%) of softwoods; 391,200 ha (11.0%) of mixed wood forests; and 362,300 ha (10.1%) are bamboo forests and ranges (Yao 1997).

There are six forest types: (1) spruce-fir: distributed at high elevations over 2,500 m mountain areas; (2) hemlock (2,000 to 3,000 m); (3) cypress: composed of red cypress (*Chamaecyparis formosensis*) and yellow cypress (*C. obtusa var. formosana*) (1,500 to

2,800 m); (4) pine and other conifers: composed of Taiwan red pine, Taiwan white pine, Chinese fir and Japanese fir (300 to 2,800 m); (5) mixed conifer-hardwoods (1,500 to 2,000 m); (6) hardwood type (from sea level to 2,000 m).

The total forest growing stock is 358.7 million m^3, of which hardwoods and softwoods account for 176.3 million m^3 (49.1%), and 182.5 million m^3 (50.9%) respectively (Yao 1997). Taiwan also supports very rich bioresources including 4,021 vascular plants, 524 algae, 4,261 species of fungi, 61 mammal species, 402 bird species, 92 reptile species, 30 amphibians, and 17,609 species of insect (Chung et al.1993).

Forest Development

1914 - 1945

From 1914 to 1945, Taiwan forestry was geared to timber production from natural forest exploitation in order to boost the national economy. In 1910, the Japanese government launched the Ali Mountain development plan. Ali Mountain railway was set up in 1912, and large-scale logging was carried out. Timber production was confined mostly to natural forests of Taiwan red cypress and Taiwan yellow cypress in the high mountains. During the 34 years from 1912 to 1945, the total cutting area in Ali Mountain was 9,773 ha, and 3.5 million m^3 were cut. During the 21 years from 1922 to 1942, the island-wide cutting volume amounted to 22.9 million m^3, and 352,889 ha were reforested (Chao 1999). Railways, forest roads, and many new villages were established to meet the needs of forest development and reforestation. During this period, the economy of the mountain communities was booming.

1946 - 1975

From 1946 to 1975, the Taiwan Forestry Policy and Management Guidelines were implemented. Soil conservation and timber production were the major projects. There were 370,000 ha of protection forest in 1958. During this period, 394,339 ha of forestland were reforested (Chao 1999, Yao 1997). However, forestry policy focused on timber production for supporting the nation's economy. The Taiwan government gained a large surplus revenue of US$5.8 million annually from forest development (Chao 1999). Timber production, agricultural and horticultural practices became the main emphases of mountain development.

1976 - 1991

From 1976 to 1991, the forestry policy shifted to support national soil conservation. In 1976, the government passed the Forestry Management Innovation Act, and formulated implementing projects, i.e., expansion of reforestation areas, strengthening forest protection and forest land management, expansion of protection forests, enforcement of hillside stabilization and flood control, forest recreation and natural environment conservation, and application of scientific techniques. The cutting volume decreased sharply. During the first four-year period of 1976 to 1980, annual cutting volume was restricted to 100 million m^3. The Taiwan Forest Bureau encountered serious financial difficulties due to the great deficit in the self-sufficient enterprise budget system. Therefore, in the second four-year period of 1981 to 1984, and the third four-year period of 1985 to 1991, the annual cutting volume was changed to 150 million m^3. From 1977 to 1989, the Taiwan Forestry Bureau accumulated a large deficit. The government started to subsidize the budget for reforestation and soil conservation in 1983. The budget of the Taiwan Forest Bureau was changed from enterprise budget system to official budget system in 1989. In 1989, timber harvesting was banned in natural cypress stands of national forests, and cutting was absolutely prohibited in protection forests, watersheds, ecological conservation areas, national parks, and steep areas. During the period, 69,798 ha were reforested (Chao 1999, Yao 1997).

1992 - 2000

From 1992 to 2000, the forestry policy concentrated on agroforestry, reforestation, windbreaks, as well as soil and water conservation (Lo and Lin 1993), with an emphasis on the establishment of environmental forestry to counterattack forest depletion and environmental degradation. In

1992, timber cutting was completely banned in natural forests. Since then, forest management shifted to sustainable forest ecosystem management. In October 1996, the government launched the All People Reforestation Movement to encourage and subsidize private forestry. During this period, cultural and recreational development, as well as environmental protection have become the main thrust of mountain development. From 1992 to 1996, 23,274 ha were reforested (Chao 1999, Yao 1997).

Mountain Development

1914 - 1945

From 1914 to 1945, great emphasis was given to timber production. Mountains with rich forest resources, such as Ali Mountain, Ba-Sen Mountain, Tai-Pin Mountain, Wan-Shian Mountain, Shiang-San Mountain and Luh-Tsang Mountain, became the target for forest development (Chao 1999). Railway and forest road construction improved transportation to mountain areas, and people migrated to mountain communities to provide the labour force for forest development. The logging enterprises stimulated socio-economic activities, and new towns were established.

In 1914, logging operations were started in Ali Mountain Forest District, which had 60,000 ha of forest. Every year 44,808 m^3 of lumber were transported to Chiayi city for processing and trading (Chao 1999). Thus, Chiayi city became the center of lumber marketing, and remains vigorous in the lumber industry.

Ba-Sen Mountain was developed after Ali Mountain in 1916. Ba-Sen Mountain Tree Farm covered an area of 12,000 ha. Fong-Yuen city was created with an annual timber production of 38,340 m^3, and it continued to prosper for 30 years (Chao 1999).

The development of Tai-Pin Mountain began in 1921. Tai-Pin Mountain Forest District had an area of 26,585 ha and timber stock volume of 13,720,280 m^3. A new town, called Lo-Dong with 10,000 inhabitants, was created as the lumber trade center in northern Taiwan in 1921. By 1945, the population had increased to 30,000, of whom 10,000 worked in forestry-related enterprises (Chao 1999).

In 1933, timber cutting was started on Wan-Shian Mountain with annual timber production of 11,600 m^3. A new mountain village, called Sui-Li with 31,600 inhabitants, was established in 1945 (Chao 1999).

Shiang-San Mountain and Luh-Tsang Mountain was developed in 1940 and 1943 respectively. Chu-Dong, located in Shin-Chu Prefecture, was the center of wood processing and timber marketing (Chao 1999). It remains a city famous for furniture industry.

1946 - 1975

From 1946 to 1975, timber production, agriculture, and horticultural practice became the emphasis of mountain development. Tairoko Mountain, with a forest area of 5,511 ha and stock volume of 1.58 million m^3, was developed for timber production in 1946. Hwa-Lian city became an important timber market. In 1948, the government passed the Mountain Reserve Management Act to protect indigenous people and to develop the mountain economy. In 1950, the provincial government passed the Forest Land Leasing Act to encourage citizens to participate in reforestation. From 1951 to 1958, 55,119 ha of forestland was leased (Chao 1999). These ACTs had led to the inappropriate use of forest land to cultivate fruit trees, teas, and other vegetables. In 1959, the Executive Yuan allocated Chi-Lan Mountain Forest District (48,766 ha of forest) and Ta-Cha-Si Forest District (46,191 ha) to the Forest Development Administration of Vocational Assistance Commission for Veterans (Yao 1997). Forest development was the major part of mountain development during this period. Exportation of high-quality timber supported the national economy. Administration problems such as illegal cutting, abuse of forestland, and forest fire resulted from agricultural and horticultural practices.

1976 - 1991

In 1976, the government passed the Forestry Management Innovation Act. Mountain development shifted from timber production to reforestation, soil and water conservation, recreation, agricultural and horticultural production for strengthening the economy of mountain communities. In 1989, timber harvesting was banned in natural cypress stands of national forests (Chao 1999). Timber production decreased sharply. A large proportion of the forestry budget was invested in reforestation, soil and water conservation, and recreation facilities. Due to the prosperous economy and the development of the transportation infrastructure, the public demanded forests for outdoor recreation. Thus, forest recreation stimulated another change in mountain development. Also, inappropriate use of forest land for the cultivation of high-value crops, such as betel nut palm, tea, and wasabi caused serious problems in forest management. Avalanches, soil erosion, and mudflows caused tremendous damage to villages.

1992 - 2000

In 1992, cutting was completely banned in natural forests, and sustainable forest ecosystem management began. Cultural development and forest recreation became the main emphasis of mountain development (Shuai 1992, 1993a). The government has invested large amounts to strengthen the development of mountain villages, and tried to set up an agroforestry scheme (Huang 1998, Lee et al.1995, Lin 1998, Lo and Lin 1992, 1993, 1995). In recent years, inappropriate use of forest land for cultivation of agricultural and horticultural crops has become more serious. Due to high demand for high-cool land vegetables, mountain development shifted to the inappropriate use of forest abuse for vegetable production (Shuai 1993b). Thousands of hectares of betel nut palm, tea, ginger, wasabi, fruit tree, and vegetables have caused serious soil erosion disasters, and undermined mountain development. Landslides and mudflows have become the nightmare of mountain villagers. Large landslides and mudflows have often occurred during the typhoon and monsoon season. Soil erosion disasters usually destroyed the results of mountain development, such as bridges, roads, railways, houses, farms, livestock, and crops, as well as killing people.

The Future

From 1914 to 1991, the role of forestry in Taiwan was to foster the economic growth of the nation. Intensive forest and mountain development resulted in forest depletion and environmental degradation. It is very important for resource accounting to be an essential ingredient in national policy formulation. Economic and environmental values must be integrated into national accounts (Brundtland 1987, FAO 1994, 1995).

Rapid deforestation and forestland abuse have resulted in forest depletion, which intensifies issues of soil erosion, sedimentation, alluvial water flow and other consequences. Thus, Taiwan forestry has adjusted toward sustainable management and raised concerns about the environmental impacts of the current shift in forest cover from marginal cropland through reforestation. Forest ecosystem management is the main basis of forest and mountain development in Taiwan today.

In the future, Taiwan's forestry policy will focus on sustainable production and environmental protection. Integrated forest management has great potential to ensure stability and sustainability in timber production and to provide ecological and economic security to mountain development, as revealed by Taiwan's experience.

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Mountain Forests and Forest Policies in Europe: Basic Considerations and Results from Case Study Comparisons

by

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Abstract

Conditions in mountainous regions are distinctive as regards ecological as well as socio-economic aspects. However, while ecological features, which set mountain regions apart from other areas, are quite similar among all mountain regions, socio-economic conditions differ quite highly between different types of mountain areas in Europe. Consequently there also exist different approaches to mountain forest policies. Based on national studies, which were undertaken in the framework of COST action E3 (Forestry in the Context of Rural Development), information on mountain forest policies in 11 mountain regions in Europe has been compiled for analysis. The comparative analysis is performed using a Boolean approach to comparative analysis which allows the comprehensive analysis of qualitative and quantitative information without having to rely on random sampling of cases. From the analysis, the cause of conflicts as being ultimately a result of struggle for scarce resources is revealed. The choice of political instruments, too, reflects power structures in a society as well as its general political culture.

Keywords: Policy analysis, mountain forests, qualitative comparative analysis

Introduction - Mountain Forests and Forest Policies

The Protective Effects of Forests as a Problem of Power and Distribution

Ownership Rights and the Control of Forest Resources

Following a critical theory approach to land use allocation, the distribution of land and land use mirrors the distribution of power within society (Soja 1989). Liberal general equilibrium theory, projected onto the allocation of land uses, suggests that under ideal market conditions, land may be allocated to the most profitable land use, meaning the one which is willing to pay most for purchasing or renting the land. Since, compared to other forms of land use, forestry is a rather low interest activity, forests have remained in areas, which were so far of little interest to other forms of land use (Hyttinen*, et al*. 1998).

Torrents and avalanches have always been a phenomenon of alpine environments; they become a problem only where they endanger the existence of human infrastructure. Thus, as long as there exists enough land for all competing interests to be allocated in areas outside the reach of these phenomena, they are not likely to become an object of policy formulation, since they are not perceived as a problem. Therefore a high population density can be assumed to be one highly relevant factor in the causal complex of conflicts related to torrents and avalanches. This is especially important in comparing different policy approaches to coping with these phenomena.

Actual control over land management regimes, which would include conversion to other forms of land use, was effectively taken away from local tenants in most European countries at some time in the second half of the second millennium. Formal land-ownership might still have remained with the local population through either direct, mostly small-scale, private tenure or community ownership, but strict regulative measures concerning the conversion of forest land to other forms of land use as well as reforestation requirements restrict land-owners' choices quite distinctively. The enforcement of management practices conforming to the aims of forest policies was handed over to forest authorities.

Power Structures and Political Instruments

The choice of political instruments to be implemented can be regarded as a reflection of power structures. Where a strong lobby of agricultural landowners in mountainous areas existed, they may have been capable of mobilising large funds for subsidies. In such conditions a general aim of rural policies to keep farmers on their land and farmland under production usually also may be witnessed. The power of the forest service here then relies strongly on its role as the institution responsible for funnelling public funds.

If, on the other hand, the population of mountain areas had no powerful lobby, the authorities could rely on regulative instruments and later on the acquisition of abandoned farm land to implement forest policies. Under these conditions, the power of forest authorities lies in their ability to impose regulations upon landowners as well as on their role as large landowners able to offer income opportunities.

Thus, under either of the two constellations, forest authorities have become rather powerful institutions in rural and mountainous regions. The theory of institutionalism suggests the existence of a powerful bureaucracy itself to be an explanatory factor for the existence of political programs, which are ultimately in the self-interest of such institutions. However, due to the fact that this factor, the existence of a powerful forest authority, can be observed in all countries or regions considered in this study, its consideration does not offer much explanatory insight.

The Protective Effects of Forests as a Problem of Policy-making

Mountainous areas are rather sensitive ecosystems, due to the harsh climatic, and the hydro-geological and geo-morphological conditions. Therefore, adequate management of mountain forests is crucial for maintaining the resource. Traditionally, mountain forests have been used for agriculture, forestry and hunting. Clear-cuts for the purpose of shipbuilding or fuelling smelting works and farmers' uses of the forests for litter collection or grazing often led to degradation of the forest ecosystem. Some formerly forested areas today are bare karst.

The research described in this paper started with the assumption that people nowhere are so dependent on the forest as in mountainous rural areas. In mountainous regions, forests provide various prominent services for the community: besides their importance for work opportunities and income, they protect the land against erosion and settlements and traffic devices against avalanches, rock-fall, mudflows and landslides. Furthermore, they are also of decisive importance for the climate and watershed management; the maintenance of mountain forests is an important factor to prevent floods in the lowlands. Last but not least, mountainous forests are highly appreciated recreation areas and enclose ecologically unspoiled biosphere reserves[1]. However, the so-called "protection functions" are often identified[2] as the most outstanding services that mountain forests offer to society. These protection effects of the forest are manifold, and for policy considerations their different characteristics have to be recognised. Two main categories of protective effects of mountain forests can be distinguished:

a) protection of the site against soil erosion and degradation
b) protection of settlements and transport facilities against natural hazards

Site Protection

Mountain forests are sensitive ecosystems, which are vulnerable to natural forces. Over-use can result in degradation of the forest ecosystem. If the forest disappears, the production capacity of the site, the good effects of the forest on climate and water budgets, and work opportunities are also lost to society. This view is well illustrated by the

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[1] COST Action „Forestry in the context of rural development", Proposal 1993

[2] Working groups E3.3 „Research into the Role of Forests in Protecting Mountainous Rural Areas – Evaluation of Policy Means" and E3.4 „Research into the Role of Forests in Protecting Mountainous Rural Areas – Evaluation of Silvicultural Means"; see GLÜCK (1998), and WEBER (1998)

Norwegian definition of mountain forests[3]:"Mountain forests are forests where the climatic conditions, especially temperature and wind, are strongly restricting factors for seed setting, seed ripening, germination and production"; and the Austrian definition of protection forests[4]: "Protection forests are forests found on easily erodible sites which, therefore, need appropriate management". The forests have to be protected against "self-destruction" (Norway), or respectively, against the "erosive forces of wind, water and gravity" (Austria). The forest laws of most countries include specific regulations for the management of mountain forests (Austria, Bavaria, France, Greece, Italy, Norway, Switzerland[5]). Management restrictions typically are the following:

- obligation for the maintenance of the forest,
- official approval of cuttings, and
- restriction of clear-cuts.

The forest areas affected by these regulations are rather extensive. In Switzerland almost 100 % of the forest area in mountainous cantons were regarded as protection forests according to the definition of the former forest law. Today's Swiss forest law no longer distinguishes between protection forests and regular forests. In Austria, protection forests are defined by detailed criteria in the forest law and all forests that meet this definition are to be managed in an appropriate way. Forests that meet this legal definition automatically qualify as protection forests (ex lege) and benefit from a special protection status. No official act is necessary to make this status effective. According to the Austrian national forest inventory, one-fifth of all forests count as protection forests. The meaning of the expression "protection forest" or German "*Shutzwald"*, comprises two aspects: on the one hand, the forest protects the site against erosion; on the other, the forest has to be protected against inadequate management. In some countries, protection forests are depicted in forest function plans (Austria, Bavaria). Contrary to this category, forests with direct protective effects for settlements and infrastructure should logically rather be termed "protective".

[3] NILSEN and SOLBERG (1998)
[4] WEISS (1998)
[5] See the country case studies prepared for COST E3

Natural hazards protection

In mountainous regions with high population density, forested slopes provide protection against avalanches, rockfall and landslides. Inadequate forest management can produce severe risk to hazard-prone areas beneath the forest. The problem in managing these forests is that the forest area produces timber and deer for the private forest owner, while at the same time owners of properties situated underneath are interested in the protection service. These goods and services are partly compatible and partly competitive with respect to each other (GLÜCK 1998). A certain degree of security will be supplied even if the forest is managed for timber exclusively. No management restrictions are required for the provision of this minimal degree of security if only the forest is preserved. If more protection against hazards is desired, timber production has to be reduced (or, forest management cost rises). The cost of foregone timber production (or game or cattle production,) in order to increase the provision of security is the opportunity cost for provision of the protection service. Protective forests directly protect settlements and infrastructure. As there is higher interest in these protection services, stronger regulations are formulated here than for site protection forests. Rights for property owners situated underneath the forest are formulated (Austria, Slovenia), or the authority has significantly more instruments for forest management intervention in this specific situation. The authority at least is advised to register areas of protective forests (Bavaria, Switzerland). The forests may be declared by an official act as protective forests (Norway), or as "ban forests", as they are called in Austria. Management measures may be prescribed by the authority (France, Austria, Bavaria and Switzerland). If necessary, they may be expropriated (Greece). In Austria the owner of the property benefiting from the protective services of the ban forest may demand special measures to enhance the protective effect of the forest. In Slovenia, the management of these forests is regulated by contracts between the forest owner and the state or the town/village. In both countries, Austria and

Slovenia, the forest owner has a claim for compensation by the beneficiary. The area of protective forests, for which the stricter regulations are effective, is much smaller than the more general prescriptions for site protection forests.

Although legal regulations in most countries clearly distinguish between these two categories, in some countries no lingual differentiation is made. The term "protection forest" (German: "*Schutzwald*") is often unspecifically used for both types (Weber 1998). In colloquial usage, the expression is linked with the "protection functions" of forests, and in most countries a range of such protection functions is attributed to the forest. So, for example, in Bavaria site protection, water protection and protection against avalanches are considered in the forest function plans (Beck/Suda 1998). According to the Bavarian forest law, the following types of protection forests are distinguished:

- absolute protection forests, situated in high-elevation or on easily erodible sites,
- limited permanent protection forests, protecting against natural hazards, and
- limited temporary protection forests, preventing neighbouring stands from storm damage.

In Austria, the forest law defines protective effects of the forest both against natural hazards to protect settlements and infrastructure, and against erosion to maintain the productivity of the soil. So-called welfare effects relate to the positive effects of forests on the climate and the provision of drinking water. The term protection forest, according to the forest law, would be reserved only for site protection, but in practice the word is also connected with protecting settlements against natural hazards. Partly this "sloppy" usage has "political" functions: protection forests according to the forest law are surveyed by the national forest inventory. The resulting figures of this survey are cited as an argument for the importance of mountain forests for protecting human settlements in mountainous regions. Yet, in contrast to the rather extensive acreage of protection forests, the forest area directly protecting human facilities is much smaller.

The consequences of these considerations for forest policy are that different instruments are adequate for regulating the different categories of forests protecting the site or protecting against natural hazards. In each case, the protection is an external effect of the forest and a public good, but the circles of beneficiaries are different. While the effects of avalanche protection clearly can be allocated to a small number of benefiting parties, the effects of the prevention of erosion and preservation of forests are for the benefit of a greater community; e.g., all cities downstream along the rivers benefit from mountain forests through reduced flood peaks.

In fact, different regulations are formulated in most countries for these two types of protection services. For site protection, restrictions of forest management are laid down in the forest laws. For natural hazards protection, further regulations can be set or the authority may take measures. In the latter case, the forest owners regularly have a claim for compensation by the state or the beneficiary.

In practice these strict regulations often are not implemented properly. A common problem for the preservation of mountain forests in most countries is that hunting or grazing uses cause damage to the forests. Most of the countries report that the problem of mountain forests is not a silvicultural problem but a question of the lack of implementation of existing regulations by the authority (GLÜCK 1998).

Besides regulations, subsidies are also granted for forest management. Where forests are damaged by improper use, subsidies instead of prescriptions are often used to restore the forests.

The comparison of mountainous countries in Europe in course of the COST Action E3 has shown that mountain forest policies are quite different in some respects. Although the analysis revealed that most countries have the common problem that protection of mountain forests is severely affected by hunting or grazing, the problem situation varies among the different countries, and instruments applied also vary.

Materials and Methods

Materials Gathered in Case-study Regions

In order to arrive at more general conclusions concerning the mechanisms governing mountain forest policy making, several case studies have been compared.

The regions and countries to be included in this analysis were chosen based on the work done in the framework of Working Group (WG) 3 of COST E3. The information needed for this analysis was derived from country reports submitted for COST E3 and from additional questionnaires sent out in spring 1998. Information was obtained for Bavaria[6] (Germany), Casentino (Italy)[7], the Catalan Pyrenees (Spain)[8], Greece[9], Graubünden (Switzerland)[10], Departement de Savoie (France)[11], Tyrol (Austria)[12], Pratomagno (Italy)[13], Trentino (Italy)[14], Slovenia[15], and Vest-Agder (Norway)[16]. For Greece, Trentino and Vest-Agder, additional information was obtained from data collected for the case study reports for the FORWARD project at the European Forest Institute.[17]

Using a method of qualitative comparison based on Boolean algebra, the combinations of different factors, which occur in these case study regions were studied concerning their relevance for observed outputs of the political administrative system. Two examples of this are presented below.

Methods of Comparative Analysis in Social Sciences

Two main types of strategies can be detected in the approaches toward comparative research in social sciences, the variable-oriented approach and the case-oriented approach.

Quantitative Techniques

The variable oriented approach encompasses quantitative strategies, using statistical methods like regression analysis to test theories against empirical evidence. These methods focus on variables and their relationships, rather than individual cases. While this bias enhances the methods' capability to address abstract theoretical concerns, the strategy is less adaptable to understanding individual cases or categories of cases.

Simply put, the result of any quantitative study is always that the analysed theory or hypothesis may be either rejected or accepted with a certain probability. The variable-oriented approach allows for the analysis of a large number of cases, but it also demands the availability of data from a comparatively large number of cases. The simplified conception of causality embodied in statistical models also enhances the aim of generality of results, but it discourages considerations towards causal complexity and thus fundamentally alters the research dialogue between concept formation and data analysis.

Also it has to be stated that quantitative statistical approaches assume the sample to be taken from a fairly homogenous population, for which general statements may then be deduced from the results. Given the complexity of historical development, this may not be necessarily assumed in development research.

Related to the assumption of a homogenous population from which the sample is drawn is the fact, that the importance of any observed causal relation among the observed cases for the final result is ultimately dependent on the

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[6] Source of information: Beck R., Ludwig-Maximilians-Universität München (questionnaire)
[7] Source of information: Hermanin L. and Freschi A.L., University of Florence (questionnaire)
[8] Source of information: Rojas-Briales E., Centre Tecnològic Forestal de Catalunya, Solsona (questionnaire)
[9] VAKROU 1998
[10] Source of information: Zimmermann W., ETH-Zürich (questionnaire)
[11] Source of information: Chauvin C., Cemagref Grenoble (questionnaire)
[12] Source of information: Weiß G., Universität für Bodenkultur Wien (questionnaire)
[13] Source of information: Hermanin L. and Freschi A.L., University of Florence (questionnaire)
[14] HERMANIN/FRESCHI in Glück, 1998
[15] Source of information: Sinko M.: University Ljubljana (questionnaire)
[16] Source of information: Solberg B. Norwegian Forest Research Institute, Ås (questionnaire)
[17] Hyttinen, Ottitsch, Pelli 1998

frequency of this observation within the observed sample. Also the sample is required to be chosen randomly from the homogenous population and to be representative for that population with regard to the distribution of explanatory variables.

Qualitative Approaches

A case-oriented approach allows for the consideration of cases as a whole and is aimed at understanding examined cases in their historical complexity. It is thus based in the tradition of qualitative social scientific research. Research dialogue is centred on intersections of causal conditions. The method allows for the consideration of causal complexity, which is mainly evident in the observation of similar outcomes from different starting conditions or, vice versa, different outcomes from seemingly similar starting conditions.

Admittedly this bias towards understanding of cases in their complexity restricts the number of cases that may be compared with this method. Consequently the potential for the generalisation of results is also diminished. The latter may be countermeasured by the categorisation of data as well as by explicitly stating the contextuality of new theoretical findings.

The different advantages and disadvantages of qualitative and quantitative strategies are not to be taken as final arguments for or against either of these approaches, but are simply to be seen as guidelines towards the applicability of the two approaches to specific scientific problems.

Another possibility is the development of new approaches that try to incorporate the key advantages of both strategies. The application of Boolean methods of qualitative comparison, as suggested by Ragin (1987), is a step in this direction, which incorporates the capability for causal complexity as well as the handling of larger sets of data, which is facilitated by software packages developed for this type of analysis. An essential difference between this approach and statistical methods is, that the frequency of an observation is not methodologically linked to its importance for the final result, even though frequency considerations may be incorporated into the analysis process.

The method requires the researcher to establish hypotheses concerning the relevance of phenomena responsible for a specific outcome. The results from different cases are compared to each other and, using logical minimisation techniques, those conditions which are seen to be most relevant for an outcome can be identified. The QCA method allows for a more detailed and systematic comparison of complex case studies than would be possible without the standardised procedure. For computing, no "quantitative" data in form of real numbers but rather qualitative data coded as Boolean variables (1=presence, 0=absence) are required. Via truth tables "necessary" and "sufficient" conditions for a certain outcome are sorted out. The method has been used in forest policy research by Hellström (1996) and Hellström and Rytilä (1998), a work which investigated forestry-related conflicts throughout Europe, as well as by Hyttinen, Niskanen, and Ottitsch (1999) for investigating the role and opportunities of forestry and the forest sector in the development of remote rural areas in Europe.

Results From Case Studies

Example for a Result of the QCA -approach

The qualitative comparative analysis was performed using Ragin's QCA-approach. An example for this step is provided here for demonstrative purposes since the listing of all the tested hypotheses would strain the available space in this paper.

Existence of Specific Programs Aimed at Restoring Mountain Forest Areas

For the existence of specific "restoration programs" the following set of explanatory variables may be taken into consideration:

> **A high share of (mountain) forest land.** If natural conditions were the main reason for related policies, then a high share of (mountain) forestland would also mean a high likelihood for the existence of related policies.

A high population density, which is an indicator for strong interests competing for an increasingly scarce resource (land).

A history of industrial forest use (i.e., planned use of forest resources for the supply of industries (mining, smelting, timber industries) as opposed to farm-related subsistence use and agroforestry systems (i.e., livestock grazing). For the needs of industries large even-aged stands were established following clear-cuts in the 19th century. These even-aged stands may now be reaching their decomposition-phase. Due to competing land uses, forest regeneration was hindered, requiring restoration measures.

A rising trend in economic development. This would mean also a good situation of public funds. This in turn means that public money is available; following theories of public administrations, one may expect that public institutions will try to find ways to spend it.

A high share of private land-ownership. Since the provision of protective functions is not in the immediate interest of private landowners and so far no markets have existed for these products, it may be assumed, that political instruments have been installed for the procurement of these services.

The truth table shows, that there exists one contradictory configuration, which is represented by the Catalan Pyrenees region in Spain and the canton Graubünden in Switzerland. In both of these cases there is a forest share lower than 50%, a low population density in relation to habitable land, a good economic development, a tradition of industrial forestry and no domination of private ownership. Yet while these conditions coincide with an existing specific mountain forest policy in Graubünden, there is no specific mountain forest policy in the Catalan Pyrenees.

Table 1: Truth table for the examined variables in the case study regions in example 1:

(For optimal presentation of results a fixed font (Courier 8pt) has to be used here.)

```
TRUTH TABLE SUMMARY
                                Old    New
 0 Configurations                 5      5
 1 Configurations                 3      3
 - Configurations                 0      0
 Contradictory Configurations     1      1
```

NUMBER OF RAW DATA CASES FOR EACH TRUTH TABLE CONFIGURATION

```
   Variable Names by Column
   HIFORSHA            High forest share (i.e.: > 50%)
   |HIPOPDEN           High population density (in relation to habitable area)100/km2
   |||HIECODEV         Rising trend in economic development
   |||INDUSTFO         Tradition of industrial forest use
   ||||PRIVOWN         High share of private land-ownership (i.e.>50%)
   |||||MFRESTPG       Existence of specific mountain forest restoration programs
   ||||||
+--||||||--------------------------------------------------------------------+
 | ||||||                   0 Cases             1 Cases             - Cases   |
 | HHHIPM                  Freq  Pct           Freq  Pct           Freq  Pct  |
+-------------------------------------------------------------------------+
   100010                     2  100              0    0              0    0
   00110C                     1   50              1   50              0    0
   011101                     0    0              1  100              0    0
   101110                     1  100              0    0              0    0
   111111                     0    0              1  100              0    0
   100000                     1  100              0    0              0    0
   111101                     0    0              1  100              0    0
   001000                     1  100              0    0              0    0
   000110                     1  100              0    0              0    0
 ---------------------------------------------------------------------------
CASEIDS FOR THE TRUTH TABLE

 100010 =>        Slovenia    =0  Pratomagno  =0
 00110C =>        Catalun Py  =0
                  Graubuenden =1
 011101 =>        Bayern      =1
 101110 =>        Vest-Agder  =0
 111111 =>        Tirol       =1
 100000 =>        Greece      =0
 111101 =>        Trentino    =1
```

```
 001000 =>        Savoie      =0
 000110 =>        Casentino   =0
```

Minimisation of Boolean equations:

Minimisation for result 0 - specific mountain forest program is NOT present:

```
Minimized Truth Table #1
File: 0MFNEU_4.QDM
Model: MFRESTPG = HIFORSHA + HIPOPDEN + HIECODEV + INDUSTFO + PRIVOWN
Outputs Minimized: 0
Method: Quine-McCluskey (Minimal)

  HIFORSHA hipopden hiecodev industfo +
  HIFORSHA hipopden HIECODEV INDUSTFO PRIVOWN +
  hiforsha hipopden hiecodev INDUSTFO PRIVOWN +
  hiforsha hipopden HIECODEV industfo privown
```

Identification of necessary conditions:

Among the cases used in this analysis, low population density is the only *necessary* but *not* a *sufficient* condition for the absence of a specific mountain forest policy.

Minimisation for result 1 - specific mountain forest program IS present:

```
Minimized Truth Table #2
File: 0MFNEU_4.QDM
Model: MFRESTPG = HIFORSHA + HIPOPDEN + HIECODEV + INDUSTFO + PRIVOWN
Outputs Minimized: 1
Method: Quine-McCluskey (Minimal)

  HIFORSHA HIPOPDEN HIECODEV INDUSTFO +
  HIPOPDEN HIECODEV INDUSTFO privown
```

Identification of necessary conditions

Necessary conditions for the presence of a specific mountain forest program:

A *high population density* AND *a rising trend in economic development* AND a *history of industrial forestry*. Each of these is necessary, BUT not sufficient.

Minimisation for result C (contradictory cases):

```
Minimized Truth Table #3
File: 0MFNEU_4.QDM
Model: MFRESTPG = HIFORSHA + HIPOPDEN + HIECODEV + INDUSTFO + PRIVOWN
Outputs Minimized: C
Method: Quine-McCluskey (Minimal)
  hiforsha hipopden HIECODEV INDUSTFO privown
```

Example 2

Which Conditions Result in a Preference for Fnancial Incentives?

For the question of which conditions more likely result in a preference for the implementation of financial incentives, the following factors are assumed to be of relevance:

A rising trend in economic development. This would also mean a good situation of public funds. This in turn means that public money is available; following theories of public administrations, one may expect that groups in society will compete to be considered in the redistribution process.

A high share of private land-ownership. Since the provision of protective services is not in the immediate interest of private landowners and so far no markets have existed for these services, it may be assumed that political instruments have been installed to provide them. For private landowners, subsidies are the most attractive form of instrument. This is also to be seen in context with the next factor:

The presence of corporatistic structures. In the presence of corporatistic structures, in which sector administrations act in the interest of their clientele, it can be assumed that they will prefer subsidies over other political instruments, since they strengthen their influence and power. Under such conditions, landowners may also be expected to have considerable political influence, especially in societies with a significant share of rural population.

Management of public land by the forest authorities, who also provide extension services for private lands (Einheitsforstamt).
This may be seen as an indicator for even stronger corporatistic connections between landowners and the administration. It may also be assumed that, if forest authorities are competing with private landowners in

markets for conventional forest products, it is difficult to impose regulative sanctions for the procurement of infrastructural services. On the other hand, it might also be argued, that the presence of an "Einheitsforstamt"-type of management is an indicator for an even more powerful forest authority, since it has not only political instruments in its hands but may also enact power as an actor on local labour and raw material markets.

Table 2: Truth table for the examined variables in the case study regions in example 2:

(For optimal presentation of results a fixed font (Courier 8pt) has to be used here.)

```
TRUTH TABLE SUMMARY
                                Old    New
 0 Configurations                 3      3
 1 Configurations                 5      5
 - Configurations                 0      0
 Contradictory Configurations     0      0
```

NUMBER OF RAW DATA CASES FOR EACH TRUTH TABLE CONFIGURATION

```
   ECODEV         Rising trend in economic development
   |PRIVOWN       Dominance of private ownership (i.e.: > 50%)
   ||CORPORAT     Presence of corporatistic structures
   |||EINHFORA    Management of public land by forest authorities (Einheitsforstamt)
   ||||SUBHI
+--|||||--------------------------------------------------------------------+
 | |||||                   0 Cases            1 Cases             - Cases   |
 | EPCES                  Freq  Pct          Freq  Pct           Freq  Pct  |
 +--------------------------------------------------------------------------+
   01010                     1  100             0    0              0    0
   10111                     0    0             2  100              0    0
   11111                     0    0             1  100              0    0
   11101                     0    0             2  100              0    0
   00010                     1  100             0    0              0    0
   10010                     1  100             0    0              0    0
   11011                     0    0             1  100              0    0
   01001                     0    0             2  100              0    0
 ----------------------------------------------------------------------------
```

```
CASEIDS FOR THE TRUTH TABLE
 01010 =>         Slovenia    =0
 10111 =>         Graubuenden =1  Trentino =1
 11111 =>         Bayern      =1
 11101 =>         Vest-Agder  =1  Tirol       =1
 00010 =>         Greece      =0
 10010 =>         Catalan Py  =0
 11011 =>         Savoie      =1
 01001 =>         Pratomagno  =1  Casentino   =1
```

<u>Minimisation for result 0 - no strong subsidies:</u>

```
Minimized Truth Table #1
File: SUBHIA08.QDM
Model: SUBHI = ECODEV + PRIVOWN + CORPORAT + EINHFORA
Outputs Minimized: 0
Method: Quine-McCluskey (Minimal)

  ecodev corporat EINHFORA +
  privown corporat EINHFORA
```

<u>Identification of necessary conditions:</u>

The absence of corporatistic structures AND the management of public forest by the forest authorities (i.e., Einheitsforstamt-type of management) are both *necessary* conditions for the absence of strong subsidies, however they are NOT *sufficient.*

Minimisation for result 1 - strong subsidies:

```
Minimized Truth Table #2
File: SUBHIA08.QDM
Model: SUBHI = ECODEV + PRIVOWN + CORPORAT + EINHFORA
Outputs Minimized: 1
Method: Quine-McCluskey (Minimal)

  ECODEV CORPORAT EINHFORA +
  ECODEV PRIVOWN EINHFORA +
  ECODEV PRIVOWN CORPORAT +
  ecodev PRIVOWN corporat einhfora
```

<u>Identification of necessary conditions:</u>

None of the conditions can be regarded necessary, since each is observed either present or absent in the observed configurations. However, the dominance of private ownership is present in three of the observed minimised configurations, this is also true for “high economic development”, yet they coincide only in two configurations.

Discussion

Example 1 – Existence of Programmes Aimed Specifically at Mountain Forest Restoration

Among the factors taken into account for this analysis, a high population density (in mountain areas) seems to be the most distinctive causal factor, although it has to occur together with other factors, especially a rising trend in economic development and a history of industrial forestry. This becomes even more obvious in comparison to the causal combinations identified for the 0-cases. Among these, there also exists a combination of rising trend in economic development and history of industrial forestry (Vest-Agder) but, due to a very low population density, no land use conflicts are observed.

Based on the analysed cases, the question of land tenure seems to be of less importance; especially it cannot be claimed that a dominance of private land ownership is more likely to produce the need for public intervention.

The contradictory cases (Catalan Pyrenees and Graubünden) require further analysis to identify the reasons for this contradiction. First it has to be mentioned that population densities in these two regions, although both being defined as low (i.e., for the purpose of this analysis a threshold value of less than 100 inhabitants/km^2 in relation to inhabitable land was defined), differ significantly. The number of inhabitants/km^2 are 80 for Graubünden and 15 for the Catalan Pyrenees respectively. Also the fact, that the mountain areas which are part of the Pyrenees make up only a comparatively small part of Catalonia, situated along its northern border, whereas Graubünden is more or less completely situated in an Alpine environment, may be of relevance. Other variables additionally to the ones considered in this example might explain the differences: with the status of a canton, Graubünden has considerable political weight in formulating Swiss policy, and furthermore, most of Switzerland can be called rather mountainous. Other variables additionally to the ones considered in this example may explain the difference such as the political power in the national context or the degree to which other regions in a country share specific conditions.

Example 2 – Preference of Financial Incentives

Those cases in which forest authorities can rely on regulative measures to enforce forest policies imply a rather weak position of forest land-owners in the whole process of forest policy formulation and implementation, which is indicated by the absence of corporatistic structures. The strength of forest authorities in addition is indicated by the presence of “Einheitsforstamt”-type of management structures.

The diversity of the observed 1-results makes it a bit more difficult to draw conclusions from this analysis. Were it not for the two cases of dominating community-ownership (Graubünden and Trentino), the dominance of private land-ownership would turn out to be a necessary condition. On the other hand, the two cases of Pratomagno and Casentino are responsible for the fact that “high economic development” is considered to be NOT a necessary condition for the observed outcome “preference for financial tools”. In this context of course it has to be remarked, that in those regions the observed subsidies derive mainly from European Union (EU) funds.

For further analysis it will thus be necessary to consider additional factors, such as the different forms of public ownership (community, province/region, country) as well as the sources of funds and the specific nature of funded projects.

Conclusions

Based on the data used for the two analyses, the dominant role of socio-economic factors in the shaping of forest policies is evident. On one hand, the cause of conflicts as being ultimately a result of struggle for scarce resources becomes apparent in Example 1. Even though this may sound trivial, it has to be kept in mind that many of the observed policy measures[1] have aimed at physical aspects of the observed problems. Another result, worth mentioning again, is that the subjection of forest land to a land use in the interest of industrial regimes has taken place in many European countries since the Medieval Ages. This fact can also be claimed to be a causal factor of high relevance for the emergence of problems in mountain forest areas.

The choice of political instruments, too, reflects power structures in a society as well as its general political culture. More centralised systems tend to favour regulative measures, whereas decentralised structures tend to favour financial incentives. The latter also points to societies, which prefer consensus-seeking processes to more direct ways of conflict solution.

The variety of factor combinations, even if logically reduced, re-emphasises that policy analysis cannot provide *turn-key-solutions* for any given problem, since it is not possible to exactly reproduce every condition in an intended implementation. It is, however, possible to demonstrate causalities under observed conditions, which may then either strengthen or weaken established theories.

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Sub-Plenary Session: E1

Cultural Diversity in Forest Management:

Interaction between Forest Science and Forest Policy

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Abstract

In this paper we share some of the experiences we have had in integrating science and policy. We have been discussing this topic and developing appropriate roles for scientists and policy makers for several years in IUFRO.

In our paper we focus on the following five points:

1. Science helps policy makers create new visions and new possibilities for forest management.
2. Policy makers have visions too, and science can help convert their visions into reality.
3. Science helps bring organization and logic to debates among policy makers.
4. The role of a scientist and scientific processes are unique and should not be compromised.
5. Science administrators have a distinct role and it is not the same as the role of a scientist.

Keywords: Forest science, Forest policy

Science Can Help Policy Makers Create New Visions and New Possibilities

*) This paper is based on a paper by Robert Lewis, Jr. ("The Role of Science in Natural Resource Policy Development") presented at IUFRO Division 6 Conference, Pretoria, South Africa, January 8, 1999.

Science can help policy makers create a new vision and new possibilities for forest management. Scientists by nature are seekers of truth. Knowledge generated by scientists can spark new ideas among policy makers at various levels of influence, whether local, regional, national or international in scope. The knowledge generated by scientists is most useful when it is clearly understood and aggressively communicated to a broad audience. We will use a few examples to illustrate this point.

In the United States about 80 percent of the population lives in urban and suburban communities. The U.S. Forest Service conducted a major research study to empirically show the value of urban forests in reducing energy consumption by residents and improving overall environmental quality. Knowledge generated by forest scientists documented the annual savings homeowners could realize by strategically planting trees around their homes to reduce heating costs in winter and cooling costs in summer. The secondary benefits were aesthetic improvements to urban communities. Also, the net savings in energy consumption by homeowners could reduce fossil fuel consumption for heating and generation of electricity, thereby improving the air quality. Results also showed that cities could reduce the rate of storm water runoff through careful management of urban forests and well planned developments. Scientists are not policy makers, but clearly developed information or knowledge useful to policy makers.

This knowledge generated by forest scientists was communicated through a network of professionals, such as American Forests, and used by city officials in Chicago, Illinois; Atlanta, Georgia; and other major cities to change city planning practices to incorporate environmental values and long-term cost savings to residents. Clearly, the science helped city officials to see a new vision for urban planning.

The second example of science helping policy makers create a new vision for forest management deals with forest health. Millions of acres of forests in the United States are at risk due to decades of fire suppression and overstocking. Fuel loads are heavy with downed woody debris, underbrush, and too many stumps per acre. Some of the forests are so weakened that they are heavily infested by bark beetles. In most cases, simple prescribed fires alone will not solve the problem, because after the prescribed fires to clear up the underbrush, the stands are still too dense to support healthy growth. If nothing is done and droughts occur, catastrophic fires will eventually result. Consequently, soils will be damaged, streams could be polluted with siltation and/or mud slides and significant wildlife habitat could be deteriorated. Science provided the clear definition of this problem and offers possible solutions to policy makers. Research at The Forest Products Laboratory in Madison, Wisconsin, is providing options for policy makers to consider while dealing with this problem. The excessive stand stocking is composed of small diameter conifers with little or no market value in local communities. The research effort is aimed at taking a non-marketable raw material such as small diameter pine trees, and converting it into a new and marketable product. Policy makers are being presented with new research knowledge and technology to craft a new vision of restoring forest health while providing economic opportunity to rural communities. The research scientist should not provide the policy or select an action for managers, but can and should present knowledge in such as way that policy makers will see new possibilities for better forest management.

Science Can Help Convert Policy Makers Visions into Reality

Policy makers have visions too, and science can help bring their visions into reality. There is an old proverb which states that "they that are without vision shall perish". Clearly, our policy makers have vision. Research scientists and research administrators should recognize and respect the visions of policy makers. Science can and should play a major role in bringing reality to the visions of policy makers. Sometimes the policy maker's visions might be presented as a challenge to science. Science can and should respond to the challenge with the support of the policy makers.

Policy makers in many countries have articulated a very good vision on sustainable forest management. This is a very worthy vision for all nations. In fact, we have criteria and indicators for sustainability. In many countries, these criteria and indicators have received much interest from all sectors, including federal and state governments, industry and environmental groups. We are very proud of the role of the global forest scientific community in developing these criteria and indicators. IUFRO's Task Force on *Sustainable Forestry* has been very successful in this matter.

Policy makers in Denmark have agreed upon a vision of "doubling the forest area in a tree generation". This vision involves many challenges to forest science in trying to find a better decision basis for answering questions like: Which kind of forest should be planted where, for what purpose and how? Forest scientists have helped bringing this vision into reality by i.a. documenting the need for new urban forests within walking distance for recreational purposes, and by finding new better and cheaper methods of afforestation.

Policy makers, leaders of government, and citizens around the world have expressed concern about documented increases in atmospheric carbon dioxide and subsequent global warming. The political impact on the physical and biological assets of the world would be at great risk with significant long-term changes, flooding, extended droughts, species migration and perhaps disappearance, and major disruption of delicate ecosystems could be reality if trends are not stopped and/or reversed. Major policy makers, such as Presidents, Kings, and Prime Ministers have expressed a vision for long-term reductions in atmospheric carbon dioxide. Forests serve as a major sink for carbon dioxide and science can help policy makers realize their vision through development and implementation of new knowledge and climate change technology. The knowledge necessary to manage forests and forest resource utilization for maximum carbon sequestration is a possibility. Options for forest management policy and practices to help stop and reverse the trend is an achievable role for science.

As scientists and science administrators, we should feel obligated and honored to respond to the call for truthful objective and useful knowledge through credible science programs. We can and should always perform our work with the highest ethical standards and never shade the truth emanating from our scientific inquiry.

Science should never taint its credibility by reporting anything less than the well planned, executed, analyses of scientific results following the scientific process. In the long run, policy makers will appreciate the truthfulness of science reports, even if the reports conflict with the policy maker's vision.

Science Can Help Bring Organization and Logic to Debates Among Policy Makers

Science helps bring organization and logic to debates among policy makers. Forest management and public policy development are subject to intense debate at both international and national levels. Policy makers in both the career and elected positions are frequently placed in the middle of heated debates among interest groups and are expected to resolve the contentious issues. In forest management, clearly articulated long-term goals and a sound basis for achieving the goals are essential for problem resolution. Science can bring relevant and unbiased knowledge to the debate and help sharply focus the decision makers attention on the success factors for consideration.

Over the past seven years, the USDA Forest Service has moved toward large-scale ecosystem management and accelerated the involvement and use of science to make policy decisions and land management plans. Large assessments documents, such as, the Sierra Nevada Ecosystem Project and Interior Columbia River Basin assessment, have played a major role in resource management planning. The current state of knowledge is placed in the hands of decision makers with a number of options available for consideration.

A Management Plan for the Tongass National Forest in Alaska was recently completed after years of debate over earlier draft plans. Throughout the process, science played a major role in helping managers decide among several options. A science consistency test was developed and used to ensure adequate consideration of relevant science in the final plan. Consequently, the decision maker was able to present a defensible plan for public review and debate. Clearly, forest scientists played a major role, but they were never placed in the role of decision maker. They simply provided credible and relevant information in a timely manner.

The Role of a Scientist and Scientific Processes

The role of a scientist and scientific processes are unique and should not be compromised. The primary role of a scientist is to develop and communicate new and useful knowledge through the scientific process. The new knowledge is subject to intense peer review and must come across as credible. Hypotheses testing experimental design and statistical analysis are essential skills for good scientific inquiry. However, the greatest attributes of a scientist are imagination, thought process, self discipline, and the ability to communicate findings.

The scientist is not a policy maker nor is the scientist a forest management decision maker. However, the knowledge generated by scientists is the basic foundation for good management and policy decisions. In an ideal situation, scientists should collaborate with forest managers and policy makers. True collaboration includes intellectual dialogue where both parties add value to the ultimate outcome of a research project. Scientists need to acquire a clear understanding of management and policy issues before deciding what problems to solve through scientific research. Scientists must relentlessly seek the truth through experimentation and scientific inquiry. Ultimately, they must also report the truth even when the truth or scientific conclusions conflict with current policy and practices.

Science has the role of analyzing issues and identifying the critical success factors for achieving the desired outcomes in forest management. Science also has the role of bringing order to chaotic discussions/debates.

However, science does not and should not have the role of policeman of forest use and public policy debates. Success can be measured in the final outcome of policy development and, ultimately resource conditions on the ground. Resource conditions are inclusive of physical, biological and social attributes.

The Role of Science Administrators

Science administrators have a distinct role and it is not the same as the role of a scientist. People in purely science administration positions are no longer research scientists and should no longer feel compelled to shy away from policy debates. However, they should be careful to not compromise the objectivity and independent thinking of their scientists. Whenever science administrators enter a public policy debate, he or she should make it clear that views expressed are personal rather than the conclusion of a scientific study, unless such conclusions are quoted.

Science administrators are primarily responsible for enabling scientists to do work. Providing the support and funding for research are two essential function for science administrators. Equally important is the direction given to scientists on program development to address the larger policy issues faced by the nation, region, or state. Science administrators should also organize and enable teams to conduct collaborative research across disciplines and organizations.

We believe science administrators should also serve as a buffer between scientists and policy makers. The science administrators must protect the independent thinking and objectivity of scientists. A scientist without credibility is a liability rather than an asset in policy debates and legal appeals to management plans. Therefore, we place great emphasis on the science administrator's role in buffering scientists from the influence of policy makers.

Conclusion

We have significantly increased our understanding of how to integrate forest science into policy decisions over the past decade. We will continue to learn more in the years to come. There are no set of rules on how this process should work, but we have tried to present a set of general guidelines which are useful in any country. We encourage us to continue to share experiences from around the world in IUFRO. We believe we all have a common goal of helping better inform our policy makers and forest managers of the great benefits of science in resolving difficult forest management and policy problems.

Using Scientific Uncertainty to Shape Environmental Policy

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Abstract

Environmental management and policy formulation are increasingly characterized by conflict. Issues concerning natural resources, land-use practices, and global climate change have been fraught with debate and indecision. Some argue that the required information and levels of certainty fall short of scientific standards for decision making; others argue that science is not the issue and indecisiveness merely reflects a lack of sufficient political willpower. In the case of global climate change, even such unprecedented efforts as the IPCC appear to provide insufficient scientific guidance to formulate decisive environmental policy. Nonetheless, science remains the foundation for informing, evaluating, and shaping policy. Yet perhaps more than ever, science is subjected to keen scrutiny; scientists are required not only to report but also infer and substantiate this inference in a range of decision-making contexts. One of the most difficult and confusing aspects of translating science to policy is the interpretation of scientific uncertainty as embodied in statistics, model output, and opposing scientific opinions. Whereas scientists are familiar with uncertainty and complexity, the public and policy makers often seek certainty and deterministic solutions. We assert that environmental policy is most effective if scientific uncertainty is incorporated into a rigorous decision-theoretic framework as *knowledge*, not ignorance. Policies that best utilize scientific findings are defined here as those that accommodate the full scope of scientifically-based predictions.

Keywords: Environmental policy, Global climate change, Uncertainty, Risk, Decision making

Introduction

The rate at which humans are altering the biosphere has increased dramatically in the past century (see Reischauer and Fairbank 1960, Vitousek et al. 1997, United Nations 1997). For scientists, policy makers, and the public at large, the inferences drawn from scientific findings concerning these alterations differ greatly. Even unprecedented efforts such as the Intergovernmental Panel on Climate Change (IPCC, 1990, 1996) appear to provide insufficient scientific guidance to formulate decisive environmental policy. Although the latest report from the IPCC was heralded as an unprecedented international scientific consensus, considerable scrutiny and debate concerning the validity and implications of its findings followed (see Shackley and Wynne 1996, Raynor and Malone 1997). This now-familiar pattern wherein policy lags behind science has been characterized as either a cautious response to uncertain predictive capabilities or as dangerous procrastination fueled by political and economic exigencies (New York Times 1997, The Oregonian 1998). Critics argue that scientists know too little about global change to warrant anticipatory policy formulation and assert that current information and their levels of certainty fall short of scientific standards for decision making. Others maintain that science is not the issue, and that the indecisiveness of policy makers reflects a shortfall of political willpower (Gelbspan 1997). In either case, science, policy, and politics are intertwined in the climate change issue as commentary on the recent withdrawal of Ford Motor Company from the fossil fuel-related Global Climate Coalition suggests (see Los Angeles Times 1999).

We discuss the means by which some dysfunctional aspects of the science-policy interface, herein referred to as the *science-policy gap,* can be ameliorated. Specifically, we suggest that inaccurate translations from science to policy derive in large part from an improper inference of scientific uncertainty (Funtowicz and Ravetz 1990). Generally speaking, whereas scientists may be familiar with the conditions of scientific uncertainty, the public and policy makers often seek certainty and deterministic solutions. In some cases, the social and cultural standards superimposed onto those of science may become critical constraints to effective decision-making (Table 1; Gunderson *et al.* 1995). This discussion underscores the need for adaptive management principles and a rigorous decision-theoretic framework as a foundation for robust policy formulation (Lee 1999, Walters 1986, 1997, Dovers *et al.* 1996).

Sources Of The Science-Policy Gap

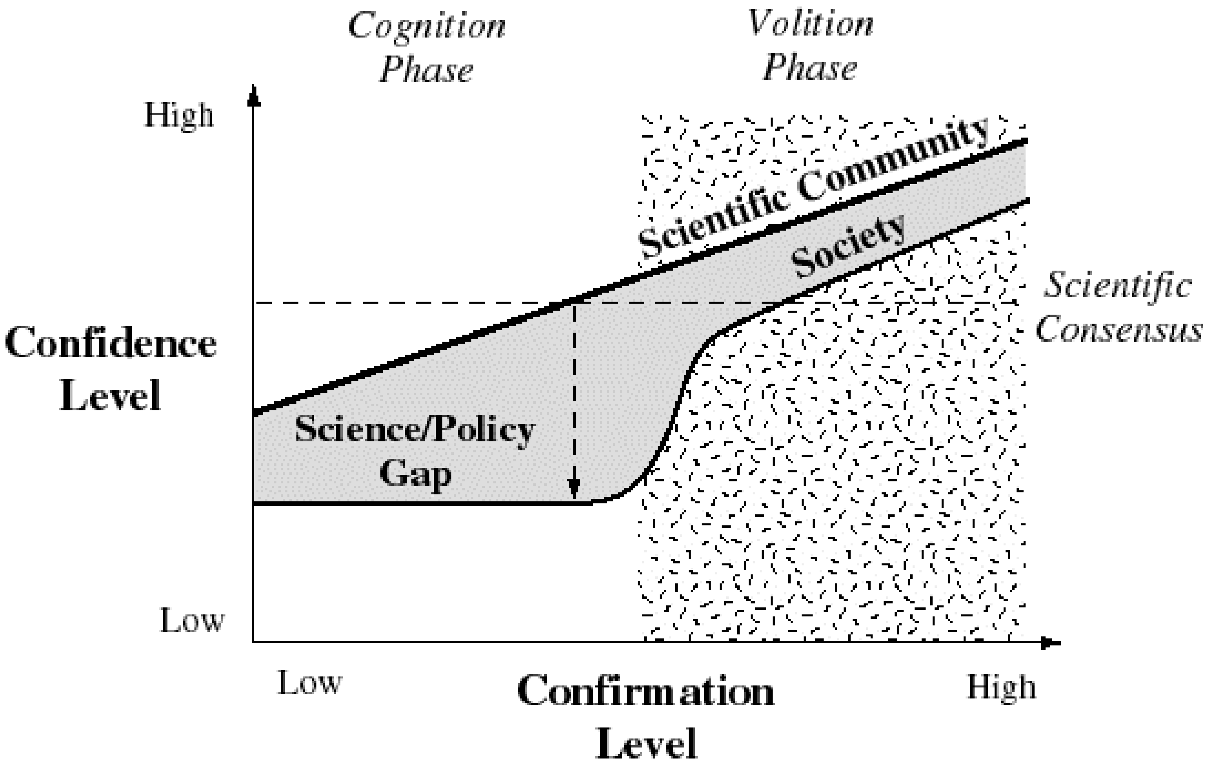
To better articulate the nature of the science-policy gap, it is useful to outline the life history of a scientific model from the perspective of Kuhn's (1962) paradigm shifts: the level of *confidence* in the model by the scientific community increases with the level of *scientific confirmation* (i.e., scientific activities that cumulatively corroborate the theory's hypotheses; Figure 1). As evidence accumulates to support the underlying hypotheses of a model, confidence in its representations increases (e.g., weather prediction models). In time, a model achieves greater standing as inferences concerning its representations are disseminated and debated in scientific literature and other fora.

Publication, citations, and merit awards, such as competitive grants, mark acceptance. At some threshold of accord within the scientific community, consensus emerges. However, the emergence of a so-called scientific consensus does not necessarily guarantee the level of certainty demanded by most policy makers (see Lemons 1996).

Table1: Characteristics of science and government (after Crerar 1987, cited in Manning 1988). The institutions of science and government are generally marked by very distinct behaviors and attributes. These differences contribute to some of the difficulties associated with transmitting and translating scientific information into policy and decisions.

Characteristics of Science and Government	
SCIENCE	**GOVERNMENT**
Probability accepted	*Certainty desired*
Inequality is a fact	*Equality desired*
Anticipatory	*Time ends at next election*
Flexibility	*Rigidity*
Problem oriented	*Service oriented*
Discovery oriented	*Mission oriented*
Failure and risk accepted	*Failure and risk intolerable*
Innovation prized	*Innovation suspect*
Replication essential for belief	*Beliefs are situational*
Clientele diffuse, diverse, or not present	*Clientele specific, immediate, and insistent*

Figure 1: Schematically, the science-policy gap is defined as the difference in levels of confidence for a given scientific finding expressed by the scientific community and society. Generally speaking, as confirmation of a model or scientific finding increases, the level of confidence in the finding increases. This relationship is portrayed as linear for the scientific community where the confidence level tracks the rate of confirmation. In contrast, the degree and rate at which social confidence and consensus develops for a given scientific finding may lag that of the science community due to a complex of social factors. In reality, the shape of this function will vary with individual scientific findings.



Even the constants of physics and chemistry are recognized as potentially inaccurate or imprecise, and subject to continual revision (Peterman and Peters 1997). In the case of large-scale simulation models, constants and parameters contain assumptions and uncertainties that propagate in uncertain ways to produce uncertain output. For scientists, this is business as usual (Raynor and Malone 1998, Morgan and Henrion 1990). For society and its decision-makers, however, such uncertainty may cast a shadow upon science itself (Shackley and Wynne 1996).

In contrast to the relatively formal process characterizing the scientific community, the acceptance of scientific results by a diverse public sector may differ markedly. We define the science-policy gap as the difference in levels of confidence for a given scientific finding expressed by the scientific community and society (Figure 1). In actuality, the broad categories of "public" and "scientific" comprise a vast array of individuals and groups having distinct histories, cultures, and belief systems that influence perceptions of non-human and human nature (Nader 1996). For example, because of their position within government, agency scientists may hold very different attitudes toward scientific uncertainty relative to their academic counterparts. An agency scientist has fealty not only to the scientific community, but also to a sometimes highly-politicized leadership that may be directly involved in defending policy. Paradoxically, the reluctance by scientists in such agencies to reveal ambiguities and uncertainties to the public out of fear of diminishing their credibility serves only to engender greater mistrust in the public (Walters 1997).

The science-policy lag is evidenced by the length of time required for a given scientific finding to assimilate into society. In part, the lag can be attributed to the rate of information dissemination. During this *cognition* phase, scientific information (e.g., effects of greenhouse gases) is disseminated by various media (e.g., Internet, science magazines, television). Realistically, the science-policy gap is more than an information gap; the extent to which society's level of confidence in a theory or model lags that of the scientific community depends on other significant factors.

The Role Of Cognitive Dissonance And Volition

Individuals and groups exhibit varied responses when faced with new information. If such information is consistent with extant behaviors and beliefs, it can be readily accepted and integrated. However, if the new information conflicts with behavior and belief, the resulting state is described as *cognitive dissonance* (Festinger 1957, Adams 1973). According to the theory, the inconsistency and psychological discomfort of cognitive dissonance can be reduced by changing one's beliefs, values, or behavior. Dissonance can be avoided by rejecting or avoiding information that challenge belief systems, or by interpreting dissonant information in a biased way.

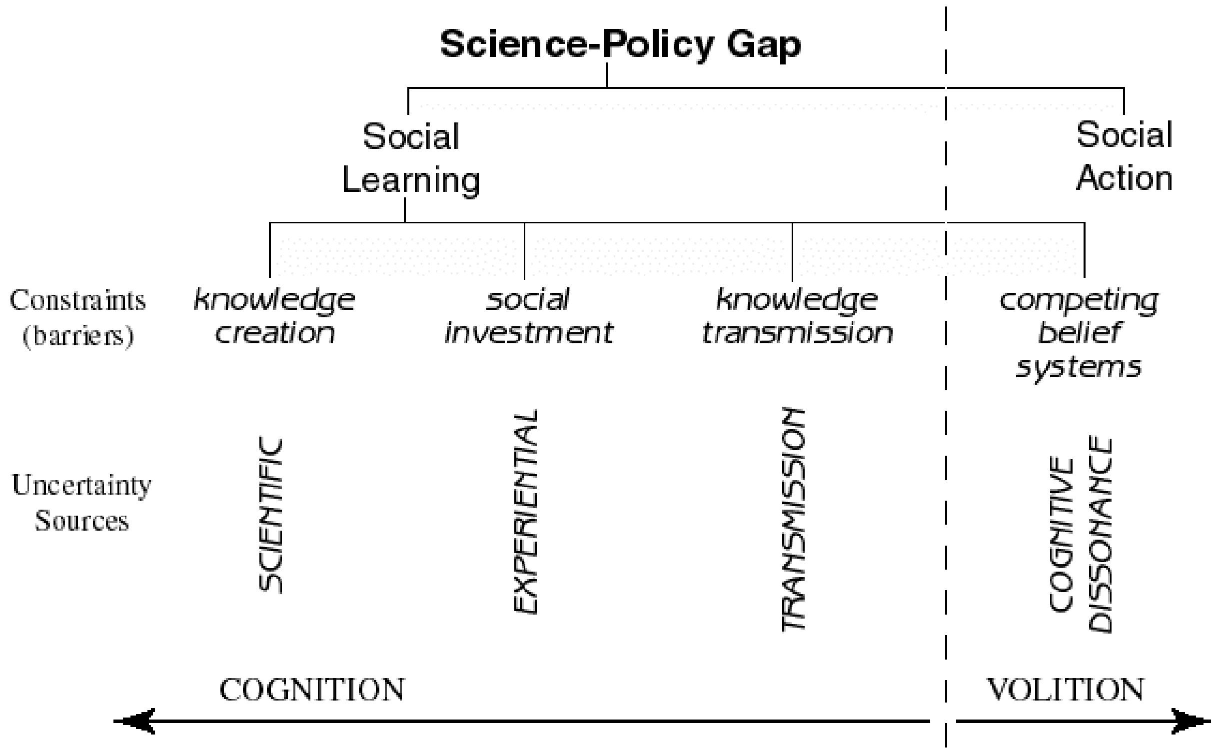
The role of cognitive dissonance can be observed in numerous contexts. One highly publicized case concerning public land use dramatically exemplifies the collision of differing world-views. As early as 1976, a landmark report was published forecasting future shortfalls of mature, harvestable timber independent of any consideration for the northern spotted owl (*Stryx occidentalis*; Beuter et al. 1976, Yaffee 1994)

In ensuing years, this shortfall, combined with improved technologies in harvesting and processing, and a vigorous raw materials export market, resulted in significant job declines. Yet despite this information, the issue continued to be misrepresented as an "owls-versus-jobs" issue, one that failed to acknowledge trends within the timber industry (Yaffee 1994). This type of oversimplification of complex issues and denial of "dissonant" information continues to embroil science in acrimonious public debates (USDA and USDI 1994, USDA 1996).

Dissonance between existing beliefs and new information may be shaped by a host of factors, all of which inhibit the rate at which scientific findings are assimilated into policy. In what we have called the *volition* phase of the science-policy gap, public debate around an emerging scientific consensus may derive from a combination of cultural, psychological, and economic interests threatened by the policy inferences of dissonant scientific findings. One obvious example is the tobacco industry, which is undergoing an onslaught of litigation decades after research confirmed the health risks of smoking tobacco. The volition phase of the science-policy gap may be described in many cases as social inertia borne not of a paucity of information, but of a complex, deep-seated resistance to change derived from numerous social, religious, and cultural sources (see Figure 2; Jasanoff and Wynne 1998, Lee 1993).

By definition, science is a provider of new information, and has always been cast in the dual role of both defending and attacking reigning paradigms (Schick 1997, Yearley 1996). For this reason, science will frequently produce cognitive dissonance, uncomfortable levels of uncertainty, and resistance in the body politic. Acceptance of its findings will be contingent upon attitudes and perceptions toward uncertainty and risk (Dorner 1996). In the case of global climate change, the challenge is to delineate appropriate responses to highly uncertain predictions of ecological and social crises in the absence of reliable estimates of risk (IPCC 1996).

Figure 2: The science-policy gap consists of related sets of constraints and sources of uncertainty.



The Role Of Scientific Uncertainty

Scientific uncertainty is typically characterized by statistical analysis (e.g., statistical confidence intervals, model output). Decision making in the sciences, such as that accomplished by hypothesis testing based on frequentist statistics, is usually performed according to consistent, though arbitrary standards (e.g., Type I error probability levels of 0.05). In less controlled situations, scientific uncertainty must be ascertained by other means, such as model prediction errors. Although a familiar companion to most scientists, there is little tolerance in the policy arena, as in most organized human activity, for the uncertainty and "ignorance" typically associated with complex systems (Briskin 1998). In contrast to the society that utilizes science to reduce uncertainty, "[d]oubt is clearly a value in the sciences" (Feynman 1998). Hence, the culture of science ends up in competition with the demanding exigencies of economics and politics, except when its findings are possessed of sufficiently high levels of certainty (Sims and Baumann 1974).

Nowhere is this truer than in the case of global climate change. The large-scale simulations presented in the IPCC reports portray a set of highly uncertain outcomes for various boundary conditions (e.g., global patterns of temperature extremes under fixed scenarios for CO_2 emission controls; IPCC 1996), which are themselves based on uncertain estimates of model parameters (Shackley et al. 1998). The IPCC reports represent both a wealth of accumulated knowledge *and* uncertainty. Unlike more tractable, data-rich scientific problems that readily yield understanding from statistical analyses, science in the IPCC report appears to confound policy makers who prefer more "certain", contained estimates of risks. The presence of uncertainty associated with climate change science has been interpreted as an undermining of scientific authority and as a hindrance to policy (Shackley and Wynne 1996, Martin and Richards 1995).

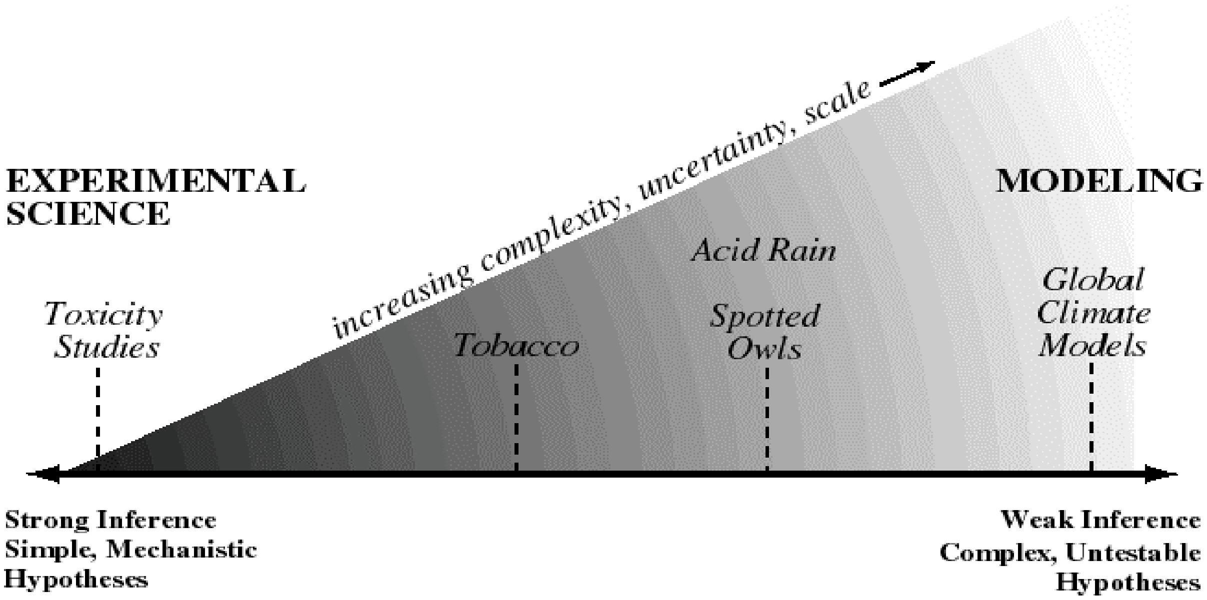
The uncertainty (or the lack of confidence in scientific findings) perceived by the public and policy makers can be grouped into two categories. First, there is uncertainty about the uncertainty. The public is puzzled by debate within the scientific community when it surfaces in the media (e.g., compare Schlesinger and Jiang 1991 and Risbey et al. 1991, Martin and Richards 1995). For example, in a recent Congressional hearing on global change, when asked about an immediate, "act now" versus a "wait and see" policy, one scientist stated that "[m]any would argue that we know more than enough…to include it at the top of the list of issues deserving serious consideration by policy-makers" (United States 1995; pp. 1127). However, a second scientist in the same hearing wrote of his concern about the continuing increase of CO_2 in the atmosphere, claiming that "[w]e have demonstrated no acceptable scientific basis for predicting catastrophic or near catastrophic effects that would council against a wait, think and see pattern" (United States 1995; pp. 1135). Such diversity in opinion may signal confusion and ignorance, thereby supporting a rationale for inaction. As one major petroleum corporation states, "Let's face it: The science of climate change is too uncertain to mandate a plan of action..." (New York Times 1997).

Uncertainty also plagues the interpretation of science in second way. For many, the significance of scientific findings is irrelevant or incomprehensible to the exigencies of everyday life. A lack of familiarity with scientific methods hinders a ready translation of science into personal choices (Smith 1996, Joyce 1995). Underlying this phenomenon are profound differences in perceptions of space and time of the type that characterize different cultures (Deloria 1995, Abram 1997). For individuals in post-industrial societies, the vast spatial and temporal concerns of science lie far outside their experiential domain of short-term, local events (Catton 1980; see Figure 3). Not surprisingly, these differences in are reflected in the relatively short cycles of funding and elections that drive policy formulation and decision making and preclude effective treatment of long-term crises in the natural world (Gunderson et al. 1997). The problem is exacerbated by the intricacies and inaccessibility of numeric models, the primary tool for investigating large-scale, complex systems (Oreskes et al. 1994). In contrast, traditional experimental science generally retains credibility, because it is conducted at scales familiar to most individuals, or at levels of complexity where scientific inference is rarely disputed (e.g., the role of micro-organisms in disease, tidal predictions; Figure 3).

Conclusions: Bridging The Science-Policy Gap

We have asserted that the normative discontinuity, or gap, between the scientific community and policy making institutions becomes increasingly dysfunctional over high risk issues characterized by large uncertainties which derive from complex, unfamiliar spatio-temporal domains. Increasingly, these conditions describe more and more environmental issues. The present attitude that "faster and better" science is sufficient ignores the source of the science-policy gap. The idea that greater certainty can be obtained and allow for more "certain" conditions for decision making with better and faster science is based on the erroneous supposition that uncertainty is finite. This attitude is in direct contradiction with the nature of scientific inquiry (Feynmann 1998). Whether or not, they continue to be science-based, environmental policy formulation and decision making will be accomplished under conditions of uncertainty.

We propose three general approaches for bridging the science-policy gap. Under the assumption that shared understanding of science and its implications will attenuate the polarity between science and society, the first, and most familiar approach is to directly enhance public confidence by increasing communication (Dovers *et al*. 1996).



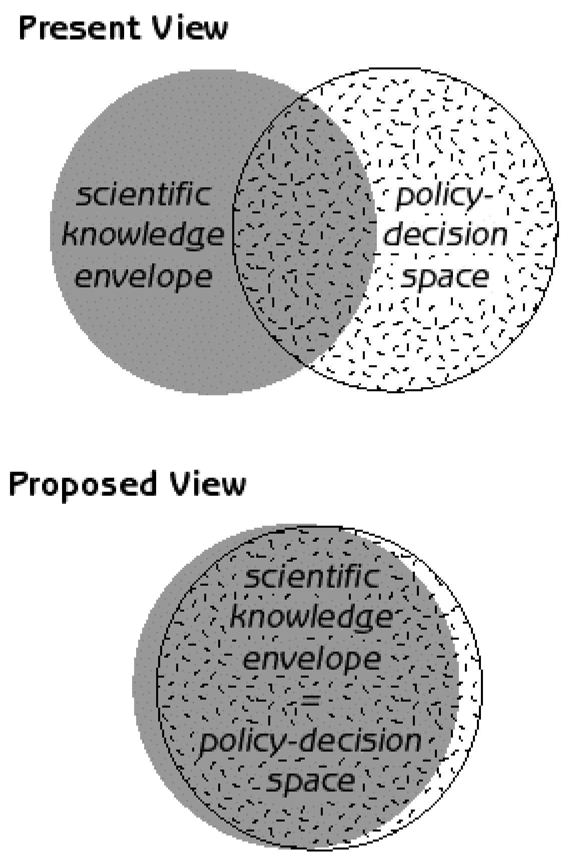
. Figure 3: Science uses a combination of data, theory, and models depending on the particular problem at hand. Increasingly, models are employed to address multivariate and large-scale environmental questions such as global climate change. The strength of inference for various scientific activities will differ; generally speaking, there is less confidence in understanding large-scale, complex systems than confined experimental systems described by simple mechanistic hypotheses. Issues such as global change, involving large-scale, complex systems, are intrinsically more uncertain

There are innumerable examples of the effects of science education and communication on changes in policy via the public. For example, many policy makers and legislators rely upon the views of concerned citizens, scientists, and lobbyists to formulate scientifically-valid law and policy (Wynne 1995). Since the 1960's, most national environmental legislation has been prompted, and to a great extent, shaped, by increasing public awareness of the scientific aspects of environmental degradation. Citizen groups are increasingly organized and well-versed in the scientific complexities of environmental issues (Dunlap 1992, Steel and Lovrich 1997). As such, they have become increasingly litigious in challenging the practices of government agencies. With the resulting judicial standoff, there are calls for broader participation and collaboration in environmental policy and decision making (e.g., Committee of Scientists 1999, USDA 1999, Shindler and Cheek 1999). When scientists and managers inform and involve their public constituencies in meaningful collaborations, the policy outcome is more likely to be consensus-based and less prone to legal challenge from disaffected stakeholders (Spinos, pers. comm., Johnson and Campbell 1999).

A second possible approach is to increase confidence by increasing the rate of scientific confirmation. This approach reflects the attitude that scientists can decrease uncertainty sufficiently to allow more precise estimations of risk for policy makers. However, in the case of global climate change, the IPCC (1996) report states that perhaps the greatest weakness in trying to formulate policy derives from a demonstrated inability to predict advances in science and technology. This may doom "wait and see" policy options; science, with its large, complex simulation models of possibly chaotic systems may never produce the needed levels of certainty (Oreskes *et al.* 1994, Casti and Karlquist 1991, Abel 1998).

To account for these seemingly inescapable uncertainties, we propose a third alternative to bridge the science-policy gap: realign the definition of scientific uncertainty as perceived by the public and policy makers with that of the science community. This means that scientific uncertainty must be regarded in the policy arena as it is in scientific circles --- as information for hypothesis building, experimentation, and decision making. In effect, the conflicting models and statistical confidence levels that represent the bounds of scientific knowledge would delimit the scope of a flexible science-based policy (Figure 4). This strategy would recognize that: (1) science and knowledge are intrinsically uncertain, with new information continually altering our perceptions and beliefs; (2) decisions based on scientific information must be made in a context of uncertainty; and (3) faster and better science as an adequate basis for policy formulation is inconsistent with the nature of scientific inquiry and resilient policy formulation.

Figure 4: Scientific information is best represented by policy if the entire envelope of relevant scientific knowledge (including uncertainty) is encompassed. This translates to formulating a policy that spans the range of scientific opinion that has undergone the process of peer review.



This perceptual shift requires policy makers to adopt a rigorous decision-theoretic framework and learning approach to policy formulation in accordance with tenets of adaptive management (e.g., see Lee 1999, Walters 1986, 1997, Gunderson et al. 1995). While there are significant obstacles to achieving such a rapprochement between science and policy (see Walters 1997, Lee 1999, Shindler and Cheek 1999, Johnson and Campbell 1999), new technologies and approaches to improve environmental planning and decision making are emerging (e.g., Lee and Bradshaw 1998, Borchers et al. in review, Reynolds et al. 1996, Berg et al. 1999). They will be most effective when utilized to enhance social learning that is linked with social action (Walters 1986, Gunderson et al. 1995). A corollary implies that scientists need to effectively articulate the true nature of science to the public and policy makers. Moreover, activities such as monitoring, designed and performed in partnership with citizens, science, and managers, can enhance public and institutional learning, especially if integrated into a statistically-sound framework for decision making (Lee and Bradshaw 1998).

Finally, as demands for more predictability have increased, the science community has become risk-averse. The charged atmosphere surrounding environmental issues threatens to obfuscate and undermine valid scientific inference (Ludwig et al. 1993). Without the freedom to engage in self-examination and self-doubt, scientific quality and integrity are diminished. This freedom, and uncertainty, is the essence of scientific inquiry.

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Forestry Research in Sub-Sahara Africa: Time for Reflection

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Abstract

Despite the great social, economic and environmental diversity in countries of Africa South of Sahara (SSA), forestry research issues and advances are quite similar. This is partly influenced by historical facts relating to forest resource ownership and management. In most countries, governments own and manage forest resources. Forestry research institutes are in many countries very tiny departments or units tucked under huge ministries or agricultural research organizations. Their visibility, much less their effectiveness in that position is barely significant, because they are also poorly staffed and financed.

The little available forestry research capacity is poorly managed. The few competent researchers are increasingly getting involved in administrative functions and also looking out for greener pastures. Economic policies imposed by global financial institutions constrain the recruitment of young scientists to take up forestry research now and in the future. Although universities are by far better resourced, their efforts are rarely linked with national research issues. They seem to operate independently, far removed from real world issues.

Through the intervention of some global stakeholders, some research institutes have developed their research agendas, but these have largely remained on the shelf for lack of resources to implement them. Most on going work is largely donor–driven. There is a serious gap between forestry research and development. Research institutes do not have the capacity to extend their findings. At the same time, they are not properly linked with agricultural extension services or NGOs in order to get their messages to stakeholders, especially farmers. This delimits the usefulness of the little that could trickle from forestry research.

In this paper, we have briefly discussed the above-mentioned issues, and made some recommendations. It is clear thats SA countries and the global community have a role to play to redress the situation. We think that unless affirmative action is taken SSA and the world stand to loose the opportunity to benefit from SSA forestry resources.

Keywords: Forestry research, Sub-Sahara Africa.

Introduction

To talk or write about Africa South of Sahara (SSA) as a region is very challenging because it is practically impossible to capture the region's great diversity, as demonstrated in the different cultural backgrounds of its people, ecology, economic development and socio-economic policies, among many other attributes. Many statements made in this presentation are of a very general nature and do not refer to specific individual countries or sub-regions. In this presentation we reflect on the growth of research in SSA as well as the potential for its future growth in a forestry sector which is rapidly becoming unbounded.

In SSA, formal forestry practice was for a long time a tree and forest focussed mission, largely serving the timber-based industry. Soldierly foresters kept the local people away from the forests taken from them, initially by colonial governments and later by post-independence governments. The gazzetement of forest resources as government property represented some of the first policies on 'nationalization' of assets Africa had ever experienced. Even today, practically all-independent African states endowed with significant natural forest resources have large tracts of such 'nationalized' forests under their control. The policies that guided the development and use of such resources largely shaped the development of forestry research in Africa. Some African countries have not managed to effectively disentangle themselves from the shortcomings of such policies in re-orienting their focus and emphasis on forest research.

The reality for all time has been that forestry in many SSA countries is inextricably linked to agriculture and therefore to food security. Local communities interact heavily with forest resources, primarily for life sustenance (food, water, medicines, fodder, and wood fuel), but also for cultural and religious purposes. There are also those who extract products for sale to generate income. Arnold and Townson (1998) estimate the number of persons in SSA that generate income from natural forest based products at about 15 million. Products such as fruits, honey, medicines, cane, bamboo, building poles and thatch grass are commonly extracted for this purpose. Previously known as 'minor forest products', these products in fact support the livelihoods of far more people than do products based on industrial timber. However, as they generated little revenue for state coffers, virtually no resources were committed to sustaining their supply.

Until recently, and most probably due to threats arising from desertification and deforestation, as well as concerns from environmentalists and the international community, SSA research revolved mainly around industrial forestry production both at primary and secondary levels. Very little research has been directed at meeting the needs of local communities.

The main shortcoming of this approach to development was to ignore the potential to improve the welfare the majority of the forest stakeholders using these resources. For example, critical areas where information continues to be scarce include, but are not limited to:

- The mutual relationship between the local communities and tree and forest resources.
- Enterprise development at local community level based on tree and forest products.
- Linking forestry with other land based activities like agriculture, livestock, and wildlife, in household production.
- Understanding and managing ecological systems with low forest/tree cover, e.g. semi-arid regions and heavily populated areas.
- Potential for indigenous knowledge in forest management.
- Steering the production of international public goods and services to also benefit local communities

Certainly understanding and incorporating these and other issues in forestry would have required a drastic departure from the traditional forestry practices, because these issues bring to the forefront the welfare of the local people, acknowledging them as stakeholders and partners in managing the resource. While the definition and content of forestry have been changing very rapidly in the recent past, traditional forestry management practices have moved very slowly in response. With the rapidly increasing number of stakeholders and diverse demands, it is now difficult to know where forestry begins and ends. There is increasing recognition that we are dealing with a very porous and unbounded sector. Forestry is increasingly being viewed as integrated natural resource management. The range and interests of stakeholders and 'players' in the 'new' forestry game is therefore orders of magnitude larger than previously. The knowledge requirements for managing such a vast sector are immense. While there are very many players and of different professional backgrounds, what professionally goes wrong in forestry is almost always ascribed to foresters. Paradoxically there is no other sector that in recent times has been so accommodative of others. This has been demonstrated by the level of consultation characteristic of the 1980s and 1990s when many of these countries formulated their National Forestry Action Plans/Programs, also known by other names like Forestry Master Plans.

So if the sector has opened its doors to so many 'new' stakeholders, why is forestry research lagging so far behind? Is it possible that the new stakeholders have either an extractive mentality or a conservationist and protectionist view of forestry with an unwillingness to invest in generating new knowledge for improving management of these resources? In this paper we highlight some key factors that have shaped and continue to shape forestry research in Africa, and how forestry research institutions can position themselves to address an ever-changing research agenda. The issues selected for this presentation are:

- Set up, growth and stability of institutions and research programs
- Managing national forestry research capacity
- Forestry research, development and extension continuum
- Collaboration between national, regional and international institutions.

Some national governments and donors have supported the revision and reformulation of research agendas, both at national and sub-regional levels. These efforts continue to be reinforced by new and emerging events in forestry like the Forestry Action Plans/Programs and several international agreements and conventions to which these countries are signatories. Forestry departments/services in many SSA countries are in a continuous state of planning and revising plans. Some of the key areas under consideration include:

- Understanding the local communities and how they relate to tree and forest resources
- Methods to conserve tree forest genetic resources
- Marketing forest products and services (other than timber)
- Integrating forestry with agriculture, for instance, understanding problems and opportunities of agricultural expansion at forest margins
- Wildlife management and user rights in forest areas
- Dry season fodder for livestock, especially for pastoral nomads
- Role of trees and forests in agricultural production, agroforestry
- Catchment forestry and water management
- Wood energy development
- Improving quality and life of timber in rural housing
- Understanding and managing ecological systems where trees are scarce, e.g. semi-arid regions

There is no doubt that forestry researchers are re-awakening, to focus some of their work on local community needs. In the discussion, we have not separated internal from external factors that affect forestry research. Shortcomings in research funding are mentioned at various stages, although we acknowledge that this topic deserves a more comprehensive treatise.

Set Up, Growth and Stability of Institutions and Research Programmes

Centralized forestry administration emerged during the colonial period and has largely been adopted by independent governments. A number of legislations were then put into place to guide selected forestry activities and the functioning of the forestry administrative units which are still operational today. For example, in Malawi a forestry unit was established in 1891 as part of a broader Scientific Department and the unit was to focus on planting Mlanje cedar, with field experimental work (research) on this species carried out in Zomba (Kowero et al 2000). The initial forest policies in Kenya were dictated by the demand for firewood for the Kenya-Uganda railway at the beginning of the last century, while in the Sahel region forest practices between 1930 and 1960 were guided by the desire to protect land where groundnuts (an important crop) were grown (Goumandakoye, 1996). Forestry institutions have for a long time been managed as small sections in ministries responsible for agriculture, natural resources or environment. As a result, not only is forestry research marginalized but the forestry profession as a whole is poorly staffed and financed.

Efforts to restructure the sector and also allow for growth of some of its sections saw research and development become some of the components of government forestry sectors. Forestry researchers as well as their colleagues in forestry development continue to be on government payrolls irrespective of the amount and quality of their output and demand for the same. With time, these two sub-sectors have become so autonomous in some countries to the extent that many related institutions, like universities, rarely link their plans effectively with one another or with forestry developments. This is confirmed by the observations made by Kowero and Spilsbury (1996) and Spilsbury et al (1999).

Some forestry research in SSA has been demand driven. Unfortunately such demand has been largely localized within the industry. For example in East Africa, considerable plantation research precluded the establishment of industrial forest plantations, because such plantations were seen profitable. This is also true for South Africa. In many other SSA countries with good and reasonable supplies of natural forests for industry, research focussed on properties of tree species for the industry. In countries like Ghana, Nigeria, Cameroon and Cote d'Ivore research in the lowland rain forests aimed at improving the silviculture and management practices in such forests, largely with the industry in mind.

So the industry created a direct demand for research for its products and exerted an indirect demand for research on its raw materials. The volume of forestry research done in SSA and for specific academic interests during the colonial period was scanty, largely because there were few advanced academic institutions like universities. Hence development of research took off on a small scale and at a very slow pace.

The independence period was marked with the advent of advanced institutions of learning, an increasing volume of forestry related demands, and problems related to desertification and deforestation. The portfolio of forest departments therefore increased, from an almost exclusive focus on forest harvesting and protection to inclusion of some social, economic and environmental aspects. Increased donor support also made it possible for national governments to address a broader spectrum of forestry and related issues, especially reformulation of national forestry policies, and strengthening and initiating new institutions to deal with forestry. Faculties and departments of forestry were established at universities and a few autonomous forestry research institutions have emerged.

As the mandate of the forestry sector expands, and with increased resources, forestry could have the potential to address a myriad of demands and problems from a larger pool of stakeholders. The demand for information is increasing. National governments and the international community have put up infrastructures to address the increased information needs, and this is leading to some growth in forestry research and training in Africa. However, this infrastructure continues to be severely weakened by ongoing economic reforms in practically all SSA countries. Generally speaking, the effects of the reforms include stagnation or decline of research in some countries. The sustainability of long-term research in some institutions is increasingly becoming questionable. Preference appears to be given to short duration type of projects, which are preferred by many funding agencies. Engagement in consultancies is increasingly becoming a coping mechanism, not only to the institutions but to individual researchers as well. Research therefore risks being driven largely by choices made by the funding institutions and not national research priorities. Availability of funding alters priority in implementing national research agendas. For example, if no donor funding is forthcoming for critical/high priority research issues, institutions might tend to continue to survive by working on low priority issues that have funding available.

The degree to which these institutions have been affected by these economic reforms varies greatly within and between countries in the region. Those that have strong links with the industry (like some in South Africa) are still managing fairly well. The forestry faculties and departments at universities are still operational, albeit with reduced real government funding in some countries.

Added to this predicament is the fact that in many SSA countries research institutes are structurally and operationally separated from universities. Their mandates are quite clearly distinguished as research and education/training respectively. This dichotomy tends to deter the universities from undertaking serious problem-oriented research. Instead, the vast majority of graduate student research is for academic ends. The net result is that few forestry problems are addressed or solved, and policy makers find no incentive to put more funds into forestry research in these institutions.

Further, the rather small size of institutions in many African countries does not allow for the development of the critical mass of scientists in many fields. For example, in North Africa, forestry research is conducted mainly by non-forestry departments at universities and research institutes. In Egypt, the Desert Development Centre of the American University of Cairo conducts forestry research. The Centre has done much work on dry forestry, but the research agenda is limited (El-Lakany 1994).

The industrial side of forestry in many of these countries is still weakly developed. In some countries the industry is in the process of changing hands from government to the private sector. It will take time before a firmly established private sector can create sufficient demands on forestry research and allocate significant resources for that. The present societal and environmental concerns that require research are gradually shifting from the domain of governments to the local communities, NGOs and the international community. A clear picture has yet to emerge as to how these stakeholders can be mobilized for effective research funding. Forestry research institutions should therefore realign themselves with the evolving forestry scenario. This means developing new capacities to address emerging problems and retraining their staff on the same. Closer collaboration among relevant national institutions and even mergers do not only increase capacity to address research problems, but increase diversity of skills within institutions, as well as their potential to attract resources. An institution that continues with a strong tree-forest focus will find it difficult to operate in this increasingly people-environment forestry world, and is likely to become irrelevant.

Managing National Research Capacity

Africa's investment in forestry education is the lowest in the world. In a continent with a forest cover estimated at 520,237 thousand hectares of forest in 1995 (FAO, 1999) and a population of 730 million people, there are only 15 professional level schools of forestry that have an annual output of at most 400 forestry professionals (guesstimate). Training outside the continent is expensive and is increasingly becoming limited. National governments and donors have largely supported these institutions. In many countries governments have also been the major employers, largely because the private sector remains small and the forest estate is largely under government. However, on-going economic reforms are forcing governments to decentralize many of their responsibilities in forestry to the private sector, NGOs, local communities, and whenever possible to the international community. Consequently the legitimacy for governments as major financiers of these institutions continues to decline, as well as the capacity for governments to employ forestry professionals.

Forestry research institutions need to strategize quickly, taking these changes into consideration. There are continuing changes on the research agenda and clients for research results also keep changing. This calls for retraining of research staff and new ones to address new and emerging issues. According to Kowero and Spilsbury (1997) about half of the forestry and related research manpower in the Southern African Development Community (SADC) need postgraduate training to equip them with requisite research skills. Spilsbury et al (1999) report that such training is required for about one third of the research manpower in West and Central Africa. Some SSA countries have very small pools of young forestry scientists. Those with adequately trained scientists (MSc. and PhD. levels) and reasonable research experience (at least 4 years) form the majority (about two thirds in West and Central Africa and half of the total in SADC). There are also problems of capacity mobilization. Measures to reduce government spending as a means in economic reforms have led to reduced or complete halting of staff employment in many government departments. In forestry research institutions the reforms have and continue to constrain recruiting young researchers. Consequently SSA is experiencing a serious imbalance between young and less experienced (but trainable researchers) on one hand, and well-trained and experienced researchers on the other. As the latter group gradually retires from forestry, moves to greener pastures or assumes more administrative responsibilities in and outside the sub-sector, there will be no adequate and suitable replacements. There is therefore, an impending vacuum of forestry expertise.

The capacity to address present day forestry and related research problems is dispersed in several institutions in these countries, and does not always reside in the traditional forestry research institutions and university forestry faculties and departments. These countries have to come up with strategies to consolidate and mobilize this capacity. At present the forestry institutions have demonstrated increased ability to interact with relevant national institutions, but the level of interaction between them and universities, where most of this capacity (human and equipment) resides, is low (Kowero and Spilsbury 1997). Such interaction is mostly in terms of training and thesis research. The 15 universities offering professional and postgraduate education in forestry have at least 250 qualified educators/researchers. Due to various reasons, including lack of funds and institutional policies, less than 20% of these highly qualified forestry experts are engaged in any research.

Forestry Research, Development and Extension Continuum

Many countries in SSA have the core forestry activities, namely research, development and extension under the direction government. Under this arrangement, development activities tend to take the lion's share of resources. Extension is given minimum emphasis, and is at times undertaken as part of other rural extension services, and by other sectors. Forestry extension is a very recent challenge, and has quite limited resources. Most resources are in the hands of NGOs. Therefore, the few research innovations in forestry continue to lack reliable outlet channels. The public is therefore often unaware of what is going on in forestry research. Even at universities where such results could complement teaching material, the packaging of such information into documents for use by students is very problematic.

Recently, governments and NGOs have gradually given considerable weight to forestry extension. Many NGOs have created awareness of key forestry issues in local communities, in addition to equipping the communities to embark on forestry and related projects. NGOs, and especially the local/national ones, are largely missing in forestry research.

With the advent of more decentralized government structures operating in a market economy, many countries fail to bring together the various stakeholders and direct their efforts towards shared goals. Governments have, and are continuing to decentralize forestry development to the private sector, local communities and other stakeholders. They therefore become increasingly less of clients for some types of research output, and therefore lack the incentive to support such research from a cost/benefit perspective. The stakeholders who take over some of the government responsibilities are scattered and lack the cohesion to make them stand as a unit and with one voice. In such a manner their collective demand for research and extension information is not usually felt strongly enough, let alone their ability to collectively finance research and extension services. The rural communities stand out very prominently in this respect.

Research, development and extension remain compartmentalized in many countries, and rarely does research feed into development and vice versa. Kowero and Spilsbury (1997) report that forestry research institutions in Central and West Africa allocate less than 10% of their budgets on interactions with user groups of their research results. In a parallel study Kowero and Spilsbury (1997) report that in the SADC countries about 17% and 28% of the institutions they surveyed allocate more than 20% of their budgets and staff time, respectively, to extension activities. The universities were found weaker in this respect as compared with other institutions. And yet the universities have the bulk of qualified researchers. The low interaction with users of research results raises questions on the relevance of research undertaken by many research institutions in SSA, as well as how they formulate their research priorities and programs.

With an ever-growing number of stakeholders, the challenge to many African institutions is how to effectively harmonize all research relevant to forestry within their individual countries and establish mechanisms for its coordination. In a market economy environment, research will largely be demand driven. The government and the private sectors have the capacity to pay for some of this research. Presently private sector research in forestry is missing in many of these countries. However, as governments continue to put more forestry responsibilities on the poor local communities, their research and extension demands must be planned for. Who shall do this and how? Further, the international community has to be mobilized for funding research that shall sustain the availability of international public goods and services. Again who shall do this and how?

Another research-development dilemma is uptake of research results, and especially in new fields. Often many institutions come up with results worth experimenting with. But then who should mobilize investment for such ventures? One case in point is that of adding value, through processing, packaging, and marketing, on some non-wood products that research has established their properties and markets, among other attributes. The absence of this linkage continues to rob those dependent on these resources of additional incomes and creates disincentives to care for such resources. The usual explanation in such cases is that research institutions have no mandate for production, while on the government side the common reason is that forest departments cannot go into business. The development of an enterprise capacity at the local community level will give more credit to research on some of the 'minor forest products'. However, how to create such capacity still eludes Africa.

The forestry sector is expanding very rapidly, overlapping with other sectors and creating new areas and disciplines like agroforestry. In many countries, demarcation of responsibilities for the emerging aspects the sector has not been done. While there is a huge potential for forestry to contribute to rural livelihood and development, the poorly equipped forestry departments are not able to cope with the challenges and responsibilities of bringing this about. Rural development planners and especially agriculturists have to step in and create conditions for alternative livelihood support systems that also have the potential for reducing pressure on dwindling forest resources. The roles of various sectors in rural development need to be clarified. In the absence of such a strategy, even with excellent forestry research the contribution of forestry to development is doomed to remain diffused and weak.

Collaboration Between National, Regional And International Institutions

The case for collaboration between national institutions has already been made. This section examines briefly collaboration between national institutions on one hand, and regional and international institutions on the other.

The world scene is changing very rapidly, and approaches to economic development and security have led to the upsurge of a number of groupings in many parts of the world. In SSA we have the Economic Community of West African States (ECOWAS), the East African Community (EAC), and the Southern African Development Community (SADC), as major economic groupings. Some of these groupings are moving very rapidly in integrating the economies of the constituent member countries. Also within them some sectors of the economy, like trade, security, and communications have moved faster than others have. The forestry sector lags very much behind in this respect.

Consonant with regional economic integration, research has also followed suit and SSA has three main sub-regional research organizations (SROs) namely Association for Strengthening Agricultural Research in Eastern and Central

Africa (ASARECA), Conference des Responsables de Recherche Agronomique en Afrique de l'Ouest et du Centre (CORAF), and Southern African Centre for Cooperation in Agricultural and Natural Resources Research and Training (SACCAR). There is an apex research body known as Special Program for African Agricultural Research (SPAAR) that is presently transforming itself into Forum for Agricultural Research in Africa (FARA). The change has arisen mainly because SPAAR is a World Bank supported organization and with its head office in Washington, whereas FARA is an indigenous organization, a brainchild of the SROs, and is to be housed within Africa. That notwithstanding, the agendas of the SROs and the apex organizations have very little to do with forestry research. All these organizations have a component of natural resources research, but this is largely restricted to soil and water issues. Very little trickles into agroforestry and practically nothing to forestry. SSA cannot continue to be represented by such organizations in matters of forestry research as long as this focus prevails. In fact SACCAR has shed off the little link it has had with forestry research in SADC, denying the SADC countries effective forestry representation at sub-regional, regional and continental levels. Either SPAAR/FARA and the SROs give significant weight to forestry and acquire forestry manpower and other resources at their establishments to address forestry research issues, or Africa has to establish other mechanisms for making its forestry case at sub-regional, regional and continental levels. The apex body and the SROs do not have forestry manpower in their establishments, and this makes their agendas hinge on food and cash crops.

Recently we have seen efforts to establish sub-regional networks on specific forestry research themes and tasks. Two such networks are the Forestry Research Network for Sub-Saharan Africa (FORNESSA) coordinated by FAO, with EC funding, and the African Forestry Research NETwork (AFORNET), coordinated by the African Academy of Sciences in collaboration with International Foundation for Science, and with Sida funding. FORNESSA is geared at strengthening forestry research institutions while AFORNET builds the capacity of individual scientists. The networks are still in their infancy and with some teething problems. They are struggling to secure support and identity so it is too early to judge their performance. SSA countries and their regional groupings should be mobilized for resources to support these networks. IUFRO as an international network with vast experience should also continue to strengthen these young networks with resources and expertise.

Many international institutions, including the CGIAR centers, work in collaboration with the SROs in identifying areas for research collaboration and support. The SROs being largely agricultural have not managed to promote the forestry side with such institutions, hence the little or scanty resource mobilization, by the SROs, for forestry over the years. Forestry oriented institutions like CIFOR, ICRAF and some northern institutions, have largely gone into partnerships with individual country institutions at their own initiative or that of the individual country NARS, and not necessarily through their mobilization by the SROs. The national forestry institutions collaborate with international institutions much more in matters of training their staff and less so in forestry research. With the forestry issues continuing to be scanty or absent on the agendas of meetings between the SROs and the international institutions, forestry research will remain marginalized at both sub-regional and regional levels. Some of the international institutions and donors have chosen to work with the SROs in taking up or funding regional activities, forestry included.

There is therefore an urgent need to educate the international community on the inability of the existing SROs to represent any sub-region in SSA in matters of forestry research. At the same time SSA should promote new and emerging forestry regional units to take the lead in negotiating with the international community on forestry research. For example, the SADC-FSTCU can assume such responsibility in SADC and not SACCAR, a SRO that has already abandoned such a mandate. In December 1999, the Association of Forestry Research Institutions in Eastern Africa (AFREA) was formed. This brings together forestry research institutes in Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Sudan and Tanzania. This body can now take on ASARECA's role to promote research in forestry. The SADC-FSTCU, AFREA and similar units should as a matter of principle be represented at all SRO regional meetings to present the forestry case, as long as the present SROs continue to gain mileage on the basis of their natural resource mandate. Such units could pioneer efforts to form independent SROs in forestry research in SSA. These units should work with AFORNET and FORNESSA.

The complexity of natural resources management, and forestry in particular, and the role played by forests in the lives of the SSA peoples and their environment, justify giving much more prominence to forestry and forestry research at sub-regional and regional levels. Such prominence has been and continues to be undermined by the focus and glaring shortcomings in supporting forestry research. It is high time that SSA countries realized that forestry research could make a major contribution towards the conservation and sustenance of agricultural productivity. This can only be achieved if sufficient resources are invested in forestry and related research. The first step is for these countries to evaluate how best to handle forestry and forestry research in particular at country and sub-regional levels. Africa has already positioned itself to move in tandem with the rest of the world in handling economic development through regional groupings. Forestry and forestry research cannot remain the exclusive domain of weak national institutions and housed in inappropriate SROs, especially considering the stakes in terms of international public goods and services that forestry can offer, particularly to agriculture and environment

Conclusions and Recommendations

Existing institutional arrangements at country and sub-regional levels in SSA are inadequate for engendering forestry research. Emerging networks are a step in the right direction, but enormous support is needed to make them operational.

The structure and development of forestry research manpower is of major concern in practically all SSA countries. An aging but well trained and experienced cadre is not only poorly managed, but also insufficiently supported by young scientists who can take over research in the future. Policy makers should consider the consequences of decisions on economic reforms that constrain staff recruitment in forestry. University research capacity should be better managed to support national forestry research units and work in tandem with them to solve real forestry problems.

The re-alignment of African nations away from centrally planned economies and with the state holding a major stake in forestry, to market economies with many government functions decentralized to the private sector and local communities creates another major challenge to forestry research institutions in SSA. The hitherto guaranteed funding of forestry research by government as well as employment of research professionals is fast disappearing. New stakeholders in forestry as well as new clients for research are emerging. There is a need to work out mechanisms to capture research demand and assign responsibilities to the various organizations involved. Participation of the private sector must be given space.

On the global front we see increased re-alignment of the world economic system into economic groupings. SSA is involved in these developments, its limited capacity notwithstanding. Forestry is increasingly attracting regional and global attention, and SSA is fully participating in this. The challenge in SSA is how to position the forestry research sub-sector in a regional setting so that it can effectively respond to challenges these global and regional changes create. We recommend the establishment of a strong forestry research capacity at sub regional level.

Ministries responsible for agriculture together with NGOs form a strong capacity for the extension of forestry innovations. There is a need establish mechanisms by which these institutions can carry forestry extension messages to stakeholders, especially farmers.

Training new and re-training old forestry staff is another important area. Given the recent expansion of forestry mandates, it is necessary to improve forestry curricula and open up the scope of serving foresters. National and regional networks, in collaboration with universities and international organizations should conduct short training courses that address key forestry research issues.

It is clear that a good policy on forestry research is necessary but not enough. Practical steps must be taken to make SSA better able to deliver quality forestry research for the betterment of human welfare and the environment.

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Forest Discussion Forums as Modern Policy Means:Bridging Research, Practice and Policymaking

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Abstract

Issues and problems relating to forests have become increasingly interdisciplinary and global. Subsequently, there is increased recognition that many problems related to forestry cannot be resolved by the forest sector in any country or any region alone. Instead, dialogue and co-operation between various sectors of society, and various regions is needed. Indeed, the forest sector has lately been concerned about the sufficient incorporation of various interests in its policymaking. However, an equally important question is whether the forest sector is itself sufficiently involved in decision-making in issues that are taking place outside the forest sector but which still have major importance to the sector. Moreover, while participatory policies are gaining increasing support within forest policy, the participation of scientists in policymaking is typically regarded as undesirable, or at least limited to science policy administrations. In this paper, both these challenges are discussed through the examination discussion forums as modern forest policy means. Ass all illustration, experiences from a new type of discussion-forum known as the Forest Forum for Decision-Makers in Finland (FFDM) are presented. During only a few years of action, FFDM has succeeded not only in improving the interface between science and policymaking, but also in increasing dialogue between decision-maker in forestry and other sectors of society. Finally, the question of the applicability of this new concept internationally is discussed.

Keywords: Forest, Research, Practice, Policymaking

Introduction

Issues and problems relating to forests have become increasingly interdisciplinary and global. The struggle for sustainable forest management, against deforestation, the loss of biodiversity and climate change have forced policymakers from different fields into more intense co-operation than ever. Such co-operation takes place in an international policy system which has transformed from a system of sovereign states into a mixed system consisting multiple stakeholders (e.g. states, international corporations and organisations, NGOs, media) that have many different types of means and strategies in their hands when pursuing their interests. Many new stakeholder groups demand that information about policy options and their consequences are made available for everyone. They also have valuable knowledge and skills that are needed to supplement the actions of sovereign states. In recognising the complexity of issues and the variety of interests relating to sustainable forest management, the international forestry community has expressed a particular need to improve the interface between the forest sector and other actors who have an interest in forests. This international strive for participatory and consensus-based decision-making is visible in most international forest policy processes since the UNCED conference.

The amount of information available for policymakers has exploded. Simultaneously as knowledge on forest ecosystems, forest management and society has grown, the understanding of the full complexity of most forest issues has become increasingly demanding. Accordingly, there is increasing recognition of the importance of sound scientific information as a foundation for policy positions (Mills & Solberg 1998). As part of the international dialogue on forests, the improvement of the interface between science, practice and policymaking has become a crucial issue for forestry policy development. Especially the need to improve the use of forestry research in support of policy decisions is frequently expressed among forest policy makers. For example, this issue was raised in Austria where the International Consultation on Research and Information

Systems in Forestry (ICRIS 1998) convened in 1998 for seeking ways and means to implement research support and provide background information for international forestry initiatives. Following the recommendations of ICRIS, the International Union of Forestry Research Organisations (IUFRO) has lately established a task force for the very purpose of strengthening the interface of science and policymaking in forestry globally.

Accordingly, the forest sector has lately been concerned about the sufficient incorporation of various forest-related interests in its policymaking. An equally important question is whether the forest sector is itself sufficiently involved in decision-making on issues that are taking place outside the forest sector but which still have major importance to the sector. Important decision-makers in forestry issues not only include top-level representatives of forest-related interests but also top-level decision-makers in banking and insurance, trade, other industrial sectors, education, labour unions, politicians, the media, etc. Moreover, while participatory policies are gaining increasing support within forest policy, the participation of scientists in policymaking is typically regarded as undesirable, or at least limited to science policy administrators (Mills & Solberg 1998, Lewis & Koch 1999). In this paper, both these challenges are discussed through the examination of discussion forums as modern forest policy means. For illustration, experiences from a new type of discussion-forum, the Forest Forum for Decision-Makers in Finland (FFDM) are presented. During only a few years of action, FFDM has succeeded not only in improving the interface between science and policymaking, but also in increasing dialogue between decision-maker in forestry and other sectors of society. Finally, the question of the applicability of this new concept internationally is also discussed.

Science and Policymaking

Utilisation of Science

Not only the production but also the effective and proper utilisation of scientific knowledge in support of policymaking is a profound goal of the scientific community. Below, three different types of utilisation of scientific knowledge in decision-making are presented, as identified by Lampinen (1985).

Instrumental utilisation has direct influence in decision-making. From a supply point of view, instrumental utilisation of science involves the well known chain of basic research – applied research – development – application. This type of approach is most typical for the innovative processes related to natural sciences and technological solutions. From a demand point of view, instrumental utilisation of scientific knowledge is best described as problem solving. This process may be described through the following chain: analysis of decision-making situation – identification of information needs – production or gathering of scientific information – interpretation of the research results within the framework of the decision-making situation – choice of solution. In short, the decision-maker uses scientific evidence consciously in order to fill in gaps of knowledge that are strategic to his decision-making. At large, the instrumental utilisation of science in decision-making is open to many types of criticism. Even in its best applications describe the utilisation of scientific knowledge only partly.

In ***conceptual*** utilisation of science, research does not provide direct answers to predefined questions but has a more indirect influence on decision-making. Research helps to conceptualise the problem in question. Most often, research has more impact on problem formulation than problem resolution. In this approach, science has no monopoly to "correct" information. Decision-making is also based on previous experiences, and other non-scientific communication.

Political utilisation is another form of indirect influence of science to decision-making. Instead of using research to search for the best possible solution, science is used to support a specific policy. Often, in political utilisation, research results are harnessed to serve purposes for which they were not produced. However, researchers may also themselves offer decision-makers such results that they are themselves comfortable with. Their motivation may be increased research funding of willingness to influence decision-making towards the researchers own views. Concern for political utilisation of science has also been expressed by many forest research administrators, emphasising that the importance of scientists in support of policymaking is based on credibility which should not be compromised (Mills & Solberg 1998, Lewis & Koch 1999).

Basically, all three approaches deal with what type of information to produce and what to do with the produced information. Indeed, the most typical forms of the science-policy interface are production-oriented; they are related to the identification of information and research needs, or to the dissemination of research results (e.g. extension, education). These two form an important feed back system where at best, the scientific community and decision-makers are in constant interaction. In order to bring valuable information to the policy table, and help focus subsequent research studies on policy-relevant topics, Mills and Solberg (1998) emphasise the need to build a collaborative infrastructure and relations between science and policymaking. This can be accomplished, for example, through proactively conducting research on anticipated policy issues, regular conferences, joint research studies, adaptive management, and boundary spanners.

Knowledge Generation

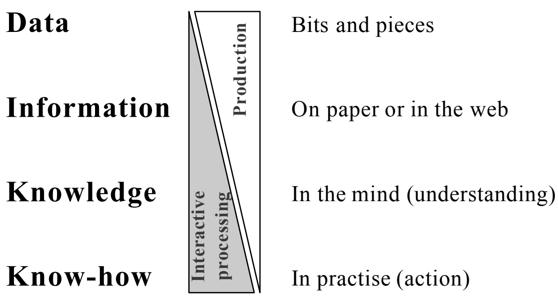
According to Seppälä (1998), the generation of know-how begins from basic or raw data; bits and pieces of unorganised information. The processing of data into time series etc. results in information. Only when such information is processed through, for example, methods of scientific research, and only when we learn to understand connections between different aspects, may we talk about knowledge. Knowledge involves synergy where the whole is more than the sum of pieces. The difference between information and knowledge can be illustrated as information being on paper or in the web, whereas knowledge is in the mind. When knowledge is supplemented with skills and readiness gained from, for example, education or learning in practice may we speak about know-how. In addition to being able to answer to the question "what", know-how implies an ability to answer to the question "how". Not even know-how is sufficient to guarantee application.

Accordingly, know-how generation is not only about what information to produce and what to do with it; it also involves the question of how to process information into knowledge and know-how. As Figure 1 illustrates, the further we proceed from data towards know-how, the stronger demand there is for interactive processing of information than for producing it.

A particular need to broaden our understanding of the role of the science community in the processing of information into knowledge and know-how arises from information overpopulation. Towards the end of the millennium, the world has been increasingly fascinated by the information revolution that is said to have been brought about by modern information technology. According to Drucker (1999), although the new electronic distribution channels will change the printed book, it will nevertheless remain a printed product, with the main task of providing information. Owing to new efficient distribution technology, the amount of printed information easily available increases at immense speed. Today, we live in a confusing situation of information overpopulation (Koski 1998).

Owing to the increasing complexity of forestry issues and information overpopulation, it has become increasingly difficult to build up knowledge from pieces of information and apply it into practice through know-how generation. A strategic key issue for future information management is to learn how to organise and increase the value added sate of information as a key resource. The processing of information into knowledge and know-how is essentially based on high quality processors. Despite modern technology, the role of key individuals and interactive dialogue in the processing of information is irreplaceable. This type of interactive and joint processing of information is based on an essentially closer connection between the scientific community and decision-makers, which may raise questions and concern related to the use of science in lobbying.

Figure 1. The roles of information processing and production within the process of generating know-how.



Science and Lobbying

Jaatinen (1999:22) defines lobbying as influencing political decision-making in the interest of a group by communicating with publics relevant to the political process in a certain issue. These publics are the political decision-makers and officials, competitors, the mass media, citizens, and the constituents of the lobbyist. Accordingly, central aspects of lobbying include communication, influence and interest. The science community is not exempt from these aspects. In fact, the science community is expected to disseminate and communicate the information provided by scientific methods in an open manner. Inevitably, one important motivation for communication is to influence decision-making. Moreover, it is in the interest of the science community that decision-making is based on sound scientific information as a foundation for reasonable and accepted decisions. This overall goal of the scientific community should be separated from the types of interests involved in political utilisation of science. From this point of view, the science community cannot be viewed as an external actor to lobbying and policymaking. This argument is also supported by another angle on lobbying.

Typically, lobbying is understood as attempts to try to influence the environmental conditions of the organisation through communication. It implies that the lobbyist knows what decisions are in line with his long term interests. This, again, implies that the lobbyist is well aware of the political, economic, social and cultural environment in which decisions are made. This is no longer self evident in modern society. In fact, the assumption that communication is interactive contains the notion of two-way communication also in relation to lobbying (Jaatinen 1999:46). As one form of lobbying, environmental scanning helps the organisation to note external and internal changes important for the functioning of the organisation early, and to take these into account in decision-making. Communication with the scientific community is an essential part of scanning the environment in which the organisation operates, and thus, an integral part of the lobbying of any organisation.

In circumstances of substantial uncertainties, instead of communicating on behalf of achieving predefined goals, communication to test and reformulate the goals of the organisations involved, so that they are better aligned with overall social, economic, and political development, is of uttermost importance. Such communication is essentially based on listening and learning more than on informing or persuading. This form of lobbying actually involves joint and interactive processing of information into common knowledge and know-how in an open manner. Moreover, lobbying does not necessarily need to be understood as a linear process of one group influencing another. It can also be viewed as a series of linear influence efforts by alternating parties in striving for an agreement (Jaatinen 1999). Discussion forums offer one important arena for such communication, and a natural arena for the involvement of the science community in policymaking.

Discussion Forums as Means of Forest Policy

According to motive, discussion forums can be divided into three main groups. Discussion forums aimed at information dissemination (left in Figure 2) largely follow the logic of typical seminars: selected information is presented and ”tested” through questioning and discussion. Such forums typically include a group of selected speakers who present their views on requested themes. The following discussion mostly takes place between individual participants of the forum and the speakers. In other words, most communication is two-sided, usually involving the speaker as one of the two communicators.

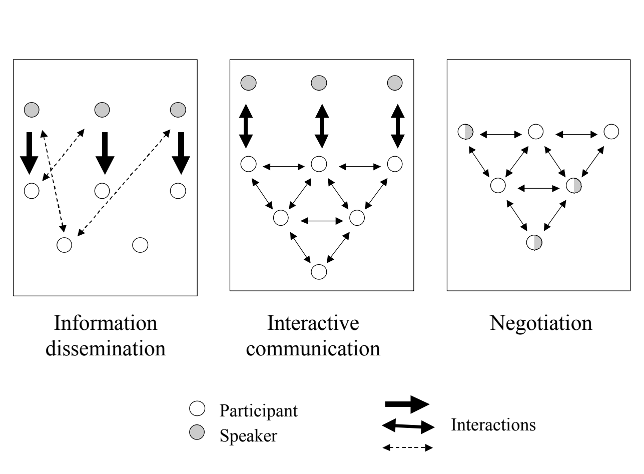
The second type of approach to discussion forums is based on interactive communication between the participants of the forum (in the middle in Figure 2). The main purposes of such forums are to a) increase the knowledge of the participants on selected themes and b) broaden the views of the participants by learning from each other through discussion or groups work involving the whole group. In such forums, outcomes are measured in the learning experiences of the group as a whole, which is more than the sum of the learning experiences of the individuals. Although it is not necessary for a successful forum of this type, they may, at best, result in joint commitment or mutually accepted strategies.

The third type of discussion forum (right in Figure 2) makes no difference between speakers and participants. Each participant shares his knowledge with others in order to achieve a common goal which is usually set by the organiser of the forum in the form of a specific task. Typically, the task is to find common ground and commitment to joint strategies through negotiation. This type of forum largely resembles working groups.

Although these three types of discussion forums are, or course, only stereotypes, a survey of discussion forums in Europe (Hamunen & Hellström 1998) indicates that this typology is applicable to most situations. Furthermore, forest discussion forums may be classified according to several organisational or operational features, such as the organiser(s), duration and regularity, size of the forum, working methods, openness, selection of participants and speakers, and the themes discussed.

The variety of motives and goals of discussions forums raise the question whether they still represent the same type of forest policy means. In forest policy text books, policy means are typically divided into the following groups:

Figure 2. Forms of interaction within forest discussion forums



Regulatory (juridical-administrative) control:
: laws and statutes, administrative guidelines, announcements, registrations, orders and prohibitions

Economic incentives:
: subsidies, subventions, loans, taxes, tax concessions, payments, material support

Public ownership, planning and budgeting:
: state owned forest industry and forests

Information means:
: research activities, education, advising, information services, communication.

Obviously, when using the above mentioned categories, discussion forums may at best be classified as information tools. Information policies include a variety of ways to produce information about forestry for the purposes of information dissemination, campaigning, education, research and development, environmental and social impact assessments, and inventories. Information policies may focus on a variety of different groups, from the industry to special interests groups or consumers. Through information policies, the society aims at advising the citizens of what is right and wrong, or what is good or bad; how citizens should act and what is permitted. Accordingly, in addition to information dissemination, information policy includes views and recommendations for behaviour. (Sairinen 1996.) Most discussion forums deal with information in many ways. They present latest research results, they try to motivate, persuade or appeal the participants of the forum and they may even search for model solutions. However, the understanding of discussion forums as policy tools does not need to be restricted to information tools.

Particularly the internationalisation of the forestry debate has highlighted the inability of traditional forest policy means in securing sustainable forest management. Simultaneously, conflict management has become an important field of forest policy at national and local levels. Problem solving in either field cannot be forced upon any of these actors through any of the policy means mentioned above. The latest approaches in policy research identify one further group of policy means, namely negotiation (e.g. Sairinen 1996). This groups comprises a variety of instruments of different nature. Yet, common denominators for means within this group are interaction, negotiating, problem solving and joint commitment by different parties to commonly agreed goals or actions. Negotiation is a communicative policy tool which also involves some elements of information exchange. Thus, it has features in common with information policy but enlarges it and adds a wholly new perspective to it.

Typical examples where negotiation-based forest policy instruments have been used are negotiations preceding international agreements, and conflict management through mediation. In international forest policy, no other policy instrument is even successful, owing to the sovereignty of nations. At national levels, negotiation-based policy tools have been used in committees and working groups of different kinds. Later, the recommendations of such committees may have been enforced through regulatory-administrative decision-making. Negotiation processes are voluntary, and not even a unanimous results guarantee that the administrations are willing to make the final decisions. Although lacking decision-making power, negotiation instruments are important tools in creating channels of communication between a large variety of interests groups, publicity and open discussion. Accordingly, the result of negotiation is not decision-making but a joint agreement which is based on common interest and which is, thus, acceptable for everyone involved. (Sairinen 1996.)

Viewed from this new perspective, discussion forums most often include features of both information policies and negotiation instruments but with different emphasis. For example, discussion forums operating as more or less in the manner of working groups may largely resemble negotiation instruments, whereas discussion forums operating as more or less in the manner of seminars may resemble information policy approach the most. Obviously, the closer we proceed from information dissemination-oriented forums to negotiation-based forums, the more concerns may be expressed in regard to the extent and depth of involvement of the scientific community.

Forest Forum for Decision-Makers in Finland

Concept and Activities

The establishment of a discussion forum on forestry issues, directed at top-level decision-makers throughout the Finnish society was considered in forest sector organisations already in the early 1990s, since a recognition of the fact that the increasingly inter-disciplinary and international forest issues cannot be resolved by the forest sector alone. Instead, cross-sectoral co-operation is needed. Finally, after careful preparation, the first Forest Forum for Decision-Makers (FFDM) was opened in September 1996.

The communication strategy of FFDM can be viewed from two aspects: forest and society (Figure 3). In the 1990s, the Finnish forest sector has readily adopted the global goal of sustainable development, and vigorously aimed at defining sustainable development in relation to forest management. In its communication strategies, the acceptability of present sustainable forest management in the eyes of decision-makers and the public ("social license to operate") has become a major concern. Typical examples of attempts to increase the social acceptability of sustainable forest management include criteria and indicator processes, image campaigning and forest certification initiatives. The forest-society relationship can be viewed from the society's point of view, too. For many decision-makers outside the forest sector, the use of forests is only one "tool" among many others that can be used to fulfil various societal goals. The key to influence decision-making that takes place outside the forest sector but which still has important implications to the sector, is largely based on creating social demand for the use of forests. Such demand has to originate from broader societal concerns and it cannot be forced upon the decision-makers by the forest sector. Instead, it requires a communication strategy that is essentially based on close interaction between the forest sector and society, and where the forest sector is ready to open up for mutual learning. These two views on the forest-society relationship are aligned with the understanding of lobbying as two-way communication, as discussed earlier.

According to these principles, FFDM is directed at top-level decision-makers of society, with main focus on participants from outside the forest sector. One third of the participants represent forestry or forest based industries, whereas two thirds represent other sectors of society (non-forest based administration, interest groups, political parties, businesses, media, NGOs). The forums have 25-30 participants in each, and each forum is participated by different individuals. FFDM aims that bringing a new proactive mode to forest sector communication by aiming to:

motivating and improving the ability of the participants to address increasingly global and complex forest issues in sustainable ways (social acceptability), and

discovering new ways for the forest sector to support the resolution of societal problems of general importance (raising social demand).

In the beginning of each forum, the participants have been asked about how the forum can help to improve their abilities in decision-making related to forestry? The answers can be divided into three main groups, with similar emphasis given to each:

Information (e.g. high quality and multiple aspect information about the present state and future economic, ecological and social challenges of forests and the forest sector in global development)

Interaction (e.g. new personal and over sectoral contacts, broadening of ones understanding of forest issues through open dialogue, and immemorial experiences in a relaxed atmosphere).

Integrated views (e.g. new ideas, integrated visions and strategies, and seeds for over-sectoral co-operation).

On the basis of the needs of the participants, the following operational concept was created for the forum. (Figure 4).

Figure 3. The communication strategy of the Forest Forum for Decision-Makers in Finland (FFDM).

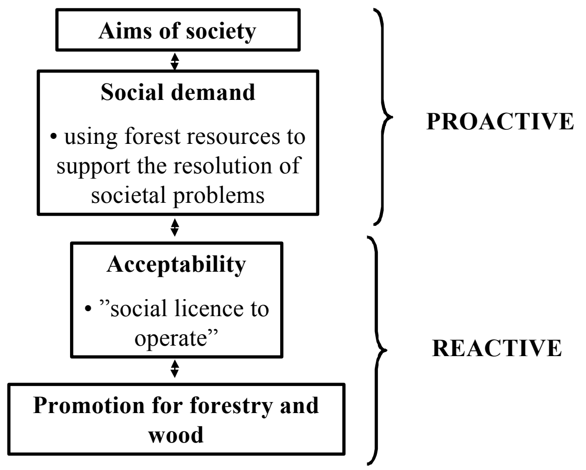
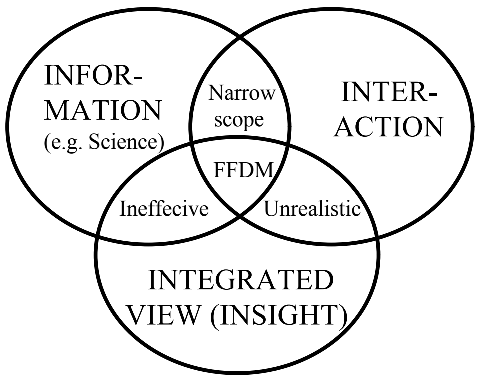


Figure 4. The operational concept of the Forest Forum for Decision-Makers in Finland (FFDM).



The most interesting part in Figure 4 are the intersections of the three elements. In a situation where interaction takes place on the basis of high quality information but without the involvement of multiple parties, resembles a situation where traditional lobbying takes place. Discussions tend to be narrow in scope and are leaned towards individual interests (not seeing the forest from the trees). On the other hand, if interaction takes place among multiple parties, without the involvement of high quality information, there is a danger that strategies may be unrealistic (roots firmly in the air). Finally, in a situation where decisions are made on the basis of high quality information and multiple parties, but personal interaction is lacking, there is still a danger that decision-making is ineffective (the forest does not answer when called at). This highlights the importance of all three aspects in discussion forums that aim at building knowledge and know-how in support of decision-making.

The forums last for a total of four days, including a seminar session arranged in the Helsinki region, and an excursion to other parts of Finland. In addition to these forums, seminars and other gatherings are regularly arranged jointly for all those who have participated one of the forums. Essentially, the

Forest Forum is not only about single courses or forums, it is about networking and “keeping in touch” with decision-makers throughout the society. Each forest forum aims at providing a general understanding of the whole branch, the so called forest cluster. It focuses on e.g. global forest development, national forest, environmental and industrial policy, rural development, family forestry, silviculture, forest ecology and protection, recreation, wood procurement, bioenergy, pulp and paper industries, wood working industries, packaging, and forest related machine industries. The forums contain short lectures that act as impulses for a number of group discussions, group work and joint strategy discussions. The speakers of the forums include e.g. cabinet ministers, administrators, leading scientists, interest group leaders, and practitioners. The participants themselves are also an important group of lecturers. In the FFDM, no one is an expert in everything, and every one has something to share. (For further information on the forum, see Hyttinen & Hellström 1997, Hellström 1999, http:www.smy.fi/pma/engl).

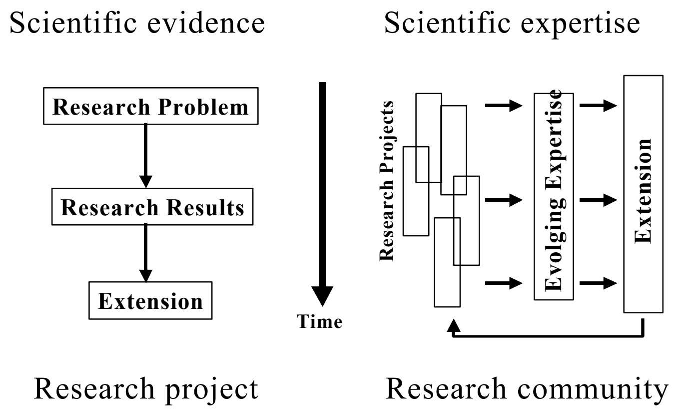
In the typology of forest discussion forums discussed above, FFDM could be classified as a discussion forum aimed at joint and interactive knowledge building (middle in Figure 2). Accordingly, FFDM is not a decision-making body, but a knowledge generation body arranged in active support of decision-making both within and outside the forest sector. If the categorisation of forest policy means is applied, FFDM can be associated with category 4 (information tools) because one of its basic elements is the aspiration to increase the forest and environmental knowledge of decision-makers. However, FFDM is much more. Although FFDM does not aim, say, at decision-making or any activities that are binding to all parties concerned, it underlines the interactive way of communication, problem solving and increased personal commitment to joint ideas. Accordingly, the Forest Forum involves many of the features that characterises negotiation oriented policy means.

The Role of Science

In relation to the science-policy interface, a relevant question is, what is the role of science in FFDM. The role of scientists and the scientific community in FFDM is two-fold. The traditional production-oriented approach to the science-policy interface is presented at the top in Figure 5. In this traditional approach, science is involved in a linear feed-back system with political decision-makers. Top-level scientists present findings of their research results and engage themselves in discussion with decision-makers on the impacts of policy options and further research needs. This approach corresponds to instrumental utilisation of science presented earlier under science and policymaking.

In FFDM, key persons within the scientific community (e.g. science administrators) are also actively involved as participants. Together with other decision-makers they involve themselves in joint processing of information into knowledge and know-how. Accordingly, they are not involved only as experts of their own research field but as participants with broad-based expertise in forest related issues, and with equal status with the other decision-makers of the forum. In FFDM, the generation of knowledge and know-how is essentially based on personal interaction. An important feature of FFDM is that scientists and policymakers interact at an individual level. Moreover, such personal interaction takes place between scientists and policymakers representing very different types of disciplines and interests. This multitude of aspects is the core of generating new, integrated knowledge. This approach is particularly applicable in dealing with issues where uncertainties related to scientific information tend to deepen the science-policy gap (see Bradshaw & Borchers 1999), and where there is need to combine information of various types in order to raise the level of understanding (e.g. scanning the decision-making situation and alternative future developments, facilitated problem solving). This approach is very close to conceptual utilisation of science, as presented earlier under science and policy making.

Figure 5. The roles of science in the FFDM.



Outcomes

By the beginning of the new Millennium, FFDM has been active for over three years, during which a total of eight individual forums have been arranged. They have been participated by a total of 205 top-level decision-makers throughout the Finnish society. This gives a good basis for evaluating its results.

Although it is, of course, difficult to point out that a certain decision in forest or other policy has been induced by FFDM, the forest sector has been convinced that the substantial results (e.g. new trends in decisions taken outside the forest sector, and increased interest and receptiveness to forest-related information) have been worthy of the input.

This is illustrated in the numerous official and unofficial recognition received from the Finnish forest sector (e.g. "Forest Action of the Year" prize by the Finnish Association of Professional Foresters). However, rather than promoting individual substantial issues of interest to the forest sector, the main substantial output of FFDM has been increased integration of the views of the forest sector and joint strategies that are better aligned with overall social development. This has been made possible through mutual learning and joint interactive processing of information into knowledge and know-how. The individual forums of FFDM form a continuum where knowledge processed in one session forms the basis for knowledge-building in the following session. Thus, FFDM has within a short period of time become a respected independent "knowledge generator" in Finnish forest policy. This is also reflected in the active involvement of FFDM in dialogue relating to the Finnish National Forest Programme, as well as co-operation during its preparation in 1998 and later implementation.

In aiming at "opening up", FFDM has been an effective means of public relations, too. Among decision-makers outside the forest sector, FFDM has succeeded to increase both knowledge and interest in forest issues – factors which are necessary for making good decisions. In particular, the participants have acknowledged the openness of communication and the way in which forest issues have been dealt with from a variety of angles, leaving the conclusions to the participants to make. This type of opening up has created increased trust and credibility of the forest sector, and reduced conflict potential among participants representing very different types of interests. The improved overall image of the forest sector helps open up new opportunities for increased involvement and integration of the forest sector in society. Moreover, the network of personal contacts created at FFDM has opened up channels for traditional ways of influence for all people and organisations involved. This also means increased influence in issues of interest to the forest sector. In relation to the science-policy interface, FFDM has succeeded in activating scientists to reach out to policymakers for communication about research needs and findings.

Although both elements of strategic goals – public relations and substantial issues – are of importance *per se*, they are very much interrelated. One would not work without the other. This is one important background for the success of the Forum.

Discussion

The example of the Forest Forum for Decision-Makers in Finland (FFDM) represents a rather untypical form of discussion forums. By actively focusing on knowledge generation, it offers more support for policy decisions than typical seminars. Yet, it lacks the decision-making power which is typical to negotiation forums, or the issue-specificity which is typical of working groups. Owing to its special role in comprehensive knowledge building, it offers an effective arena for strengthening the science-policy interface in a way that does not compromise the integrity or credibility of the science community. Moreover, FFDM illustrates one possible way to address the challenges related to participatory policymaking, communication with other sectors of society, and decision-making under information overpopulation.

Considering the success of FFDM, is there any reason why – with slight modifications - the concept would not work in other conditions, even internationally? Plans to establish similar types of new, knowledge building forums at the national level are already being made in a few European countries. In 1999, the FAO/ECE Team of Public Relations Specialists in the Forest and Forest Industries Sector launched the idea of establishing a new type of discussion forum at the Pan-European level, the European Forums for Forest and Society. Strategically, it would largely follow the logic of the Forest Forum for Decision-Makers in Finland, but with some practical modifications in implementation (http://www.unece.org/trade/timber/pr/effs).

In the global forest policy sphere, it is also evident for the need to reach out from the forestry community towards other parts of society, and strengthening the science-policy interface. Reaching out in an open manner is only possible as a joint effort of the international forest community. The scientific community can play an important role in identifying such needs and promoting action.

This paper only scratches the surface in trying to understand the role of discussion forums as modern forest policy means though the examination of a specific example. Even this example illustrates the difficulties involved with trying to understand modern discussion forums in the framework of traditional forest policy means. Rather than providing scientific analysis, this paper raises abundant questions. One of the most important questions for the future is the potentials of this type of forums in the prevention and management of conflicts within major policy processes. Considering the growing amount and importance of discussion forums in forestry, there is urgent need to address the role and effectiveness of forest discussion forums as policy means, through the use of formal means of policy analysis.

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Cultural Diversity in Forest Management:

Networking and International Cooperation

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Priority Themes In Tropical America For Agricultural/Forestry Development: Importance Of Networking

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Abstract

The main potential advantages of networking, for agricultural, agroforestry and forestry development in Tropical Latin America, are: 1) synergy and complementarity among national research institutions; 2) improvement of the bargaining position of producers; 3) support for biotechnology development; 4) protection of germplasm and intellectual property rights; 5) upgrading postgraduate education; 6) recognition of institutional capabilities; and 7) exchanging and managing information.

The main limitations to networking in the region are: 1) weak national information transfer structures; 2) slow development/adoption of electronic media, 3) inappropriate choice of network activities; 4) low network sustainability due to weak commitments from members; 5) inflexibility of networks; 6) dispersal of participants (larger countries); and 7) insufficient donor coordination. Eight research/development priorities are suggested for the region: 1) accelerated recovery of degraded pastures (e.g., using agroforestry and forestry technologies); 2) policy issues, regulations and practices that affect land use (e.g., impact of reforestation incentives); 3) increased quality of products (e.g., "organic" markets/"green" labelling and certification criteria); 4) development and massification of biotechnology and biocontrol techniques (e.g., coffee or cocoa shade systems); 5) demand and quality requirements (i.e., market intelligence and prospection) along with the development, valuation and marketing of new products, goods or services (e.g., certified tradeable offsets [CTO´s], water, recreation); 6) diversified sustainable use of natural resources in flexible production systems that can adapt to changing market prices and other demands (e.g., timber-coffee combinations, annual crops and fruit trees); 7) silviculture of secondary forests (bio-physical and socio-economic analyses); and 8) protection of improved and natural germplasm, and intellectual property rights.

Keywords: Agroforestry, Extension, Information transfer, Institutional development, Planning

Introduction

There has been a gradual shift in the priorities of the national and regional organizations involved in agricultural, agroforestry and forestry research in Tropical America towards specialized areas such as: genetic exploration and improvement; bio-technology; integrated pest control; and in the case of some institutions, such as CATIE, to a systems rather than a commodity focus (i.e., farming systems). Forestry research has increased slowly over the past 25 years, but research and development projects focusing on the tree component of natural and managed ecosystems have become much more common (Box 1).

The breadth of topics has widened, taking into account issues of current interest in the region, such as the use of geographical information system (GIS), biodiversity prospection, conservation, sequestering Carbon, gender analysis, as well as the traditional emphasis given to productivity and socio-economic analyses. As the degree of specialization of individuals and organizations increases, there is an increased need for horizontal collaboration (e.g., networking) to resolve complex land use problems.

There has been also a gradual change in the nature of international collaboration over the last three decades, from large regional "donor-driven projects", which carried out all of their activities with their own resources (very little counterpart contribution), to small multiple-funded projects, that depend on local/national collaboration, including financial and human resources from all the participating institutions. In the process, the Latin American countries have gained more power over priority setting, which is now carried out in consultation with target groups and international collaborators rather than as a direct response to each funding opportunity. Simultaneously, the main approach to agricultural, agroforestry and forestry development problems has changed from an on-station, bio-physical emphasis to on-farm, participatory research in which socio-economic aspects are given increasing priority (Prins et al. 1999). Most agricultural, agroforestry and forestry research is now carried out by graduate students and national collaborators, sometimes advised by international staff. At the same time, international donors have become more focused on promoting institutional development (e.g., SIDA-Sweden, NORAD-Norway, DANIDA-Denmark, COSUDE-Switzerland and USAID-USA).

Most of this research is now designed to solve specific problems identified nationally and regionally, involving strategic or applied approaches. Within this continuum, applied research is usually carried out by or with national institutions while the international partners, such as the European universities, are more involved in strategic and basic research. It is hoped that this mixture of different levels of collaboration and complementarity will continue in the future, since it allows all partners to participate to varying degrees at all stages in the process of identifying, researching and solving high priority problems in the region. Collaboration at all stages, including different forms of networking, is essential to increase the information flow between the different actors with the goal of increasing the efficient use of ever scarce research resources, and hence the impact of the research community on the priority problems of the region. Nevertheless, although there are many potential advantages from networking, there are also many limitations to increasing cooperation between institutions working in Tropical America.

Advantages of Networking and Global Cooperation in Tropical America:

Compensating for Weak National Research Departments

The small countries of Central America cannot support independent forestry research units and even agriculture research is severely limited by scarce resources. A fundamental change has occurred in their national agricultural and forestry institutes. Services have been privatized (e.g., extension activities given to producers or NGO's) and research departments have been cut back and de-centralized. The clients for agricultural research and development results are increasingly in the private and less in the public sector. Trade barriers are reduced, competition to sell products increased, and quality becomes more and more important. Since many of the bio-physical problems faced by these countries are similar, and even some of the socio-economic limitations, it is clearly beneficial to promote regional research programmes and data bases that can support national technical assistance and training activities.

Improving the Bargaining Position of Producers

The increasing demand for standardized quality products in ever greater quantities, in order to attract buyers/processors, and the need to improve efficiency for both producers and clients, suggests that the forestry or agricultural organizations of a country, and even for a whole region like Central America, will need to increase cooperation and coordination. An example is coffee production and sales. The competing countries are in agreement that the Central American region as a whole must cooperate to produce and market high quality products which are recognized as being produced in an environmentally friendly and sustainable way (IICA/PROMECAFE 1997). Market share in the recently developed "green" labelled timber and "organic" agricultural product segments, where costly certification is required and actual production volumes are very small, will be improved (and costs reduced) by cooperation between organizations who could otherwise be seen as competitors.

Biotechnology Development.

In addition to medicine, biotechnology is revolutionizing agriculture, agroforestry and forestry throughout the world. The ability to compete in future markets, especially where quality requirements are strict, will partially depend on adopting these modern technologies, but costs are high and requirements for professional staff exacting. Once again, networking/cooperation between countries in Tropical Latin America will be needed to be able to access these costly new technologies. An example is the joint programme of CIRAD (France), the national coffee institutes in eight countries, and CATIE, which is aimed at reproducing improved coffee germplasm. However, in many cases, these technologies are better developed by the private sector, particularly large corporations, where horizontal cooperation is more difficult because of the proprietary nature of the discoveries.

Protection of Germplasm and Intellectual Property Rights

As one of the foundation stones for sustainable research and development programmes, regional and national research organizations need to ensure mass adoption and commercial return from their products. The issues involved in protecting improved or natural germplasm and intellectual property rights are complex and require world wide cooperation to develop and implement a common strategy. IUFRO could play a valuable role here, leading the dialogue and accords taken in this strategic matter

Upgrading Postgraduate Education.

The increasing demand for specialists within the general fields of agriculture and forestry has provoked many Latin American universities to offer higher level degrees. However, the quality of such advanced degree programmes depends on the availability of highly specialized Professors, sophisticated laboratory equipment, research funding and well equipped/funded experimental stations, as well as access to real life conditions; e.g., on-farm research. When the quality of the education is world-class, costs per student are high. Cooperation, not only between Latin American institutes, but also with Universities in Europe and North America, is required to develop joint degree programmes which will offer comparative advantages over existing degrees, not only to Latin American students but also to students from temperate countries who wish to specialize in tropical subjects. Access to funding and to existing networks of Institutes in developed countries (e.g., NATURA in Europe) is an attractive option for advanced Latin American degree programmes because it is too expensive for any one Latin American or European University to offer all of the specialized courses which one or more students may require.

Recognition of Institutional Capabilities

As a result of access, language and historical priorities, Latin America is still the "New World" for most scientists (and some institutions!) in other continents. For example, despite increased attention to divulgation of its programmes and results, CATIE is still an unknown institution to many European decision makers. On the one side, CATIE has seen many bilateral funding/resource opportunities limited because it has been perceived as an "International Institute", while on the other, it has not been considered when the distribution of international research funds is discussed! In order to apply for EU or bilateral funds, CATIE often has had *to work through* a European lead institute. On one occasion, CATIE was advised that it could not be accepted as the coordinator of a European Union INCO research project; however, a later proposal, modified to comply with this requirement, was rejected because "It is not clear why CATIE needs the European lead institute to carry out the proposed plan of work"! Networking helps an institute like CATIE to become recognized and helps to resolve these contradictory instructions/perceptions about its status for regional and bilateral cooperation and support.

Box 1. Principal Agroforestry Systems in Latin America [@]

Agro-silvicultural systems (trees with crops)

- *Trees in perennial crop plantations such as coffee or cocoa* (Beer et al. 1998, Muschler 1999). Includes timber trees, multiple-purpose trees and service trees (N fixation, shade management, mulch producers). Service trees are managed only for the benefit of the crop; i.e., they produce no or only low value products (e.g., *Erythrina* spp. in coffee or cacao).
- ***Taungya*** (Schlönvoigt 1998). Crop planting in tree plantations during the establishment phase of the trees.
- ***Slash and burn*** ("Barbechos"). Traditional agricultural system using natural plant regeneration to recover soil fertility and control weeds (Nye and Greenland 1960).
- ***Line planting around crop fields*** (Méndez et al. 1998). Includes living fence posts, hedges, boundary line tree planting (often timber species) and windbreaks.

Silvo-pastoral systems (trees with pastures and/or animals only) (Pezo and Ibrahim 1999).

- ***Grazing in secondary forests and plantations.*** More common in recently regenerated/planted forests.
- ***Fodder trees/shrubs.*** A traditional but underutilized practice, with especially high potential for seasonally dry areas.
- ***Line planting around pastures*** (see above for details).

Agro-silvo-pastoral systems.

- ***Homegardens*** (Lok 1998). Very complex multi-strata mixtures of trees, shrubs, vines, perennial and annual crops, that usually include small animals, especially chickens and pigs. Home gardens generate a wide range of products for family use or sale.
- ***Grazing in agro-silvicultural systems*** (Pezo and Ibrahim 1999). Very common during the dry season, after crop harvest, to utilize crop residues (stubble) as well as the only green fodder available (tree foliage).

@For a general reference to the range of agroforestry systems, including those named above, see Nair (1989).

Improved diffusion of information about the particular interests of individuals and research groups, and a small amount of seed funding, would facilitate student/professor interchanges leading to new collaboration and hopefully, in the medium-long term, new joint research projects. This could provide the foundation for a successful application to some collaborative research programmes such as INCO of the EU. Distance, time and financial constraints severely limit the ability of Latin American institutes to follow-up promising initiatives and obtain opportune, precise information from donors, which often requires personal contact. They need partners who will represent them and defend an equitable share of resources for all collaborators, and hence contribute to establishing sustainable research programmes in Latin America (for the benefit of all concerned).

Exchange and Dissemination of Information and Results

Latin American research and development institutes need feed-back from all of their clients and collaborators as an essential input to dynamic planning and institutional development. The environmental and economical context within which they operate is changing rapidly and they need a close and constant interaction with international organizations in order to be able to take into account political/scientific trends and developments that will influence their programmes. They can also make a reciprocal contribution to non-Latin American organizations, by presenting the priorities and developments in the region (e.g., at this symposium) as well as the results, technologies and methods (including scientific) they have developed.

Limitations to Networking and Global Cooperation in Tropical America:

Weak Information Transfer Structures

Most Latin American countries do not have a clearly defined political structure to support and promote the transfer of research and development results and other extension activities. National extension services, if they exist, are poorly structured and seriously limited by a lack of operational resources. Transfer of information to groups outside of the research community, ranging from farmers to politicians, also has been limited because the format, language and content of most dissemination materials were choosen by the authors and not by the target group. There is a clear need for researchers to collaborate more closely with NGO and other organizations dedicated to technical assistance and training to ensure the use of the information they generate and that they are focusing on the priority topics of their target groups. In many cases, continued funding for research activities will depend on demonstrating compliance with these aspects.

Two examples of how CATIE has adapted to satisfy these requirements are: 1) the integration of its research, postgraduate and outreach programmes, with staff having principal responsabilities in one programme but being required to participate in all three; and 2) the formation and support of commodity, theme or system networks (e.g., coffee, educational and agroforestry networks) in the Central American countries that, amongst other activities, hold annual planning meetings to agree on their research, technical assistance and training priorities and mechanisms. The activities of these networks has brought the researchers and their clients into closer contact with benefits for all involved. However, additional specific projects are needed to synthesize research results, and to develop and test dissemination materials and other methods of divulgation to ensure appropriate packaging of forestry, agroforestry and agricultural information in a form which target groups can assimilate. There is also the need to promote contact between the different professional groups involved in agricultural, agroforestry and forestry research and development. IUFRO, the biggest forestry research network in the world, makes major contributions in this respect, especially during its international meetings where joint or parallel sessions of different groups are encouraged. Another example is NATURA, which promotes horizontal cooperation of the principal agricultural research institutions in Europe. However, full membership of NATURA is only available to European institutions and not to the “associated” members from tropical countries such as CATIE.

Slow Adoption of Electronic Media

In Tropical America, access and familiarity of agricultural, agroforestry and forestry extension-technical staff with electronic media is still very limited. For example, an internal evaluation of the use of a diskette containing an annotated bibliography of all of CATIE´s agroforestry publications (1950-1996), that was distributed principally to the members of agroforestry networks in Central America, concluded that, even when access to a computer was not a limitation, very few of the recipients ever consulted this data base. Another concern is that these same national staff rarely publish their valuable experiences with agroforestry technologies, hampering dissemination and massification of the best results.

Following the example of many international and national organizations (e.g., CORPOICA 1999), CATIE may produce an extended and improved version of its agroforestry annotated bibliography on CD ROM, but for a different class of clients (e.g., Universities within and outside of the region). The revised agroforestry bibliography has also been printed as a book (CATIE 2000) and distributed, especially to national field staff in order to encourage the application and adaptation of some of the technologies described in the over 700 publications that are included.

In order to promote the use of electronic media, it is not enough that the research/development community produce attractively packaged products (e.g., CD ROM´s) of their results, which may serve the purpose of promotion of the institution but are not effective in transfering information. Priority should be given to equipping/training national staff in the use of these media; e.g., producing self-training forestry and/or agricultural modules where the need for and the benefits of using electronic media are more obvious, and hence recipients will be motivated to learn and become accustomed to the new media.

If well managed, Web pages can be a very important source of information, a medium to market services and products, and a powerful tool to position an institution in the ever more competitive international environment. However, Web pages can create a negative impression if not constantly updated and if there isn´t a rapid reply to the enquiries they generate. It is recommended to keep Web pages simple and always assign responsability to a person to carry out permanent monitoring/updates from the moment of their establishment.

Inappropriate Choice of Network Activities

It´s important to carry out internal reviews with network members to identify the activities where the programme/network has been most useful for them. For example, for training and information transfer, the Central American agroforestry networks promoted by CATIE have been effective mechanisms but they have not been successful to date as a means to promote certain research topics or the adoption of standardized research methodologies. An additional mechanism, run with the networks and which offers some seed money conditional upon acceptance of standarized methodologies, is however showing promise.

Low Network Sustainability

The sustainability of national networks depends upon having one or more national institutions providing medium-long term support to one or more persons who have a genuine interest in the continuation of the network. There also needs to be some minimal independent resources available to support the logistics of the network. Some of the most successful examples of research networks have been the series of international provenance trials organized by the Oxford Forestry Institute (Box 2).

Inflexibility of Networks

If they are to be sustained, network programmes have to be flexible to allow for changing priorities of the members; e.g., there should be flexibility when deciding what kinds of annual meetings, which range from planning workshops, courses or symposia, can be supported. Conformity of national networks to a standard model to provide a basis for a regional/international network is not necessarily a desirable goal. Indeed the interest of an international organization to achieve its predetermined goals *via* networks may bias activities away from national priorities. On the other hand, it is important to avoid that one member directs activities of a national network to serve his/her particular interests only.

Costs and Dispersal of Participants

Face-to-face meetings are necessary to sustain networks because electronic media are poorly developed and little used by network members (see above). At least one General Assembly per year, involving all network participants, is recommended for reporting, planning and exchanging information. In some cases, a national network is facilitated by proximity of members and their institutions, and relatively easy logistics; e.g., El Salvador. In other cases, it may be desirable to form regional networks within a country (e.g., North coast of Honduras;Petén of Guatemala) because of cost and time limitations to attending events in a central location such as the capital city. Obviously this is an even greater limitation in the larger countries of South America.

Box 2. Oxford Forestry Institute provenance trials: examples of successful research networks

The Oxford Forestry Institute´s international provenance trials (e.g., *Pinus caribaea, Gliricidia sepium, Leucaena* spp.; *Calliandra* spp.) (Pottinger 1992) are examples of successful forestry research networks that involved many collaborators in diferent countries, who collected information on their own particular trials and additionally made this available to a central coordinating group. These networks succeeded because they offered rewards to all involved: e.g., 1) quality certified seed from many provenances of one or more forestry species (each country or collaborator had the opportunity to identify the best provenance for their own situation); 2) research support (e.g., short courses and statistical support was provided and sometimes analyses were run free of charge for collaborators); 3) standard designs and evaluation methodologies, which were carefully prepared and clearly explained; 4) recognition of all contributions was provided and in many cases collaborators were encouraged/helped to publish scientific articles; and 5) technical assistance was provided in collaborating countries *via* visits of coordinating scientists and on request (e.g., *via* e-mail). It is noteworthy that individual trials were supported by local resources in almost every case; i.e., the network did not offer financial support. In reality, many networks were established, one for each set of provenance trials, and the networks ceased to exist once the experimental programme (or project) terminated. These networks were carefully designed, planned and monitored for specific clearly defined and agreed purposes. Another key element of this success story was the selection of strong, stable, reliable national partners.

Insufficient Donor Coordination.

Despite the emphasis given by many donors to networking and efficiency, networking and coordination between donors, for the management of international research and development programmes, needs improvement; e.g., review/evaluation missions are rarely combined (ASDI-DANIDA-NORAD are a notable exception in the case of CATIE). The cyclical support of donors for research is an example showing that most donors follow the current trend rather than agreeing on a division of support for all the steps involved in the Generation and Transfer of new technologies. Again, some notable attempts have been made by the Nordic countries to improve this situation. In CATIE, attempts to establish a single system to coordinate monitoring, evaluation and financial reporting, of all European donors, have been unsuccessful. This happens because the donor organizations also have limited resources available for coordination activities and they are subject to inflexible and slowly responding government frameworks.

Future Agricultural, Agroforestry and Forestry Research Priorities in Tropical America

In addition to the three priority topics of product quality, use of biotechnology, and protection of germplasm and intellectual property rights, which have been discussed above, five other priority themes for agricultural, agroforestry and forestry development in Latin America have been identified by CATIE staff and collaborators (Box 3).

Accelerated Recovery of Degraded Land

One of the most serious land use problems in Tropical America, and possibly the most obvious, is the conversion of forests to pastures on inappropriate sites and inadequate pasture management, leading to low productivity and unnecessary damage to nature resources, especially water and soil. Although the problem is widely recognized (Kaimovitz 1996) hard statistics on the extent, kind and degree of the damage are needed. Some potential solutions are known (e.g., establishment of improved pasture systems and/or silvo-pastoral systems [Bouman et al. 1999, Pezo et al. 1999] but their application is limited, apparently because of socio-economic limitations (see next section). In order to remedy the problem, pilot scale participative research with rural communities, that is flexible enough to focus on limiting factors, be they bio-physical or socio-economic, is recommended. Basic research on, for example, soil processes, or further on-station applied research on, for example, management regimes for fodder trees, should not be the priority.

Box 3. Priority themes in Tropical America for agricultural, agroforestry and forestry development*

1. Accelerated recovery of degraded land, in particular of the degraded pastures that occupy large areas of land previously under forest cover, using agroforestry and forestry systems.

2. Policy issues, regulations and traditions that negatively affect land use (technical solutions exist for many of the problems but are often not applied).

3. Increased quality of products produced with less or even no agrochemical inputs; e.g., develop "organic" technologies, markets, "green" labelling and certification criteria.

4. Development and massification of biotechnology and biocontrol techniques for tropical crops and timber trees.

5. Improved links to markets, which are increasingly international, and immediate access to information on actual and predicted prices, demand and quality requirements (market intelligence), including the development, valuation and marketing of new products, goods or services: e.g., Carbon credits; market niches, such as tropical fruits; water; eco-tourism; bio-diversity; and reduced off-site contamination.

6. Diversified sustainable use of natural resources in flexible production systems that can adapt to changing demands: e.g., improved silviculture of timber trees as shade in coffee plantations as an alternative to high input unshaded coffee monocultures.

7. Silviculture of secondary forests (bio-physical, socio-economic and ecological analyses).

8. Protection of improved and natural germplasm, and intellectual property rights, by patents or other means.

*Adapted from Beer and Guevara (1998)

Socio-political Limitations

Whilst it is obvious that market opportunities can have a strong positive or negative effect on land use, there are many other framework conditions that affect the application of known improved technologies. Laws regulations and Government incentives have stimulated conversion of forests to pastures (Kaimovitz 1996) and *vice-versa* (Giovanni 1999). Poor and sometimes corrupt application of regulations can influence farmer's perceptions, and hence acceptance of new technologies, for many years after that limitation has disappeared (personal observations). On the other hand, cultural perceptions can be changed when conditions are favourable; e.g., the rapid adoption by Ngöbe indigenous people of Panama of a timber tree planting technology, in abandoned cacao plantations, once they accepted that timber trees are just another crop (Neri et al. 2000). In view of the interdisciplinary nature of research on this and the preceeding topic (degraded lands), the importance of collaboration between individuals and organizations with different expertise is obvious.

Marketing Products and Services.

Markets are becoming increasingly complex, demanding quality, diversity and attention to many factors which were previously ignored in economic calculations. The market for organic agricultural products is expanding rapidly and has recently become an important new opportunity for tropical farmers; e.g., for coffee producers (Boyce et al. 1994). Many tropical fruits offer interesting alternatives (Leakey et al. 1996) but the lack of market development is a major limitation to their promotion. Financial compensation for service functions, such as Carbon credits, water, eco-tourism, bio-diversity and reduced off-site contamination, is beginning to affect land use in some areas (Giovanni 1999) but there are few concrete experiences to date, and even fewer studies of their positive and negative aspects. Hard facts on both the bio-physical, and especially the economic results of promoting tree planting in pure plantations and agroforestry systems, are still inadequate to convince many decision makers to promote wide scale changes in land use.

While there have been huge steps forward in the development and study of sustainable forest management and certification (e.g., criteria for "green" labelling) there are still doubts about the true potential and mark-up premium which can be sustained. Markets are becoming increasingly internationalized and immediate access to information on actual and predicted prices, as well as demand and quality requirements (market intelligence), has become a necessity in order to compete successfully.

Diversified Production Systems

The trend to change traditional diversified land use systems, such as the agroforestry systems found in Latin America (Box 1), to high external input monocultures, has slowed, and even reversed in the case of Latin American coffee culture (IICA/PROMECAFE 1997). As in the case of degraded pasture lands, socio-economic research on these positive developments will provide more dividends than further bio-physical studies that contrast alternative land uses. In addition to the service functions, such as reduced contamination and preservation of biodiversity, which are increasingly recognized and demanded by consumers, these systems can be more flexible and reduce financial risk (Ramirez et al. 2000). An example is the potential of timber tree planting on both small and large private farms, which is now recognized by farmers, scientists and decision markers (Beer et al 2000). Nevertheless, due to limited experience, new participatory on-farm research on the management of these plantations and quantification of all the benefits which they can provide, as well as detailed evaluations of the success of initial attempts to promote such positive changes, are needed to avoid repeating mistakes (Viera et al. 1999).

Silviculture of Secondary Forests

While it is now widely recognized that secondary forests can replace primary forests (at least partially) as a source of wood and non-wood products in Tropical Latin America (TCA et al. 1997), the wide range of conditions and tree species associations require a much greater research effort to develop practical management protocols for each situation and to be able to generalize the lessons learnt. As is the case throughout the examples discussed in this paper, socio-economic research to determine real potentials has lagged behind bio-physical research which has already provided silvicultural recommendations for many forest types (Dawkins and Philip 1998). Also in parallel to the need for research on the impact of laws, regulations and traditions on the actual and potential use of degraded pasture lands, there is an urgent need to evaluate how these framework conditions can promote or hinder adoption of new technologies to manage secondary forests in economically and ecologically sustainable ways.

Conclusions

The rapid changes in the international context within which Latin American forestry, agroforestry and agricultural research must develop, have lead to the need for increased information flow between countries and institutions, and hence have increased the potential importance of networking. Nevertheless many structural and planning weaknesses reduce the effectiveness of networks and, like all tools, they should be constantly modified taking into account the specific limitations in the region: i.e., inadequate information transfer structures; slow adoption of electronic media; inappropriate choice of network activities; low network sustainability and flexibility; cost and distance limitations; and inflexibility of donor institutions. Reduced resources, increasing competition for all institutes (including universities) and the need for rapid responses to both mitigate natural disasters (e.g., flooding in

Central America and Venezuela) and to take advantage of new technologies and market opportunities, are all factors which are forcing Latin American forestry and agricultural organizations, and their overseas partners, to increase cooperation and efficiency. There is also a clear need to truly integrate bio-physical and socio-economic research at different levels (e.g., organism, plantation, farm, eco-region, national, international) if the research and development community wishes to have any impact in terms of improving land use and on the socio-economic situation of rural communities. It is recommended that the Latin American agricultural and forestry research and development community focus on the following eight priority themes: accelerated recovery of degraded land; policy issues; product quality; biotechnology; market intelligence on products and service functions (carbon, water, biodiversity); farm diversification; management of secondary forests; and germplasm/intellectual property rights.

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Operational Networking: An Effective Mechanism To Promote Tropical Forest Management Promising Experiences In Central America

by
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Abstract

The Ongoing processes of deforestation are rapidly diminishing primary tropical forests in Central America. Tropical forest conservation requires that these forests be integrated into the local economies of rural communities and indigenous groups. The achievement of this integration is a complex endeavor involving diverse technical, sociological, cultural, biological, economic and political concerns. To better address the complexities involved, over 75 entities with interests in tropical forest management and conservation have joined together in three operational networks in Honduras and Nicaragua. Network members include public sector entities, NGO, communities and producer groups, universities and technical schools, projects and private companies. Networks collaborate in technical aspects of forest management, in research, in training and higher education, in industry and commerce, in community development, in information dissemination and recently in policy dialogue. This paper discusses progress to date, initiatives to achieve network sustainability, problems and future directions.

Keywords: Tropical forest management, Operational networks.

Introduction

In Central America, primary tropical forests are rapidly being diminished by ongoing processes of deforestation (Current et al. 1995, FAO 1995). The causes of deforestation are diverse: conversion of forest land to agriculture, ineffective control of illegal logging, limited institutional capacity to monitor forest management, problems in the marketing of timber and non-timber products, the lack of tradition in sustainable, tropical forest management, the existence of governmental policies that discourage attempts at forest management, among others. Taken together, these problems limit the long-term integration of tropical forests into the local economies of communities and indigenous groups.

The value of tropical forests (environmental services, source of wood and non-wood products, biodiversity, etc.) is widely appreciated. This appreciation has led to important investments in forest management within community development projects, research initiatives, university programs, and in the formulation of public policies to protect this important resource. Unfortunately, these initiatives are often quite limited in scope and tend to be implemented in an isolated fashion. As a consequence, their influence on forest management and conservation has usually been limited to local, temporary improvements.

In an effort to have a larger, more sustained impact on tropical forest conservation and management, over 75 entities involved in activities related to these forests have joined together since 1997 in three operational networks in Honduras and Nicaragua. This paper discusses the formation of these networks of horizontal cooperation, their expanding role in tropical forest management and initiatives aimed at achieving their sustainability. Problems that reduce the effectiveness of the networks and future directions are also covered.

Formation of Operational Networks in Honduras and Nicaragua

The first experiences in operational networking in Central America took place during the third and final phase (1991-1995) of CATIE's Madeleña Project (madera=wood, leña=fuelwood), an initiative aimed at expanding the incorporation of multiple-use trees into small and medium sized farms in Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica and Panama. Initially, Madeleña was mainly a research project carried out in conjunction with national counterpart institutions in each of the aforementioned countries. After eight years of silvicultural and socioeconomic research, the emphasis was shifted from research to the dissemination of promising research results. This shift was facilitated by the decision to involve other organizations dedicated to forestry extension in the dissemination process including public institutions, nongovernmental organizations and reforestation projects. In this way, the regional Madeleña Network was formed encompassing over thirty entities cooperating in training, extension and research activities (Cannon and Galloway 1995).

The success of the Madeleña Network suggested that a similar approach could be utilized to promote the sustainable management of humid, lowland tropical forests. During the past 20 years CATIE, in collaboration with diverse entities, has generated substantial experience and knowledge on the management of humid, lowland tropical forests. Thus, the decision was made in 1996 to develop an outreach project with Swiss financing to promote tropical forest management in Honduras and Nicaragua. The resultant TRANSFORMA project established as one of its strategies the formation and consolidation of operational networks in each of the regions where the project would be implemented. After several workshops, in which the potential advantages of cooperating within regional networks were discussed, over 40 entities embraced the proposal and formed three operational networks: REMBLAH in Honduras and REMAB-RAAN and REMARIO in northeastern and southeastern Nicaragua respectively (fig. 1). Participating organizations include national forest services and other public sector entities, community and producer groups, universities and technical schools, non government organisation, projects and private companies.

In the 2.5 years since their formation, membership in the three operational networks has increased to over 75 entities. Each member organization designates a representative (and substitute) to participate in network meetings and planning workshops. The term "operational" refers to the fact that member organizations establish shared goals and responsibilities; cooperative activities are carried out and evaluated in a participatory manner. It is precisely this characteristic of the networks that contributes to their effectiveness and viability.

The Role of the Operational Networks

The conservation and management of tropical forest is a complex endeavor involving a wide range of activities of diverse nature. Once initial enthusiasm that led to the founding of the networks had waned, many members felt that cooperative efforts required more direction. In response to this concern, representatives of REMBLAH took the initiative of forming "Working Groups" within the network in order to insure that adequate attention would be given to specific crucial areas. The Working Groups include 1) technical aspects of natural forest management; 2) research and technology transfer; 3) training and higher education; 4) industry and commerce; and 5) community development. REMAB-RAAN and REMARIO in Nicaragua followed suit adding an additional Working Group dedicated to the dissemination of information. In all three networks, each member organization became part of the Working Group(s) that most related to their area(s) of interest and expertise. In this way, the contributions of each member could be channeled more effectively

To provide further direction to network endeavors and to improve the chances for long-term success, each network underwent a preliminary process of strategic planning. Shared long-term visions and prioritized strategic objectives were established for each of the aforementioned Working Groups. Within each strategic objective, prioritized indicators have been proposed to help each network monitor success and advances towards shared long-term visions of the future. Since late 1998, strategic plans have been used as platforms for operational planning. Although the process is only 2.5 years old, some progress has been made, examples of which are now provided (by Working Group).

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Figure 1. Geographical regions in Honduras y Nicaragua that participate in the operational networks REMBLAH, REMAB-RAAN, REMARIO

In Technical Aspects of Forest Management

Network members have collaborated in standardizing inventory procedures and data processing, in improving the structure and content of management plans and in prescribing silvicultural operations. Successful efforts have also been made in disseminating techniques of low-impact harvesting including directional felling and processing of timber. Through the establishment of Operational Management Areas (OMA), pilot communities and industrial operators are participating in achieving a multiplier effect of these efforts.

In Research and Technology Transfer

Organizations in each region are participating in the installation of standardized, permanent plots for monitoring natural regeneration and growth and yield of tropical forests under management. Installation and monitoring costs are shared, as are generated results. This effort, which forms part of CATIE's regional network of long-term research sites, provides an important opportunity for university professors and students to participate in field research in tropical forest management. Undergraduate and graduate thesis research is being carried out in the aforementioned OMA in biophysical and socioeconomic aspects of tropical forest management.

In Training and Higher Education

Over 40 training activities are being carried out each year on diverse topics related to tropical forest management. Costs are shared as are technical concepts leading to a gradual standardization of forest management methodologies among network members.

In a parallel effort in higher education, eight universities from five Central American countries are participating in a shared, systematic production of teaching materials to be used in courses related to tropical forest management. To date, five regional workshops have been carried out yielding teaching manuals on tropical silviculture, inventories and timber harvesting.

In Industry and Commerce

Network members have jointly financed market studies in Honduras and Nicaragua. In addition, support is being provided to participating community and producer groups and private companies in their efforts to achieve certification and eventually improve access to international markets. Where certification has been attained costs of annual audits are shared.

Efforts have also been made to expand markets for wood of non traditional species and to improve local wood processing.

In Community Development

Improving technical aspects of forest management and increasing income from harvested wood do not necessarily enhance community development. Participating communities have solicited and participated in workshops related to community organization, administration and accounting to ensure that increased benefits from forest management contribute to community well-being. A decision was made in 1998 to seek out increased membership of producer groups (including indigenous communities) and private companies in each operational network; an initiative that has been successful. Network success will largely hinge on a gradual increase in the successful participation of rural communities in forest management and conservation activities.

In Information Dissemination

Documentation centers have been established in each region to provide a place to deposit and access information related to tropical forestry development. Network members are encouraged to contribute “gray literature” to these centers, since this invaluable source of information is frequently lost when projects terminate or when officials change in public institutions. REMARIO publishes a periodic bulletin to inform the public about ongoing activities and future plans.

In Policy Dialogue

As REMBLAH, REMAB-RAAN and REMARIO gain credibility through successful cooperation, opportunities increase for participation in policy dialogue and in influencing laws and regulations. REMAB-RAAN and REMARIO have been instrumental in organizing large, regional forum on the conservation and management of tropical forests. A representation of REMBLAH has participated in an ongoing national dialogue in Honduras on problems threatening the future of broadleaf tropical forests and on opportunities to improve their conservation and management. A recent decision was made to designate REMBLAH as the technical arm of the Honduran National Forestry Agenda in aspects related to tropical broadleaf forests. In the Rio San Juan region, REMARIO has taken a similar advisory role to the Regional Sustainable Development Council. Finally, REMAB-RAAN provides consultation services to the regional government and to public institutions in the RAAN.

Initiatives to Achieve Sustainability of the Networks

CATIE’s TRANSFORMA project initially financed a large proportion of the costs incurred during network meetings. Increasingly, these costs are being distributed among network members. Nonetheless, there exists a general consensus that the networks should not be wholly dependent on contributions from projects and other network members. Efforts are being made to establish the legal status of the networks and to develop proposals to finance their day to day operations. The idea is not to create another local NGO that competes for limited financial resources, but to provide adequate funds for network meetings and planning workshops, for participation in policy dialogue, for internal communication and for dissemination of experiences. Funds may be sought to remunerate the post of coordinator in each network; at present this position is voluntary.

Problems that Reduce the Effectiveness of the Networks

A few of the problems reducing the effectiveness of the networks are briefly discussed in this section. Although some are beyond the control of the networks, it is important to mention them here.

In both Honduras and Nicaragua, the forest services have passed through a period of crisis and restructuring in the last year or two. Field presence has been greatly reduced diminishing the follow-up of management plans and leading to an almost total lack of control of illegal logging. Communities that make attempts to manage forests responsibly are required to invest in management plans, acquire permits and pay national and municipal taxes. Illegal loggers face none of these bureaucratic hurdles or costs. What’s more, they often flood local markets with illegal timber at reduced prices, making it impossible for responsible communities to compete. In policy dialogue, illegality is one of the key issues the networks currently address.

A second problem relates to the persons delegated by participating organizations to take part in network activities. At times, the delegates lack authority to make decisions and/or commit resources. This problem has, at times, led to planning difficulties and the perception that member organizations fail to take seriously their participation in cooperative activities. As the networks gain credibility, this problem has tended to wane.

The regions where the networks operate tend to be isolated from the major spheres of political influence concentrated in Tegucigalpa and Managua. As a consequence, the networks have not always taken part in policy debates relating to lowland humid tropical forests. Again, as networks gain credibility, their participation in policy dialogue is increasingly sought out.

The policy of the networks has been to allow membership to any entity interested in tropical forest management and conservation. At times, this policy has resulted in the presence of environmentally oriented NGO and wood harvesting companies at the same table. In most cases, the networks have served to help resolve conflicts of interest and have provided a forum to discuss steps taken to mitigate impacts of logging through the application of responsible harvesting techniques.

Finally, Hurricane Mitch dealt a huge setback to tropical forest management in northern Honduras. Downed timber flooded local markets, bridges and roads were destroyed and crops had to be replaced. Network members did collaborate to aid communities during the emergency and in the reconstruction phase.

Future Directions

In both Honduras and Nicaragua, there is a move towards decentralization of functions traditionally carried out by national institutions. In this light, municipalities are expected to play an increasing role in the conservation and management of natural resources. Unfortunately, most municipalities have little or no technical capacity and lack resources (human and financial) to sustain field presence. Increased participation of municipalities will be sought out in the coming years to bring networks' technical capabilities to bear on shared objectives.

The incorporation of a growing number of producer groups (representing communities and indigenous groups) and private companies into the networks is a trend that will continue. Network members recognize that forest conservation and management requires that the activity be viable from economic, social, cultural and biological perspectives. Thus, network efforts to improve the markets for forest products will be strengthened through cooperative efforts of participating organizations. Increasing attention will also be given to the social and cultural dimensions of sustainable forest management. Network members will collaborate with participating communities to enhance community organization and to improve administrative and accounting skills. Long-term success will require attention to improved agricultural practices as well, especially when crop production is carried out on steep slopes (i.e. northern mountains of Honduras). Each of these future directions were identified as priorities in the strategic planning process. Since 1999, activities in these areas have been included in operational plans and have been and are being implemented.

Finally, it is not realistic to expect that all network members collaborate together to the same degree in all activities. Some organizations and projects share substantial overlap in objectives and operational strategies and are encouraged to cooperate bilaterally when possible. To provide more structure and formality to cooperative ties, organizations and projects have begun forming "strategic alliances" through the cosigning of "letters of understanding". These non binding documents outline areas of cooperation, indicate individual and shared responsibilities and specify resources each entity will contribute. Since these letters are signed by the director or coordinator of each organization, they insure that good intentions are included in annual operating plans.

Final Comments

The consolidation of the operational networks discussed in this paper is an ongoing process. The importance of the process becomes clear in the following table which contrasts the situation prior to network formation with the present one.

As has been pointed out, results to date are promising. Without doubt, the major impetus for continued participation in the networks will be tangible, shared success and gradual progress towards strategic objectives.

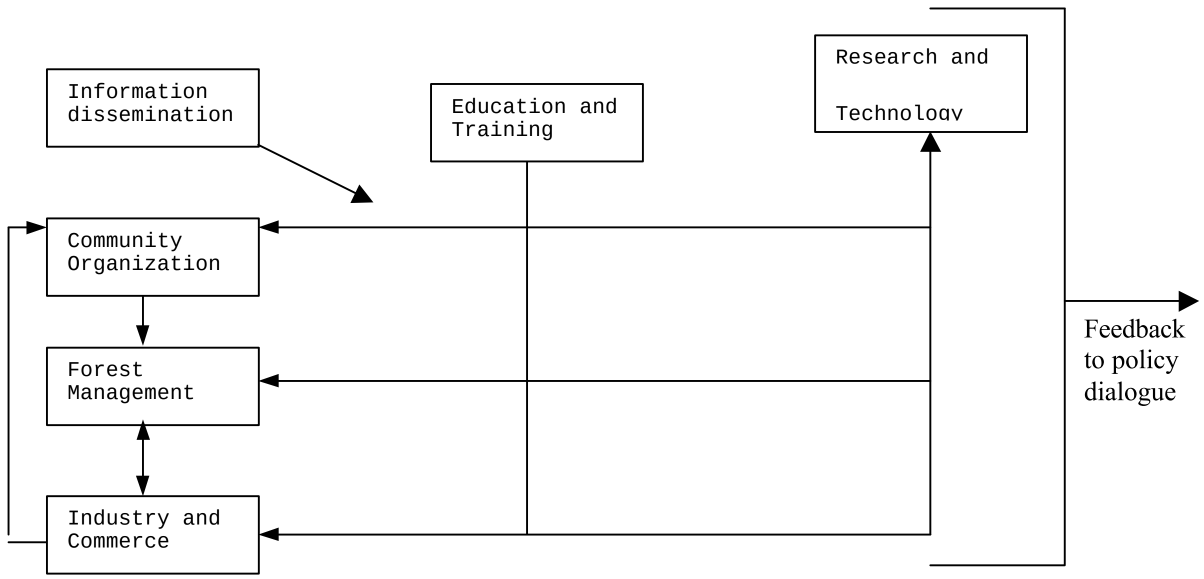
The formation of working groups within each network has enhanced understanding of the multiple dimensions of tropical forest conservation and management (fig. 2). Community organization is required to successfully carry out planning and operational activities and to put to good use generated income. The strengthening of community organization depends, in part, on access to favorable markets and fair prices. Interest in products from tropical forests hinges on the production of reliable volumes of timber of acceptable quality. Determination of allowable annual cut, minimum diameter for harvesting, the need for silvicultural treatments, etc. requires good information from inventories and permanent research plots.

Every aspect of this multifaceted endeavor can only improve over time through the implementation of appropriate training and technical assistance programs. Mid level technicians and professionals are key players in the process, which emphasizes the need for strengthened educational programs. Finally, a favorable political and legal environment is essential to encourage a growing participation in tropical forest conservation and management. Thus, regional efforts must provide feedback to policy makers so that regulations actually favor and not discourage forest development initiatives.

Situation prior to network formation[1]	Current situation
Isolated efforts to promote tropical forest management and conservation	Existence of regional networks that promote cooperation and sharing of experiences
Lack of long-term vision and objectives related to natural forest conservation and management	Public sector institutions, NGO, producer groups, universities and private companies cooperating in strategic planning
Disparate efforts to improve forest management	Cooperative training in all technical aspects of forest management favoring the application of uniform criteria
Weak local technical capacity	Strengthened local technical capacity – formation of trainers for planning and operational aspects of forest management
Little to no local research	Shared local research agenda, cooperative efforts in the establishment and monitoring of permanent plots, undergraduate and graduate research
Few opportunities for communities and companies involved in forest management to access technical assistance	Opportunities to request assistance from network members and/or become part of the local network
Weak links between universities and field activities	Growing participation of university students and professors in training and outreach activities in operational management areas
No entity to represent regional interests in policy debates	Growing participation of networks in policy dialogue

[1] In some aspects, this table is a generalization. Important advances had been made by the PDBL project (ACDI/COHDEFOR) in promoting tropical broadleaf forest management in the mountainous region of northern Honduras prior to the formation of REMBLAH.

Figure 2. Interrelations among "Working Groups" within operational networks in Honduras and Nicaragua. Shared experiences generate important feedback to policy dialogue.



The conservation and sustainable management of lowland humid tropical forests will require a large concerted effort of numerous, diverse organizations. The flow and exchange of information among these diverse entities is essential if progress is to made. Just as the internet requires physical networks for its functioning, the operational networks described in this paper provide the framework for information sharing to enhance success in tropical forest management initiatives. Added to this important function, members in the operational networks jointly implement training, research and operational activities contributing to a shared vision of the complexities involved in attaining the sustainable management of these vitally important ecosystems.

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Global Expertise for Solving Local Problems – Web-based Distance Learning Technology in the Transference of Know-how and the Construction of Expert Networks

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Abstract

Recent information technology has opened up fascinating new visions for global networking, cooperation, and exploiting expert services and education through the use of the Internet. Web-based learning environments and distance learning offer one of the most promising areas for taking advantage of the new technology. As the new technology shifts from pilot projects to every-day use it is likely to cause remarkable structural changes in the education markets, changes which will lead toward new expertise and globalization.

Keywords : Expert Networks, Distance learning, Website

New Internet Technology Points Toward the Virtual School

The idea of the ”Virtual School” is not a new one. The challenge of creating net-based environments for efficient and on-time delivery of study materials, communications, personal feedback and cooperation between students and teachers has puzzled thousands of pedagogics and programmers since the 1980s. Crucial technological steps were taken in the late 1990s when the new programming tools permitted the development of pure browser-based applications. These innovative applications can be used on a standard Internet browser without the necessity of extra installations on students' or teachers' PC. The learning environment (database and user interface) can simply be placed in a given URL on a university's or service providers' server and the users' rights to use the learning environment are controlled by means of usernames and passwords.

Over the same period, the number of Internet connections has exploded, and in developed countries most university students now have access to the Internet. The costs involved in using the Internet have declined, while the quality of the various connections has improved. Most of the net-based distance learning is arranged in an asynchronous environment, but some of the learning environments also support synchronous (online) interaction: chat, shared documents, blackboard, video meetings and video lectures, etc. (Fig. 1). Although it is possible to arrange pure distance learning courses, the new methods are in most cases used in combination with traditional face-to-face teaching. (Pulkkinen & Peltonen 1998).

Tools for Better Education

The freedom to choose the time and place for teaching and learning is a basic advantage in the use of distance learning. This kind of freedom is useful in all education, but it can be especially valuable in further education and in training busy working people with their tight schedules. Distance learning can offer individual and flexible learning experiences and thereby improve motivation, especially amongst adult students. (Linder 1999).

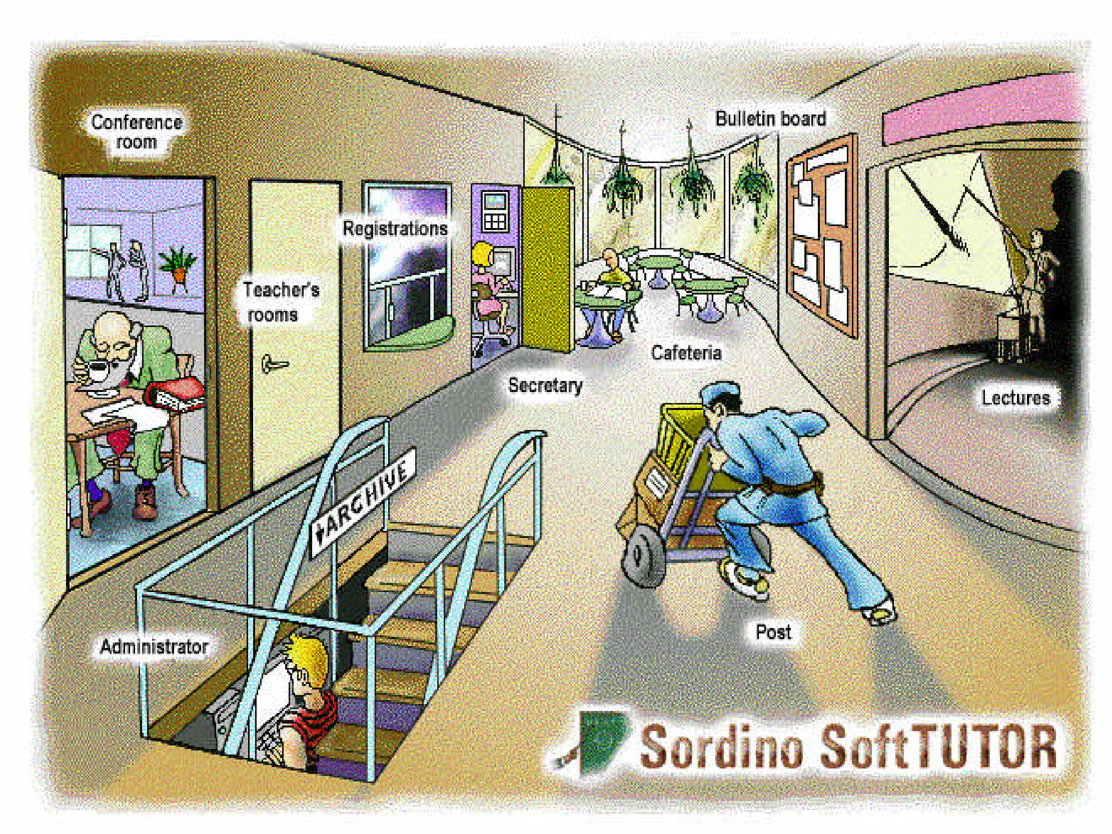
Moving information from place to place is much easier, faster and less expensive than moving people. For example, for a course using video or face-to-face lectures the teaching can include preliminary tasks and exercises through which the students can prepare questions intended for the lecturer. The virtual learning environment is efficient in spreading material, tutoring, giving feedback and evaluating assignments. For many people it is easier to express themselves in writing than by speaking in a crowded classroom - for people like this, distance learning can provide better facilities for communication both with their fellow-students and with their teachers or moderators, and thus can lead to improved learning results. Hence, a net-based learning environment can also provide the tools necessary for improving the quality of learning (In 1999).

From an expert's point of view, net-based distance learning offers new opportunities for marketing one's expertise as a form of educational service. Well-planned and -produced study modules at a moderate cost will be received with delight by many educational organisations whose own resources for both teaching and preparing materials are restricted. Flexibility in the use that can be made of the material can provide an expert with the means to prepare good, up-to-date materials, and the use of distance learning makes it possible to offer services over a wider geographical area and involving a moderate amount of time actually spent in teaching.
[Fig. 1]

A Networked World

Developments in North America indicate that the expansion of Internet and distance learning is rapidly changing markets and placing familiar educational organisations in a new position. Some private universities in the USA have started offering well-produced educational services and curricula that make use of totally net-based learning. Thus, it can now be assumed that in some areas where the contents of education can be standardized they will soon be competing globally (Wagner 1999).

Figure 1. The user-interface of a virtual school often makes use of the metaphora of a real school



Another sign of change is in the globalization of the forest industries. As the companies become larger and spread from their national and continental markets to global markets, so too the sphere of operations of each individual professional undergoes expansion. This, in turn, means that there are new demands for personal skills and expertise. National expertise is no longer enough - students and professionals must prepare themselves for new international tasks by developing their skills in:

- learning about the facts and practices in other countries
- combining different items and curricula to develop an individual curriculum
- acquiring the skills to learn more and to adapt to new environments

In globalization there is often a need for speedy standardisation in different practises. New methods that have been successfully used in other parts of a company can be swiftly spread to new units once the company has acknowledged their value. Inside large companies, new concepts such as forest certification or new technologies such as the cut-to-length method in forest haulage can sometimes cross traditional geographical and traditional barriers with very little delay. Whatever the case, the new situation involved in transferring new technology and practises creates a need for large-scale education programs and efforts. For experts in a company's more traditional areas or for technology-providers the new situation means adaptation to a new environment. Both situations pose considerable pedagogical challenges which could be tackled successfully by means of web-based distance learning. And since enterprises have a tendency to minimize their own educational units, outside services will be needed.

Experiments in the SILVA Network

The newly networked world with its global markets emphasises the need for expertise and ability in organizing, finding consumers, and marketing. The individual or organization which can offer the best expertise in a tempting package will win the client. Hence, the opportunities for the older education organisations lie both in their good reputation and in their wider cooperation in creating new contents and also in marketing.

These trends have been recognised in the SILVA Network, which consists of 32 European universities offering higher education in forestry. The universities involved in the SILVA Network are producing joint European teaching modules and digital materials related primarily to this field. The first module, "Forestry in Changing Societies in Europe", will also be developed for use in an EU-Canada exchange program. The European network has increased bilateral cooperation between the participating universities for example by means of visiting lectures for special courses. Distance learning has proved to be useful in the arrangement of these courses and in enhancing contact between students and foreign experts. During the winter 1999-2000 the Web-based learning environment SoftTUTOR was piloted in the form of two visiting courses: ”Growth Trends in European Forests”, at the University of Joensuu (Finland), presented by Prof. Spiecker, of the University of Freiburg, and ”The Production and Energy Use of Wood Biomass", at the Agricultural University (BOKU) of Vienna, presented by Prof. Pelkonen, of the University of Joensuu. For the coming semester there are also plans to increase cooperation in particular by means of special courses. At the University of Joensuu a number of new courses will be prepared for a web-based learning environment. In combination with video lectures and video conferences these courses are to be offered to other Universities so that some of the students will be taking the same course solely through distance learning. These pilot courses are likely to provide valuable insight into the nature of communication and interactivity in an international ”virtual classroom”.

Difficulties

In practice, there are still both technical and other barriers that continue to reduce the effective implementation of distance learning: inadequate or expensive Internet connections, the actual cost of technical equipment, and a lack of basic ADP and Internet skills amongst both students and teachers. Nevertheless, technology is no longer a major obstacle in developed countries to the adoption of web-based distance learning. Several commercial software products are already available that offer very similar basic properties for net-based distance learning, and the situation is improving year by year. The main impact of low capacity in Internet connections is that there may be some reduction in the use of synchronous activities such as video-conferencing in a large scale.

One of the main problems involved in spreading the use of distance learning is probably a shortage of the pedagogical skills needed for converting teaching to the new format and new learning environments. To make successful use of distance learning the teacher or expert preparing the study materials must already possess reasonably good basic skills in terms of using computers and software. Thus, in addition to his or her professional competence and pedagogical knowledge the teacher should also understand something about the interactive nature of network environments. (Bacsich & Ash 1999)

Producing good-quality study materials and building up a complete distance learning course is also quite time-consuming, especially when it is being done for the first time. Also the costs of copyrights can reduce the use of digital materials. In general, monetary savings in shifting education to the net can only be achieved if the same materials are to be used several times with different groups or where recycling the same digital materials for various different purposes is possible. Part of the costs involved can be avoided by cooperation - jointly preparing materials for wider use - and by using specialised services in converting old materials for use in a new digital environment. (Bacsich & Ash 1999, Peters 1999). Unfortunately, the benefits of using distance learning are hard to prove because there is still a lack of scientific evidence about the results of this method in comparison with traditional educational methods. Comparable test conditions are difficult to arrange and the technology is also still developing very fast. The most valuable advantages attached to the use of distance learning are probably connected with better quality or will emerge in the long run through the development of enhanced methods of updating and revising materials.

Concluding Remarks

The advantages of net-based distance learning are so inevitable that only one (two-sided) question remains in our minds: how fast are the new technologies developing and how can these challenging opportunities be used in everyday teaching and learning situations? These changes are likely to provide new opportunities and wider markets for both organisations and individual experts, and the key factors for success are specialization, international cooperation and networking, and the ability to take advantage of new technologies.

Perhaps, in the not too distant future, every student will be carrying a virtual school in his or her pocket!

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IUFRO's New Era of Scientist Communication

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Abstract

The development of IUFRO's communication to utilize Internet based technologies is reviewed. During the past quinquennial a WWW based information system was built for IUFRO and its working units. A task force (IUFRO Task Force on Internet Resources) was established to coordinate and facilitate this work. The information system now covers most of IUFRO's activities and a user study helps to plan future development.

Keywords: Research communication, Information system, Internet

Introduction

The utility from scientific research depends on both the properties and the availability of the new knowledge. As noted by Harold Mooney, the Secretary General of ICSU, a relatively small amount of resources spent on enhancing communication and interactions among scientists and with 'the outside world' has a very high value added to the costs of scientific work (Mooney 1999). With the modern communications technologies this enhancement is even more pronounced.

During the 1990's, internet technologies have revolutionalized communication also within forestry sciences. Computer based person-to-person communication (e-mail) and information supply (WWW) are becoming more and more popular (Fig.1). It is both natural and inevitable that these developments deeply affect the functions of an international science organization such as IUFRO. This was also emphasized during the 20th IUFRO World Congress in 1995. The Congress Resolutions "encourage the use of innovative technology to increase data sharing and research efficiency, and to optimise timely delivery of research information to the widest array of users" (Declaration 1995).

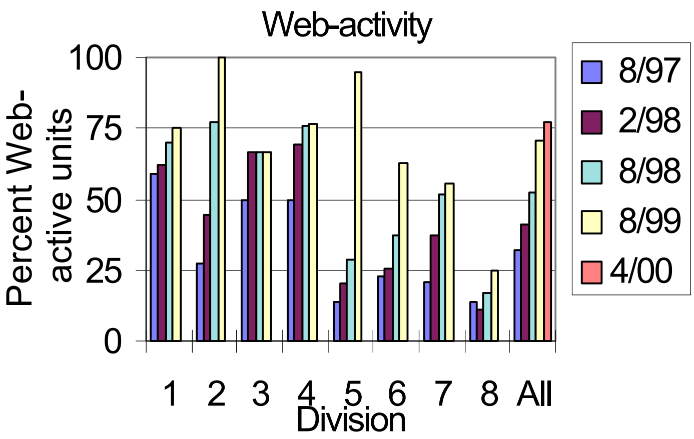
Added to the development of electronic communication, the degree of internationalization has markedly increased in many issues of forestry sciences. The activities related to biodiversity conservation, forest certification, climate change and the Kyoto Agreement have made many forestry issues international. This increases the importance of international communication.

IUFRO Networking Development Plan

To be effective and important, the communication requires both content and infrastructure. Supporting the latter was adopted as an important IUFRO activity: Following a period of exchange of ideas, a common view among IUFRO Secretariat and a group of "activist" scientists was formed and it led to the development of IUFRO Networking Development Plan (Valsta *et al*. 1996a).

The plan was largely developed during a group activity in November, 1995, in Vienna, hosted by IUFRO Secretariat and sponsored by the Finnish Forest Research Institute, the Swiss Federal Research Institute WSL, the Oxford Forestry Institute, the USDA Forest Service, and the University of Agriculture, Vienna. The process was based on sharing experts' views about:

Figure 1. The development of activity in providing information for the WWW system of IUFRO.



- the groups/kinds of users of IUFRO networking services
- the needs of the different user groups
- the services that respond to these needs
- the services that should or could be provided by IUFRO organization

The group performed a rating that produced a list of the most important services at the time (in the order of importance):

- Research Group information on the WWW
- IUFRO organisation information
- Electronic mailing lists
- Proceedings and newsletters on-line service
- Electronic research news
- Translation of documents between different electronic forms
- Person database
- Member organisation information service
- Literature databases
- Terminology database
- World Congress information

In a perspective of about 4 years, we can see what the emphases turned out to be in the realization of this plan. Research Group (now, Working Unit) and IUFRO organization information have become the core of the WWW information. Some of the specified services, such as Proceedings and Newsletters, and Person database have become part of the core area. The three last items on the list have been managed by specialized people as independent projects, but they importantly complement the other services. Translation of documents between different electronic forms was never realized in large scale as a service. Rather, that task is being handled mostly by information providers, themselves.

The IUFRO Task Force on Internet Resources

To bring forward this plan, the Executive Board of IUFRO established a task force in February 1996 (Valsta 1996a, b). The objectives of the IUFRO Task Force on Internet Resources have been to

- enhance international communication among forest scientists and with other parties having an interest in forest research,
- support the goal of decentralising IUFRO and strengthening regional activities,
- coordinate the development and use of internet services so that efforts in the area yield greater benefit, and
- share expertise and services so that the technological advances in computer networking are put in use globally in forest research and among member organisations.

The task force had to be organized so that it brought together a large number of people within IUFRO, working with various tasks. The two main groups of persons in the TF are the *core group members* and IUFRO unit *contact persons*. In addition, members of the secretariat work in close cooperation with the

TF. Additionally, the persons maintaining the regional servers have an important position. About 20 persons made up the core group and at least one person in most IUFRO units has been involved.

The Development

Two major information flows can be identified in IUFRO's internet activities. The first one concerns IUFRO organization information, meetings and publications, SPDC as well as literature and terminology projects, and this is principally managed by IUFRO Secretariat. This is also the more comprehensive and up-to-date part. The second kind of information deals with IUFRO's working units. Although here basic information is generated by the Secretariat, the unit coordinators are responsible for producing information about the mandate and activities of the units. This task is facilitated by Division Webmoderators who help the unit coordinators and division coordinators in producing and updating information concerning the units.

A major strategic step was taken here, supported by IUFRO's Executive Board, as every unit became visible in the Internet by the unit's home page. Not only are the names of the unit officers known to people who have worked around IUFRO in their field but to any person who browses the WWW pages or searches their contents. Needless to say, this situation creates expectations about each unit's activity and accomplishments.

The new communication atmosphere and increased visibility was new and partly unexpected to many of the officers in IUFRO units, especially as this change has been realized after the time when the officers had given their consent. Among other things, this situation shows in the rather unequal speed, at which the units have been giving out information that has been placed on their pages. It is expected that the proportion of units that are active in the WWW has reached its maximum with the current officers: 77 % of units were classified as being Web-active. It can be anticipated that officers selected for the next quinquennial will take the WWW information as a standard procedure.

To enable efficient global reach to IUFRO's WWW information, a set of regional servers was created. It includes locations on different parts of the world: Austria (University of Agricultural Sciences, Vienna, Austria; the main server), USA (University of Minnesota, St. Paul, Minnesota), Costa Rica (CATIE), Chile (CONAF), South Africa (CSIR), Australia (CSIRO), Japan (Mie University) and Finland (METLA) (Fig. 2). This setup reflects the strength of IUFRO being able to rely on support from member institutions.

A User Study

Following a plan of the Task Force, a questionnaire for the users of IUFRO's Internet resources was performed in June-August, 1999. This survey was targeted to IUFRO officers with e-mail addresses, the group obviously representing only a certain proportion of the users, albeit an increasingly common one.

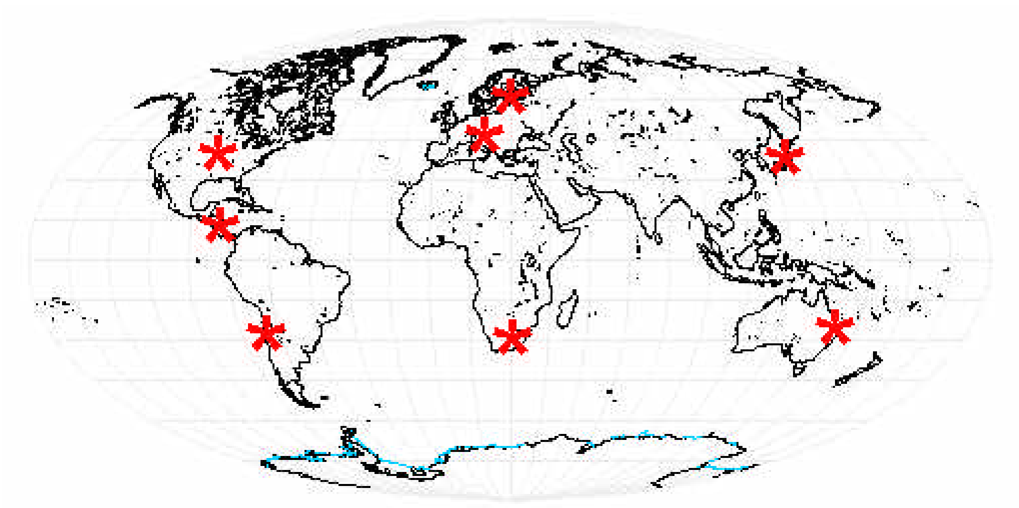
The purposes of the study were to obtain basic information about the views of IUFRO officers on IUFRO's Internet services. Primarily, the present services were evaluated, but the respondents were also asked to suggest improvements and changes.

The response rate following a reminder in July amounted to 63 %, excluding the non-functional email addresses. Those included, the rate drops to 56 %, which can still be considered acceptable.

IUFRO News had been the most important source of knowledge about the existence of web activities. About half of the units of the officers had been active in IUFRO web; notably, 25 % did not answer the activity question.

One third of those persons who had checked their personal information had found it not correct. Much of this number is due to the failure of people in submitting their notice of address change. The questionnaire did not distinguish between people who actually had sent an update on their personal information from those who had not.

Figure 2. The sites of IUFRO's WWW servers.



The strongest features of the web system were meeting announcements, ease of use, and layout of information. Problems were seen in the timeliness of information and data entry overall.

E-mail was, by far, the most popular way of communication. However, hardcopy still was considered indispensable, especially keeping in mind the situation of officers without an e-mail facility. Most of the respondents had used both e-mail and WWW but the circumstances among officers outside this questionnaire were also important.

Future Directions

The expectations on rapid global communication are ever increasing. It is expected that the Internet based services of IUFRO will be central to the organization.

One to One Communication

The database of contact information of the more than 800 IUFRO people is a vital source of basic information. The value of this information is crucially dependent on persons themselves in that they keep the contact information up-to-date. Both the commitment of persons themselves and the technical help provided by IUFRO will help updating.

One to Many Communication

Sharing information is naturally a core function of research. In the global context, WWW is seen to increase in importance for research. Locating the useful information is a key problem with the ever-increasing amount. IUFRO has a great potential in collecting information of a very large number of experts in the field of forestry research. The present WWW system of IUFRO has several strong areas that are likely to retain their value.

The diversity of IUFRO people in their ways of retrieving and supplying information is a challenge for the organization. How to combine simplicity and manageability while maintaining flexibility and alternatives? The solutions to this must include some rigid administration but also approaches that enable the full utilization of grass root activity in IUFRO units and of the contributions of IUFRO people to information sharing. Pilot projects like those of SPDC in the GFIS vision can broaden the geographical outreach.

The Strengths of IUFRO Communication

Although the main form of scientific communication takes place through research reports, one can ask whether that it enough. Do international users of forestry research information also need to interact with a large number of people? The network of forestry scientists that IUFRO represents is a unique phenomenon.

Much of the communication through IUFRO's internet services connects to publications, meetings and individuals. It was very early realized within IUFRO that providing personal information is a sensitive issue and is threatened by misuse. That is why the present system is designed so that only one person's data can be retrieved at a time. On the other hand, combining traces of information from IUFRO's thematic structure and its reference data can provide insight to a valuable knowledge base with respect to forest sciences.

In the Internet context, forecasting is a difficult business. However, community building will continuously be a main activity independent of the specific technology in use. As the availability of computer-mediated communication and web services will increase, the toolbox for international cooperation in forestry research will gain in variety.

The member organizations have not yet had a prominent role in producing their own information to be connected to the IUFRO WWW system. This area has a large potential: how to design data and searches to yield information about the activities and specialties each member institution has. Combining individuals and institutions will bring IUFRO's information system to its greatest value.

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ITTO Initiatives for Networking in Forestry

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Abstract

This paper begins with a discussion of the term 'network'. In the context of this paper, it is taken to mean the flow of information between individuals, institutions and nations. The International Tropical Timber Organization (ITTO) has been developing networks since it commenced operation in 1987. Not all such networks have not been created from 'scratch'; ITTO has been able to tap into existing networks and in many cases strengthened them. These networks extend in all directions – from the international arena to the field level and back again.

ITTO's networks extend to the field level primarily through its project program. In its 13 years, ITTO has distributed funds to about 400 projects in its member countries, predominantly those in the tropics. This creates a natural flow of information: projects consistent with ITTO objectives are proposed by member countries and vetted by an international team of experts. They are then submitted to the International Tropical Timber Council; if approved they may attract funding, which is provided in the form of grants rather than loans. Once a project is implemented, information exchange continues between ITTO and the implementing agencies, and between the ITTO Secretariat and field staff associated with the project. Thus, networks are established or maintained that link the international arena (at the Council level), through national governments, to national and sub-national agencies and non-government organisations, and to field staff.

Complementing this approach are two projects aimed at developing a more structured information network: one produces a newsletter, the Tropical Forest Update, and the other a tropical timber market information bulletin. The newsletter has evolved considerably since its beginnings in 1991, but its aim has remained constant: to promote the exchange of information on the conservation and sustainable development of tropical forests. It has a circulation of about 7,000 and is distributed in English, French and Spanish. It publishes basic information such as the availability of short courses and scholarships and information on recent publications, meetings and other events. But it also provides analyses of the tropical timber trade and sustains a global-level dialogue on the role of forestry in conservation and development. It also feeds back into the ITTO project program by publishing reports about such projects, usually co-written by project field staff and members of the ITTO Secretariat. This affords project personnel the chance to articulate and communicate the outcomes of their work and to learn about the activities of their counterparts in other countries and regions.

The Tropical Timber Market Information Service is aimed specifically at tropical timber traders and trade analysts and operates principally via the internet. It carries price data on over 300 tropical timber items and has developed a price database to service specific trade inquiries and for the production of price trend data. These data are also provided to other international agencies for their own reports on the tropical timber trade.

ITTO has never seen itself as the sole institution with responsibilities in the field of tropical forest conservation and sustainable development. It currently contributes around $20 million a year to field projects; these, on their own, will not solve the tropical forests crisis. But other institutions – global, regional, national and local and the individuals within them can learn from our experiences and we can learn from theirs. This is the value of networks.

FAO Initiatives for Networking in Forestry

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Abstract

The paper reviews examples of networking efforts by FAO in forestry, within different regional or global framework, and with broad or more specific objectives. Factors of success and issues in operating the networks are presented. Relatively less complex to operate, theme-specific networks generally achieved good results although inadequate capacity of some collaborating institutions can be a constraint. A stepwise approach was successfully applied for some more complex networks with broader objectives. Generally, regional technical cooperation networks, established to common regional issues, well fulfilled their role in exchange of information and experience. They have created, over the years, competent resource groups, which however need external support to be maintained. Efforts in support to regional networks of forestry research institutions, to enhance national and regional capacities to prioritise and undertake research in an effective way, are presented. Cooperation with other regional or international programmes and institutions has constantly been an important factor of success in all the networking efforts facilitated by FAO.

Keywords : FAO, Networking, Forestry.

Introduction

Networking refers to formal and informal ways in which individuals and organizations establish contacts with one another and develop working relationships to exchange information and cooperate and coordinate activities. Networking is a tool commonly used by FAO in fulfilling its mandate of information gathering and dissemination, technical assistance, and facilitation of international cooperation, across the whole spectrum of frameworks, objectives and activities of the Organization, from broad areas of interest and global networks to topic specific and local networks. The present paper reviews the experience on networking and other collaborative efforts by FAO in forestry, based on representative examples of different kinds of networks. The topics considered are (i) theme-specific networks, (ii) networking under FAO statutory bodies and regional commissions, and (iii) the support to regional networks of forestry research institutions. Factors for success and problems encountered will be analysed.

Theme-specific Networks

International Species and Provenance Trials

The Forestry Department of FAO has been facilitating and coordinating a number of international species and provenance trials, which can be considered as networking activities with well defined objectives, outputs, and time frame.

International provenance trials of teak (*Tectona grandis*) were established in the early 1970s under the coordination of FAO and the Danish International Development Agency (DANIDA) Forest Seed Centre (DFSC). Seventy-five provenances, both from within the natural range of the species and from areas of introduction, were collected and exchanged for trial establishment at over 50 sites in 16 countries. Coordinated evaluations undertaken from 1981 to 1984 and from 1991 to 1992 showed important differences among provenances for growth and stem quality traits. These evaluations resulted in recommendations concerning provenances to be used in different regions.

In 1979 FAO, with financial assistance from UNEP and IPGRI, started a project entitled Genetic Resources of Arid and Semi-arid Zone Arboreal Species for the Improvement of Rural Living (1979-1987) which represented, at the time, the first internationally coordinated, systematic effort for the exploration and evaluation of genetic resources of dry zone multipurpose woody species. Eleven countries in the arid and semi-arid regions of the world participated in the systematic collection of seeds of some 281 provenances of 43 species (mainly of the genera *Acacia* and *Prosopis*) and established field trials. A global evaluation of selected field trials was initiated in 1989 by FAO and DFSC in collaboration with national institutes in the countries concerned. During 1990-1994, 26 trials in 6 countries were assessed. Assessment reports of the individual trials have been prepared. A global synthesis is under preparation as a joint effort between national institutes involved, DFSC and FAO.

Well defined, specific objectives and activities were an important factor of success of these "networks" with relatively limited set life-time. Cooperation among international agencies and programmes was also essential. FAO's role was to provide technical assistance, facilitate global coordination and technical cooperation among countries and regions. A main difficulty was the inadequate capacity of some of the network collaborators, which did not allow them to fully participate in, and benefit from the common research efforts. The number and geographic distribution of adequately maintained trials allowed the achievement of the global objectives to identify species and provenances which are adapted in different conditions and regions. However, a number of collaborating institutions could not maintain the trials over the years because of the deteriorating of budget situation and/or because of changes in priorities.

International Neem Network

Neem, *Azadirachta indica* A. Juss. (Meliaceae), is an evergreen multipurpose tree. Neem is native to the Indian subcontinent and South-east Asia, where it has been traditionally used for centuries. The species adaptation to hot and dry climates has made it one of the most commonly planted species in arid and semi-arid areas both within its natural range and outside. In the African Sahel, neem is mainly planted as shade tree and in windbreaks, although production of firewood by pruning and use of neem in local pharmacopoeia are important. In its natural range, particularly in India, products derived from neem have traditionally been widely used for centuries for many medicinal and pest management purposes. Extracts of oil and chemicals compounds from neem for industrial uses are gaining more and more attention worldwide.

Despite the widespread use of neem, programmes for the evaluation and improvement of genetic resources of neem were not initiated, mainly because of seed viability and handling problems, which placed a serious constraint on seed collection and transfer. As a result, the genetic material presently used in plantations is generally thought to have been originally collected on few stands or trees, and its genetic base is frequently likely to be very narrow, particularly in countries outside the natural range of the species. Neem decline is periodically affecting many Sahelian countries and is alleged to be caused by a number of interacting environmental and genetic factors, possibly aggravated by pathogens.

The International Neem Network was established in 1994, following the recommendations and agreements of the First and Second International Consultations on Neem Improvement in Thailand 1993 and India 1994. The following working principles were agreed upon by network collaborators representing 22 countries from within and outside of the natural range of the species:

- Free availability of seed for research purposes on exchange basis and mutually agreed terms;
- Standardised trial designs and standardised evaluation procedures (common guidelines);
- Free availability of results of trials and research to Network collaborators;
- Provenance seed collection/ handling/ despatch for trials included in the programme to be done by collaborators, with technical support - and limited financial contribution - from the Network;
- Establishment and maintenance of trials to fall under the responsibility of Network collaborators with technical support by the Network;
- Complementary studies (phenology, genetic diversity/reproductive biology,

seed physiology) to be undertaken through specific research projects discussed and approved. Each project has a coordinator and can be presented for funding to potentially interested agencies;

Each Network collaborator can be involved in the various activities according to his interest and capability;

Each participating country has a national focal institute which coordinates the Network activities at national level;

The Network is coordinated by an informal panel formed by representatives of national focal institutes from at least three participating countries, DFSC, CIRAD-Forêt, IPGRI, FORTIP and FAO. Global coordination is entrusted to FAO.

During 1993 and 1994, seed sources were surveyed and documented throughout the natural range of the species and in areas of introduction. Pilot seed collection and exchange were undertaken to improve the procedures used in these difficult operations in view that, neem seed has a recalcitrant or intermediate behaviour. A training course was organised in 1994 in India to familiarise network collaborators with the improved procedures. A total of 25 seed sources from 11 countries, representing the entire eco-geographical variation in the range of distribution of the species were described and collected using agreed common guidelines. The 25 seedlots were exchanged among 21 countries. Field trials were established in 1996-1997 and their assessment started. The next very important step will consist of their evaluation and this will provide information on the extent of the genetic variation of neem. Provenance recommendations for planting at different sites will become available based upon the results of the assessments. This information will be valuable, in particular, to broaden the genetic base of the species outside of its natural range with well adapted and good quality material.

Achievements by the International Neem Network include the establishment of more than 30 provenance trials with a common set of provenances representing the full range of the distribution of the species, and successful exchange of seed and of information, experiences and knowledge between more than 20 countries. This constitutes a basic pool of materials, knowledge and know-how that can pave the way to further developments in conservation, tree selection and improvement, and plantation establishment. Capturing the potential offered by neem is a contribution to the overall development and to meeting the requirements of rural people.

Factors for success include:

Problems and requirements are identified and shared by all collaborators, allowing the finalisation of common, realistic, agreed upon objectives.

The enthusiasm and dedication of individual collaborators have never diminished.

The principles have been agreed among collaborators as one of the first steps taken by the network.

All partners have been identified properly (e.g. relevant national institutes, research institutes, regional and national organisations).

Many personal contacts and very good collaboration between institutes, regional projects, national and international organisations, NGOs have helped the network function in harmony.

Frequent meetings have been held (approx. one each year) to get an overview of the status and progress of work in each country, to exchange information and experience, to discuss and eventually agree upon the next operations to be undertaken.

This stepwise, pragmatic and realistic approach has been recognised and appreciated by many collaborators.

The many booklets and practical guidelines have streamlined the procedures; few serious problems have been recorded during implementation of very delicate operations such as the large scale collection, handling and international exchange of recalcitrant seed.

All data and information have been thoroughly documented. This is extremely important as provenance testing is a long term task which results rely on precise and accurate records of operations and activities.

Many international partners and programmes contributed to different stages of preparation and implementation of the Network's programme: the Forest and Fuel wood Research and Development Project (F/FRED) funded by USAID, DANIDA through DFSC, the French Cooperation through CIRAD-Forêt, IPGRI, and projects executed by FAO such as the project on Improved productivity of man-made forest through technological applications in tree breeding and propagation (FORTIP) and the Forestry research support programme for Asia and the Pacific (FORSPA).

FAO has provided a neutral forum for the exchange of information, experience and know-how; the framework of the international organisation has contributed to smoothen initial difficulties, and facilitated the coordinated participation of other international partners and programmes.

The following key constraints were identified:

Although its programme and activities are well defined, there is no specific budget to support the Network. Activities have been achieved to date thanks to very active contacts and cooperation among national, regional and international partners. However, it has been difficult to get financial support for all activities that collaborators were keen to undertake.

Travel costs for participants in meetings, training courses etc. are high when the Network is operating at a global scale.

The end uses and also the importance of neem differ from country to country. Therefore, the Network needs to be flexible in order to accommodate all collaborators with different interests and capacities. Flexibility is also needed to accommodate new members, and to take new requirements and needs into consideration.

The International Neem Network is entering its seventh year. After a promising and successful start, it now faces new challenges such as the conservation of genetic resources and the selection, improvement and breeding of neem. Considering the under-utilised potential offered by the multipurpose tree, further work could be realised within the framework of the International Neem Network. All information, knowledge, methods and skills are now assets of the collaborators who will decide the next steps. The guiding principle in the activities of the International Neem Network is that full responsibility rest with the Network collaborators. The majority of the activities is undertaken using the collaborators own funds and the activities are to a large extent integrated into the work programme of the organisation. This guiding principle is thought to be a key factor in the long term sustainability of the Network.

TEAKNET (Asia-Pacific Region)

Teak is one of the most important hardwood species planted extensively in several countries in the Asia-Pacific. Being indigenous to the Region, substantial experience bas been gained in the management of natural and man-made stands of teak. Notwithstanding the large scale introduction of fast growing exotics like Eucalyptus and Acacia species, teak continues to lie an important species, especially on account of the high quality of wood, the increasing demand, and the ease of cultivation and management. Growing private investment in teak plantations is a clear indication of the perceived potential of the species, although deforestation and unscientific management have substantially reduced the area of natural stands.

While problems in the countries in the Region are similar and considerable experience exists in dealing with them, there is no effective mechanism to share this and to facilitate the improvement of techniques for conservation, management and utilization of teak plantations and forests. The need for developing a suitable mechanism to facilitate exchange of information was discussed during the China/ESCAP/FAO Regional Seminar on Research and Development of Teak held at Guangzhou, China during March 1991. There was a general consensus to the proposal for establishing an "Asia-Pacific Network on Research and Development of Teak", TEAKNET. It was proposed that ESCAP and FAO should jointly develop a detailed plan for the network mechanism.

A proposal for establishment of the "Asia-Pacific Network on Research and

Development of Teak", TEAKNET (Asia-Pacific Region) was discussed and agreed upon at the Second Regional Seminar on Teak organised, in Yangon in 1995, by the Ministry of Forestry of Myanmar in collaboration with FAO.

The objectives of the network are: (i) exchange of technology and information on sustainable management, silviculture, processing and promotion of teak; (ii) exchange of genetic materials, plants, soils and timber samples together with standardisation of trials to facilitate international comparison; and (iii) collaborative studies on critical areas that are of common interest to member countries.

To fulfil the above objectives, TEAKNET will undertake the following activities: (i) review major developments in the conservation, management and utilization of teak (through a seminar organized once in three years); (ii) information dissemination through: publication of (a) a newsletter (quarterly or half yearly) and (b) case studies and reports on problems of wider interest; maintaining and providing access to data bases on area, production, productivity and trade, individuals and institutions involved in research and development of teak trade and marketing; (iii) support and catalyse collaborative research on problems of common interest; (iv) facilitate the exchange of genetic materials, plants, soils and timber samples for research purpose; (v) facilitate the exchange of expertise and training among the countries/institutions who are part of the network; and (vi) any other activity that are relevant to the main objective of the network.

Considering its broad objective, TEAKNET aims at a diversified membership: (i) institutions, agencies, departments, from both the public and the private sector involved in managing plantations and forests, undertaking research and studies, processing and marketing teak products; (ii) consumer associations; and (iii) individuals with demonstrated and sustained interest in various aspects concerning growing, managing and processing of teak.

A Steering Committee was formed with representatives from member countries and FAO. Efforts to secure specific funding to support activities proposed in the work-plan of the network have been unsuccessful to date. TEAKNET has been able to maintain the information link among its members. It organised a regional seminar on Site, Technology and Productivity of Teak Plantations, 26-29 January 1999, Chiang Mai, Thailand, in collaboration with the Chiang Mai University and FORSPA. The seminar was attended by experts from all teak growing regions of the World, and provided a good review of the state of knowledge and practice, which is very timely during this period when teak plantations are developing at a very high rate, following new short rotation, high-intensity silviculture regimes and based on very high yield projections.

One reason why it has been difficult to find specific financial support to the full set of activities of TEAKNET is probably the width of its scope, covering all aspects from tree improvement to marketing. While keeping its holistic approach, the network might identify areas of focus to be covered by projects with more specific outputs of interest to the members from the public and the private sector.

Networking under FAO Statutory Bodies and Regional Commissions

Networks and networking are part of activities undertaken in the framework of Statutory Bodies and other commissions of FAO, which often include exchange of information and technology in their programmes.

Silva Mediterranea

Mediterranean forests share many common features, which argue strongly for regional cooperation. In 1911 the idea of Mediterranean forestry cooperation was launched and, in 1922, a Mediterranean Forestry League was established under the name of "*Silva Mediterranea*". In 1948, *Silva Mediterranea* evolved into a statutory body of FAO as a Committee on Mediterranean Forestry Questions where the Mediterranean countries members of the FAO European Forestry Commission, Near East Forestry Commission and African Forestry and Wildlife Commission could meet, share their experiences and establish cooperative programmes.

The purpose of *Silva Mediterranea* is:

- to periodically review the trends in the use of forest land in the Mediterranean area and to assess the impact of changes implemented in the agricultural, industrial and urban sectors, and to advise Member Governments accordingly on reorientation or improvements necessary to meet changed situations or newly-emerging needs; conversely, to periodically examine progress in forestry technology within regional and ecological contexts in order to better assess present forest land utilization methods;
- to identify forestry research priorities in the Mediterranean area, determine forestry research projects of common interest to Member Governments in the region and recommend to the Director-General of FAO and Member Governments the adoption of measures necessary to coordinate the concerted execution of these projects by the forestry research institutes in the Region;
- to determine and carry out, in collaboration with Member Nations and with the support of the appropriate national forestry agencies, the technical studies and surveys which are deemed necessary to assist governments of the region formulate national forest policies or facilitate their implementation.

Silva Mediterranea holds its Session every two years, to discuss and address common problems. Where research is needed, the Committee establishes cooperative research networks on subjects identified during sessions. Presently six research networks are operating: a) Forest fire management; b) Selection of multi-purpose species for arid and semi-arid zones; c) Silviculture of species: *Cedrus sp.*; d) Silviculture of species: *Pinus pinea*; e) Selection of stands of Mediterranean conifers for the production of seed to be used in reforestation programmes; and f) Silviculture of species: *Quercus suber*. Each of these networks designates a coordinator and has a focal points in each interested country. Activities are conducted within normal research programmes of national research institutions, and no special funding is allocated to the networks. Nevertheless, these networks can be supported by international organisations such as IUFRO, UNESCO, the International Center for Advanced Mediterranean Agronomic Studies (CIHEAM) or FAO, mainly for meeting organisation and publication of research results. Some donor countries may also support a given network through trust fund projects.

Silva Mediterranea research networks have had variable performances, depending on funding at country level and from external sources. Recently, a regional trust fund project on "Co-operative information on prevention and control of forest fires in the Mediterranean Region", funded by France, was implemented in the framework of the network on "Forest Fire Management". Regional workshops were held in Tunisia and Morocco on the design demonstration of the newly established computerized databases on forest fires in selected countries of the Region and on their effective use in forest fire management. The workshops achieved excellent results in particular in training of national staff and capacity buiding, and awareness raising of issues related to forest fire information generation and management. The research network on "Silviculture of species: *Quercus suber*" looked for ways and means to support the sustainability of the cork oak agro-silvo-pastoral systems through promoting the trade and the use of cork products. This activity was supported by the private sector including producers, manufacturers and users. The cork oak network also developed activities on genetic resources conservation and improvement, in cooperation with the "Mediterranean Oak Network" of the European Forest Genetic Resources Programme (EUFORGEN) coordinated by IPGRI in collaboration with FAO.

Regional Networks in Latin America and the Caribbean

Technical cooperation networks, sponsored by the FAO Regional Office for Latin America and the Caribbean, were established with the following objectives: (i) promote cooperation among the countries of the region through joint efforts and the exchange of knowledge and experiences; (ii) promote the countries' self confidence in their own resources, knowledge and abilities; (iii) strengthen the technical capacities of national institutions above all to identify problems and formulate adequate solutions; (iv) promote capacities and human resources training at all levels; and (v) accelerate development through a more effective use of human, physical and financial resources available in the region.

Technical cooperation networks are integrated by national institutions sharing the common technical interest of the network. These generally are public or semi-public institutions, but may also be non-governmental organizations. Normally, a country is represented by only one institution in each network. This institution coordinates the network's activities at the national level, and must ensure the adequate participation of other institutions interested in the network's activities and cooperate with them.

The technical cooperation networks include (i) the Latin American Technical Cooperation Network (LATCN) on National Parks, other Protected Areas and Wildlife (established in 1983); (ii) LATCN on Watershed Management (1980); (iii) LATCN on Agroforestry Systems (1986); (iv) LATCN on Dendroenergy (1986); and (v) the Caribbean Technical Cooperation Network on Forestry and Related Environmental Matters (1992).

The networks resort to various methods and mechanisms to exchange information and experiences and implement their programmes of activity. They include the following: (i) round tables, workshops and expert consultations to analyze technical matters and coordinate programmes of work of common interest; (ii) training activities through courses and seminars; (iii) study visits and technical exchange; (iv) exchange of research findings, publications and audiovisual materials; (v) periodical communications by means of circular letters and informative notes, (vi) preparation of technical documents and manuals to disseminate appropriate technologies; (vii) cooperation in the execution of national, bi-national, sub-regional, regional and interregional activities such as technical cooperation projects, studies, technical documents or specific programmes.

The FAO Regional Office for Latin America and the Caribbean provides the networks with a Secretariat to coordinates them, both technically and logistically. The Secretariats collaborate in identifying activities of common interest to the countries, as well as their technical and institutional capacities. The Secretariat, jointly with the regional coordinators, proposes a programme of activities for the networks and coordinates FAO's financial and administrative support. It also helps regional and national coordinators in the implementation of network activities and coordinates the edition and publication of technical documents. To ensure the effective dissemination of network activities and achievements at national level, the establishment of national networks was promoted. However, it has been possible to implement national networks only in some of the participating countries. In general FAO support has been fundamental in obtaining the necessary funds to carry out the network's activities. These funds are generally provided by FAO's Regular Programme, in ever decreasing amounts, and by other regional and inter-regional institutions such as UNEP, IUCN, the Inter-American Development Bank, Unesco and the Amazon Cooperation Treaty (ATC). In addition, some regional projects executed by FAO have contributed to finance network activities.

Achievements of the networks have been satisfactory over the years, through activities mentioned earlier. It has however become more and more difficult to sustain them without external funding, although active collaboration with other regional and international initiatives and programmes have produced important outputs. Following consultations with the networks' members, and considering other related ongoing programmes or initiatives under development in the region, decisions will be taken as to the future of the networks.

At national level, two important elements for the satisfactory operation of the networks are: an adequate national coordinating institution and the respective national coordinator. Good results have been obtained in some countries in both aspects, while in others results have been weak. Some important problems are: lack of dissemination of the results of the network's activities at the national level, which is more apparent when there are no national networks, scarce or no communication between the national coordinator and forestry authorities and frequent changes of national coordinators.

Support to Regional Networks of Forestry Research Institutions

The recognition of the need to strengthen the global forestry research system has been concretised in recent years by the establishment of CIFOR and ICRAF as International Research Centres of the CGIAR system, and the broadening of the programme of IPGRI, an other Centre of the CGIAR, to cover forest species. By mandate, the Centres of the CGIAR focus on strategic research and applied research at global level.

National Research Systems, including institutions from both the public and the private sectors, are an essential component of the global research system, to undertake applied and adaptive research, capitalise and transfer research results to local development. International research programmes will have limited impact without appropriate participation and complementary research by national institutions. Most developing countries do not have the adequate capacity to participate in international research projects and to capitalise, adapt results and transfer them at local development level. This essential function of national research systems, including governmental and non-governmental institutions, is reinforced by a new trend of increased involvement of non-governmental actors in forestry and agroforestry development activities, and the need to adapt research to better serve a broader array of users, and get closer to their needs. Thus, strengthening of national research systems is of highest importance.

A regional approach is privileged, as shared and coordinated support at regional level is an efficient means for strengthening of national forestry research systems, while developing adequate co-operation among them.

The Forestry Research Support Programme (FORSPA) and the Asia-Pacific Association of Forestry Research Institutions (APAFRI)

Forestry Research Support Programme for Asia and the Pacific (FORSPA)

FORSPA was launched in 1991 to formalise the informal networking of forestry research institutions that existed earlier in the Region. During Phase 1 (1991-94), funded by the Asian Development Bank and UNDP, research capacity building was attempted through (a) funding field research projects in regional priority areas, (b) strengthening access to information including the provision of hardware and software to national institutions and development of supporting data bases, (c) organizing and supporting meetings and seminars on topics relevant to research, and (d) training researchers and research managers.

Among these activities, funding field research projects was considered to be the more important. Based on inputs from a pre-implementation seminar, five regional priority areas were identified: (a) upland watershed management, (b) improving sustainability of plantation forestry, (c) reforestation of degraded lands and problem soils, (d) ecosystem conservation and maintenance of biological diversity, and (e) promoting community participation in forestry development. Over time, problems inherent in implementing a regional support mechanism emerged. Some of the projects took much more time than anticipated. Partly this was due to the artificial time frame imposed by FORSPA's limited project duration, and partly it resulted from poor project designs. It was also noted that participants in the projects did not take advantage of the networking opportunities provided by the commonality of the themes. Further, it became evident that many institutions participated in the programme to take advantage of the funding opportunities, rather than because of any importance attached to the research theme. Also, much of the support went to countries with already well developed research systems.
The lessons learned from Phase I resulted in a shift in strategy during the bridging phase (1995-96) supported by the Asian

Development Bank and the follow-up Phase Il (1996-2000) funded by the Netherlands Government. To sustain long-term research networking, FORSPA facilitated the establishment of the Asia Pacific Association of Forestry Research Institutions (APAFRI). Funding for small-scale field research projects was discontinued, and instead, support is being provided to networks focused on priority topics and collaborative arrangements like twinning. Country capacity building, especially focused on those where national research systems are inadequately developed, is a major thrust of FORSPA Phase II. Such support includes (a) development of research strategies and plans for research, (b) human resource development to improve research proposal formulation and implementation capabilities and to address specific technical constraints through on-the-job training. (c) improving access to information and (d) promoting collaboration through twinning arrangements.

The lessons learned from FORSPA since its beginning in 1991 suggest that networking and collaborative research at the regional level require:

- a highly flexible approach to address the specific needs at the countries;
- a commitment for long-term support by donors;
- some minimum capacity at the country level to take advantage of the regional support mechanism;
- clear and concise strategies at the national and institutional levels so that network-based research becomes an integral part of the ongoing research and not an additional item that will strain already limited resources.

Asia Pacific Association of Forestry Research Institutions (APAPRI)

As indicated earlier. APAFRI was established as regional non-governmental organization to sustain FORSPA's regional research networking functions. A meeting of the Heads of Forestry Research in the Asia Pacific convened in Bogor, Indonesia in February 1995 approved the constitution of the Association and elected an Executive Committee to initiate its establishment. APAFRI's long-term objective of fostering development of forestry research for sustainable forest management in the Asia Pacific Region is to be achieved by:

- promoting exchange of scientific and technical know-how and information;
- promoting cooperative research and training programmes; and
- strengthening linkages among national, regional and international research organizations.

Until early 1997 APAFRI was managed by FORSPA. During this period the main emphasis was on nurturing the organization, canvassing the membership and providing necessary visibility to APAFRI so that it would be seen as a viable networking mechanism. It became evident that the organization's long-term sustainability would require member institutions to assume managerial responsibility and widen the resource base. Accordingly the APAFRI General Assembly decided to relocate the Secretariat to the Faculty of Forestry, Universiti Putra Malaysia.

APAFRI has developed a strategic plan and has been able to increase the membership to 47 institutions, including private enterprises and NGOs in addition to most of the leading national forestry research institutions and several international organizations. Each member institution pays an annual fee based on the economic status of the country to which the institute belongs. APAFRI has recently been recognised as the first Regional Chapter of IUFRO. FORSPA continues to support APAFRI in its main activities, and facilitated a CIDA-funded project, TREELINK, which is expected to enhance APAFRI's information and research support for ASEAN members.

Since APAFRI is in the initial stages of development, it is too early to judge it's long-term viability. While all research institutions in the region agree on the need for a regional networking mechanism, several have not yet joined APAFRI and there is an attitude of "wait and see". The network's success will depend on its ability to provide high-quality, unique services to its members, develop strategic alliances with international organizations, ensure that core funding is available to sustain key networking functions. and attract external funding for collaborative activities.

Forestry Research Network for sub-Saharan Africa (FORNESSA)

In 1993 IUFRO and FAO convened in Ouagadougou (Burkina Faso) a workshop between representatives of forestry research institutions of the region to look into the urgent needs of the forestry research in Africa. The workshop issued a number of recommendations which, among others, requested FAO to take the lead in facilitating measures and initiatives to support development and funding of forestry research, training of staff and institution building.

In 1994, to follow up with these recommendations FAO took several initiatives among which: i) the participation to a meeting convened in Nairobi (Kenya) in July 1994 by the International Foundation of Sciences, the African Academy of Sciences (AAS) and IUFRO which dealt with support to Forestry Research in Africa; FAO presented then a concept paper on strengthening and networking forestry research in Sub-Saharan Africa; the initiative was unanimously supported and FAO encouraged to follow up; ii) the support for the convening and holding of a technical meeting attended by a group of forestry research experts in November 1994 in Accra to further develop the recommendations of the Nairobi meeting; four research institutions of Côte d'Ivoire, Kenya, Malawi, Senegal and the African Academy of Sciences decided to create a nucleus of a Forestry Research Network for Sub-Saharan Africa (FORNESSA) to promote cooperation among them; Senegal, Kenya and Côte d'Ivoire subsequently approached FAO for support.

In reply to the expressed needs and to the requests received from countries, the FAO and the Special Programme for Developing Countries (SPDC) of IUFRO undertook to formulate a regional project proposal involving interested countries and sub-regions of Sub-Saharan Africa. The project aims at capacity building, development of collaborative research activities and networking; the ultimate result of the project would be the creation of a network of forestry research institutions in Sub-Saharan Africa, a federating mechanism across language boundaries, which will strengthen and build on sub-regional networks already active such as the Forestry Network of WECARD, in Central and West Africa, and the SADC-FSTCU Research Sub-committee in Southern Africa. A draft proposal was discussed and its objectives, outputs and activities were approved in the Expert Consultation on Forestry Research convened by FAO and IUFRO/SPDC, in October 1997, at the FAO Regional Office for Africa, in Accra.

Since June 1998, the Deputy Coordinator for Africa of IUFRO-SPDC has been hosted by the Forestry Group of the FAO Regional Office for Africa to facilitate cooperation in activities in support to forestry research, and in particular in support to FORNESSA.

Following recommendations made by the Accra consultation, the original "FORNESSA" proposal was reorganised into components, which can be supported by different donors. Activities in strengthening of sub-regional forestry research networks or groups, such as the SADC-FSTCU Research Sub-committee, the Forestry Network of CORAF in West and Central Africa and the recently established Association of Forestry Research Institutions in Eastern Africa (AFREA), and in linking them together were included as a component of an FAO-European Commission partnership project on "Sustainable forest management in African ACP countries", which started in January 2000. Activities include:

1. Assist with the establishment and management of databases on institutions, human resources and activities. Databases are tools useful to avoid undesirable duplications of activities and to identify and contact potential research partners. Existing sub-regional databases will be surveyed and reviewed in order to identify those which can be developed into coherent sub-regional and, later on, regional databases. This activity will then update and expand these databases to make them more comprehensive and start to

establish networks of researchers working on common research topics.

2. Support the preparation of thematic sub-regional and regional syntheses and research working groups. Some national institutions have been working in isolation on themes of common sub-regional or regional interest, but not disseminating their results. This component will gather, synthesise and publish such results and, from these, develop a process for collaboration in research areas of common interest to network members. Thematic working groups will be established to prepare and undertake common research projects in these areas.
3. Support greater information exchange and communication on forestry research issues.

A meeting of AFREA, the SADC-FSTCU Sub-committee on Research, and WECARD Forestry Network is planned to be held in July 2000 to formally federate themselves and form FORNESSA.

Activities in sub-Saharan Africa will continue to be undertaken in collaboration with concerned institutions and networks such as IUFRO-SPDC, CIFOR, ICRAF, IPGRI and the African Forestry Research Network (AFORNET), a network of individual scientists supported by the AAS.

The emergence and strengthening of associations and networks of institutions to represent forestry research and facilitate priority setting and cooperation at regional level are a necessity, and very timely, considering the ongoing international initiatives in agricultural research, in particular the Global Forum on Agricultural Research. The Global Forum on Agricultural Research (GFAR) was established in October 1996 by a group of representatives of the developing-country national agricultural research systems (NARS), advanced research institutions, regional and sub-regional organizations, universities, non-governmental organizations, farmers' organizations, the private sector, international agricultural research centres and the donor community, "to mobilize the various stakeholders that constitute the global agricultural research community in their efforts to alleviate poverty, increase food security, and promote the sustainable use of natural resources."

NARS are represented in the GFAR by a steering committee composed of the chairpersons of the five NARS regional fora on agricultural research (i.e., Asia and the Pacific, Central Asia and the Caucasus, Latin America and the Caribbean, sub-Saharan Africa, and west Asia and north Africa). Although covering forest and environment issues in principle, these regional fora are dominated by agricultural concerns in the narrow sense.

"Natural resources management and agro-ecology" is one of the five high priority areas identified by GFAR in its program of work. To appropriately cover this priority area, GFAR will need to open develop a real forestry dimension at all levels (NARS, regional and sub-regional for a, global). Regional networks and associations of forestry research institutions, including APAFRI (now a Regional Chapter of IUFRO) and FORNESSA, should play an important role in this process.

Concluding Remarks

Networking is an approach and a tool, which is widely used in FAO programmes. Networking efforts have concerned all the spectrum of activities: theme-specific projects, regional programmes and global initiatives.

This brief review showed that, although generally successful because of their well defined and specific objectives, outputs and time-frame, theme-specific networks also have constraints. The main one is the inadequate or unsustained capacity of some collaborating institutions to fully participate in the network's activities and benefit from them.

The International Neem Network and TEAKNET are two species networks with broad objectives. The stepwise approach taken by the neem network allowed it to go beyond symposiums and planning meetings, and successfully undertake activities in its first area of focus: coordinated international collection, exchange and assessment of genetic resources of the species. The challenge for the neem network will now be to successfully develop activities to achieve its other objectives (steps), either by involving new collaborators with the required expertise or through collaboration with other concerned initiatives.

Technical and research cooperation networks to address common regional issues have generally fulfilled their role in exchange of information and expertise. These networks require external support to maintain contacts and remain competent resource groups able to provide valuable support to projects and initiatives in their field of expertise. One necessity for these networks, which were established a long time ago, is to periodically critically review and update their objectives and work plans.

Support to the networking of forestry research institutions has been a main thrust in recent years, to enhance national and regional capacities to prioritise and undertake research. FAO will continue to cooperate with IUFRO and other partners in these efforts.

Finally, it should be stressed that, in all the networking efforts facilitated by FAO reported here, a constant factor of success is the active, and often creative, cooperation with other regional or international programmes and institutions.

Sub-Plenary Session: E3

Cultural Diversity in Forest Management:

Regional Scenarios in Management of Forest Resources in the Tropics

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Forest Resources Management in Southeast Asia: New Directions

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Abstract

Over the last decade clear trends have emerged with the management of forest resources in Southeast Asia. Some countries have ceased timber production from natural forests, and are now net importers. Others are beginning to perceive declines in production. While these have serious economic implications to many countries in the region, concern for the rapid degradation and loss of some of the world's greatest species diverse forests has been turned into international issues. A number of international initiatives were made to bring about improvement in the management of these ecosystems and to ensure they are not totally degraded. Forest management has ceased to be mere pursuit of yield increments. It now has to address an array of issues collectively described under the principles of sustainable forest management. They encompass socio-economic considerations, environmental issues, and biodiversity conservation matters. Currently, there are approaches to enforce such measures by introducing certified "green" timber only to be traded in the international markets. There are calls to have independent assessment of the forest management as well. Since natural forest management is undergoing heavy scrutiny and greater controls, there are now moves to overcome the decrease in production by investing heavily in timber plantations. As a consequence, the private sector is beginning to participate in an industry that was once the domain of the public sector. Overall, forestry in Southeast Asia is facing considerable challenges ahead. Some future directions for achieving sustainable forest management in the region are discussed.

Introduction

A cursory glance at the timber trade worldwide would reveal some important clues. The area of closed forest in North America and Europe does not come close to that found in the Third World Countries of Africa, South America and Asia, yet the former have higher sector production and exports (Table 1) (FAO 1999). This could mean that the wealth of forests in the third world countries, which are mainly in the tropics, has not been truly realized as the case is with developed nations.

It is also apparent that among the third world countries, Asia and the Pacific region, while not in possession of the largest forest area, is yet enjoying a bigger production and export level. The Asia-Pacific region exports about 33,000 m^3 of industrial roundwood, against about 17,000 m^3 from Africa and South America. Likewise, the export value of forest products from the Asia-Pacific region in 1988 was over US$10 billion while that from the other two regions wass a dismal US$4 billion (FAO 1989).

What are the specific factors behind the strength in the Asia-Pacific region for the high productivity? A glance at the forest production and export values from Asian countries would provide the explanation (Table 2). Aside from the developed Asia-Pacific nations, the Southeast Asian countries are unusually productive, particularly Indonesia and Malaysia. The Asia-Pacific countries export over US$10 billion worth of forest products annually, of which half of it is coming from the two Southeast Asian countries.

Table 1. Total Forest Cover and Exports, 1995 (FAO 1999).

Region	Total Forest Area (x 1000 ha)	Industrial Roundwood Export (mil. cu. m)	Sawnwood Export (m. cu. m)
Africa	530273	7439	1351
Asia	503000	14336	6666
Ocenia	90695	18347	1067
S. America	870594	10066	3493
Central N. & America	536529	23701	58185
Europe	933326	46074	41865

With such a background, the management of forest resources in the Southeast Asian region deserves a further examination. There are numerous questions behind this review:

What circumstances have led to this apparent success?

Can the productivity be maintained?

Are there threats to the resources?

What are the strategies for long term sustainability and growth?

Forest Resource Base of Southeast Asia:

The Southeast Asian countries can be subdivided into the continental and insular Asian countries (Table 3). With the exception of Thailand and Vietnam, all the countries have between 30 and 66% of the land covered with closed forests. In general, the insular region is still well covered with forests, whereas the continental Southeast Asia appears to have lost some considerable areas. In terms of economic importance, forestry is critical for many of these countries. But for Thailand, Brunei and the Philippines, all the rest appear to derive around 10% of their GDP from forest products. Of them, the biggest money earners are Indonesia and Malaysia.

The forests in the continental region are tropical seasonal forests, and those in the insular areas are the rainforests (Whitmore 1974). The rainforests are the major source of hardwoods from the region. For example, of the 25 million m^3 of tropical hardwood logs traded at the world level in 1986, 21 million m^3 came from Southeast Asia and the Pacific region (Nectoux *et al*. 1991). Of that, 19 million m^3 came from Malaysia. It is the same case with sawn hardwood – a total of 6.7 million m3, which is 70% of the world's tropical sawnwood trade, originated from Southeast Asia. This is repeated with plywood as well – Indonesia is now the world's biggest tropical plywood producer, with an export of 5.5 million m^3 in 1987. The strength of Indonesia and Malaysia in the hardwood export market is mainly due to the presence of dipterocarps which dominate the rainforests of the region. These forests are particularly rich in timber as a result.

Forest Management or Forest Degradation

Considering the huge volumes of timber extracted from the natural forests in the region, naturally there is tremendous concern over the consequences:

Will the resource last into the long term?

What about environmental problems?

What are the economic consequences of forest loss?

Table 2. Summary of Forestry Statistics for Asia-Pacific countries (Only countries with >5 mil. ha of closed forest included) (ca. 1988) (FAO 1989)

Countries	Closed Forest Area (x 1000 ha)	Forest Sector Production (mil. US$)	Forest Products Exports (mil. US$)	Round-wood Exports (1000 m^3)	Mechanical wood (1000 m^3)
Australia	41,658	2,549	352	8,497	4,416
China	97,847	17,007	772	10	29,908
India	51,841	10,691	16	76	17,902
Indonesia	113,895	8,450	2,873	1,131	16,807
Japan	24,158	17,566	1,031	16	39,507
Kampuchea	7,548	154	0	0	45
Lao, PDR	8,410	101	10	34	21
Malaysia	20,996	3,922	2,572	20,853	7,706
Mongolia	9,528	128	0	0	474
Myanmar	31,941	599	87	206	498
New Zealand	7,200	1,485	439	1,728	2,445
Papua New Guinea	34,230	265	109	1,383	136
Philippines	9,510	1,349	279	603	1,573
Thailand	9,235	1,403	130	152	1,295
Turkey	8,856	1,629	37	23	5,704
Vietnam	8,770	756	0	0	394

Table 3. Forest resources of Southeast Asian countries (000 ha) (ca. 1985)

Countries	Land area	All forests	Closed forests (% land covered)	Timber Plantations	% GDP
Continental:					
Kampuchea	17,550	12,648	7,548 (43.0)	6	14.0
Lao PDR	23,080	13,625	8,410 (36.4)	11	12.9
Myanmar	65,770	31,941	31,941 (48.5)	15	7.5
Thailand	51,180	15,675	9,235 (18.0)	129	2.4
Vietnam	32,540	10,110	8,770 (26.9)	204	8.1
Insular:					
Brunei	590	560	393 (66.6)	0.5	1.0
Indonesia	181,160	116,895	113,895 (62.9)	1,918	7.4
Malaysia	32,850	20,996	20,996 (63.9)	120	10.0
Philippines	29,850	13,330	9,510 (31.9)	300	3.3

Deforestation

The Asia/Pacific region has for more than three decades been experiencing an exceptionally high rate of tropical hardwood removals (Table 4) (Grainger 1986). As noted earlier, most of it, over 60% comes from just two countries. This appears to result from forest conversion to other land use, mainly agriculture, logging activities.

A step back to the past would provide future scenarios. Not too long ago, countries like Thailand and the Philippines, well endowed with forests, were important exporters of hardwoods. Their rate of deforestation was in excess of 2%, and by the mid-1990s they ceased to be exporters, and are now net importers (Table 5) (WRI 1990).

Table 4. Trends in tropical hardwood removals (1965 – 1995)(in millions of m3)

	1965	1975	1985
All Tropics	77.746	113.747	134.418
Africa	11.666	14.296	17.370
Asia/Pacific	51.348	77.647	85.955
Latin America	14.732	21.804	31.084

Table 5. Area of natural forest and deforestation rates (ca. 1980) (area x 1000 ha)

Countries	Land area	% as cropland	% as forest land	Annual Deforestation rate
Continental:				
Kampuchea	17,550	17	76	0.3
Lao PDR	23,080	4	57	1.3
Myanmar	65,770	15	49	0.3
Thailand	51,180	39	29	2.8
Vietnam	32,540	20	40	0.6
Insular:				
Brunei	590	n.a.	79	0.3
Indonesia	181,160	12	67	0.9
Malaysia	32,850	13	60	1.2
Philippines	29,850	27	37	2.7

Indonesia and Malaysia, although still in possession of over 60% of their forests, are currently losing about 1% of their forests annually. If this trend is not arrested, these timber-rich countries would see the same fate of several other countries in the region.

Causes of Deforestation

Deforestation and the causes behind it are numerous and complex. The following are the leading factors behind deforestation (Panayotou & Ashton 1992):

a) Conversion to Other Economic Uses:

Large tracts of easily accessible natural forests have been converted to other forms of land use such as agriculture, mining, timber plantations, pasture land, urban development, hydroelectric dams, etc. Conversion of natural forest to perennial tree-crop agriculture such as rubber, oil palm, cacao, fruit trees, spices, coffee, sugar cane, etc. have been important economic developments in the region. The pressure to convert more forested land for such development has not ceased, considering the apparently high profits from such activities. These activities result in definite loss of tree cover from the area.

In several countries, governments sponsored settlement programs whereby people were relocated. This has been done in Indonesia, Malaysia and Vietnam. They are called the FELDA scheme in Malaysia and the Transmigration or resettlement scheme in Indonesia (Whitten et al. 1991). The schemes were a means to raise the economic standards of the settlers. Under the schemes, in excess of 10 million ha of natural forests were converted in the region to oil palm and other tree crops for the settlers to work on.

b) Uncontrolled Exploitation:

Although statistics are not available, effects of over-harvesting, overgrazing and fire damage, all of which lead to forest degradation must also be taken into account. The incidences of fire are increasing in the region, with three major episodes of fires in the region in the last two decades. In each instance, about 1 million ha, mainly the peat swamps were burned (e.g. Leighton & Wirawan 1986).

c) Shifting Agriculture:

The problem of shifting agriculture has been highlighted extensively. Easily more than half of deforestation in the region can be attributed to unsustainable shifting agricultural practices (Spencer 1966). The rapid growth of the populations and shrinking of the existing forested areas are the main reasons behind the failure of this age-old system of agriculture. Besides shifting agriculturists, encroachment by landless populations into newly logged forests is also taking its toll.

d) Logging:

Commercial extraction of timber in Southeast Asia has been shown to be largely destructive. An ITTO study concluded that very small percentage (less than 1%) of the natural forests in the region are managed on a sustainable basis (Poore et al. 1989). In all cases, over-harvesting has been the usual practice. The growth figures obtained from more recent studies rarely support the rate of harvesting, and the cutting cycles of 25-40 years are believed to be on the short side. The harvesting using heavy skidder-tractor machinery usually results in damage of over 60% to the residual vegetation (Appanah & Weinland 1990). The loss of potential tree crops as a result of logging damage has not been clearly recognized, but it is showing up to be considerable, and extensively depletes the stock left behind for the second cut (Appanah & Harun 1999). Logging is carried out with maximum speed, and rarely skidding tracks are pre-planned and controlled, very little road maintenance is carried out, directional fellings are rarely employed, pre-felling climber cuttings are not conducted, and little silvicultural tendings are done to improve the commercial regeneration. Besides damage to vegetation, the poor construction of roads, low maintenance, and the use of heavy machinery result in excessive soil erosion.

The overall conclusion is that in the long term, there will be less and less commercially valuable timber left behind. While total destruction of forests is not likely in every country, many of the logged forests would be poorly stocked, and natural regeneration would be scarce

Environmental and Economic Problems:

While deforestation is required in order to develop sustained agriculture and viable cash crop plantations, beyond certain limits such forest openings would cease to be economically beneficial. Some of the countries are already beginning to reach such threshold levels. But agriculture on poor or ill-suited soils has proven to be disastrous and wasteful. The harvests have declined, and farmers have become impoverished as a consequence.

Deforestation, besides loss of valuable wood which was often burned, has resulted in other serious problems. Heavy and unplanned encroachments have resulted in loss of major watersheds, which are facing severe devegetation and erosion (Hamilton & King 1983). This disrupts the water cycle, rivers and lakes become sedimented, and they finally affect agricultural development, hydro-electric dams, and silt up ports. In many cases, the economic gains from logging are heavily offset by costs to society from the environmental damage ensuing. The cost of repairing flood damage has not been estimated in the region, but in the example of the Himalayas, it was estimated at US$250 million per year (Spears 1982).

Logging often comes at the loss of environmental services whose values may even exceed the gains from timber (Repetto & Gillis 1988). Forests are the major source of potable water for large segments of the populations in the tropics. Many countries in recent times have experienced acute water shortages during unusual drought periods. The impact was most severe in areas which have lost their forests. It is indeed ironic that Southeast Asian countries which are some of the wettest in the world suffer from water shortages. A whole lot of other economic activities can be disrupted as a result of deforestation. They include river transport and ecotourism benefits. Climatic changes are also beginning to become apparent as a result of large scale logging activities (Sagan et al. 1979). Scientists speculate that large scale clearing of tropical forests may affect the reflectivity of the surface of the earth, which could alter global climatic patterns and shift rainfall distribution. Another deep concern is the release of carbon into the atmosphere as a result of burning of tropical forests. This additional carbon dioxide in the atmosphere can cause global warming as a result of the green house effect.

The loss of forests has been considered to have affected the livelihood of the indigenous and forest-dependent populations. Large-scale logging has resulted in loss of non-timber goods and environmental services, impoverishing the local people dependent on them. People who subsist on hunting, gathering fruits, nuts, cane, bamboo, medicinal plants, etc. have been affected (Caldecott 1987). Increasingly, non-governmental organizations have been vociferously campaigning against large-scale commercial loggings.

An additional facet to deforestation and forest degradation is the loss of biodiversity (Myers 1984). The rainforests of insular Southeast Asia fall among the richest zones for plant and animal biodiversity known in terrestrial ecosystems (Whitmore 1974). The loss has not been quantified, but considering some countries have already lost about 60% of the forest, the loss in biodiversity should have been substantial. Since not all the countries have done adequate surveys of the plants and animals, the losses may never be even recognized. The loss of biodiversity is not one of scientific curiosity. Biodiversity is necessary for: i) to sustain and improve agriculture and animal husbandry; ii) to provide opportunities for medical discoveries and industrial innovations; and iii) to preserve the choices for future generations (OTA 1987). The rare discovery of an important drug can revolutionize medicine, and that option should not be lost to future generations which may face new and unknown life-threatening diseases. Well-known drugs derived from tropical forests include the rosy periwinkle (*Cantharanthus roseus*), steroids from Mexican yams (*Dioscorea composita*), and antihypertensive drugs from serpent-wood (*Rauwolfia serpentina*). Next, the discovery of rubber tree in the Amazon should trenchantly state the point. Within this century, the crop has grown into a US$4 billion industry, and many countries are quite dependent on rubber exports for their foreign exchange. We are certain there still are economically important plants in tropical forests waiting to be discovered.

A Future for Southeast Asian Forests:

The overall situation for the remaining forests in the region appears gloomy. The once abundant and majestic moist forests have been reduced to half the original extent. If the deforestation and degradation trends persist, these forests will remain as small and isolated pockets in a landscape dominated by agriculture, scrubland, bamboo and grassland. This, however, need not be the case, and neither would the solution lie with locking these forests away for total preservation forever. Indeed this may prove to be disastrous in the end.

The rapid loss of tropical rain forests is easily explained. The populations are growing explosively in the region, and more people are forced to open up forests for a livelihood. Governments are also forced to open up more lands for cash crop plantations to create a cash economy for the rural poor. Besides the growth in populations, the region's economies are growing rapidly as well, creating a high demand for goods and services. Next, many governments, starved for funds, are treating forestry as a major source of foreign exchange. The result is liquidation of forests, and the funds are channeled to other sectors believed to have more growth potential. In all these cases, they do not recognize that forests can yield a perpetual flow of benefits from non-timber goods and services as well as timber. Neither are the costs of compensating for lost services taken into consideration. The result is heavy deforestation and under-investment into forest protection and management. Therefore, the future of tropical forests will depend on realizing their real economic value, and making economics work in their favour. Some of the steps towards making that possible are outlined below.

a. Reclassification and Gazettement of Forests:

In all these countries, forests have already been classified into totally protected, production, and conversion forests for economic development. With the exception of Burma, Laos, and Kampuchea, protection areas covering much of the biologically rich forests have been gazetted (Green et al. 1991). But problems still abound, and the governments' good intentions are often not matched with their capacity to manage them.

What is needed is a mechanism to implement the good policies which have been developed. In addition, many of these countries need to take a second look at their forest classification for production, protection and conversion. There are still large tracts of land which may be unsuitable for production or conversion to other uses. They are best as are, protection forests. On a positive note, in the last two decades, more areas have been classified into protected forests (Table 6).

b. Under-valuation of Forest Resources and Services:

Governments, as typical owners of forests, have consistently undervalued their resources (Repetto & Gillis 1988). They only capture a small fraction of the stumpage value or rent of the timber resource. This and the overvaluation of forest conversion have led to excessive deforestation and under-investment into forest management. The tax system is based on trees removed, with little consideration for the condition of the forest left behind. The additional costs of future silvicultural tendings are not captured. Neither are the economic losses resulting from logging taken into consideration – like the losses of minor forest produce, biodiversity, and fisheries. Similarly, the siltation and flooding problems downstream, additional costs incurred in treating water that is heavily sedimented, weather damage, and loss of recreational benefits and aesthetic values are never accounted for.

c. Multiple-use Management:

If forests are managed, it is usually for a single product, viz. timber. Although this pattern is beginning to change, nature reserves are being policed, and recreation is gaining importance, it is minimal compared to the logging industry.

Table 6. Forest areas devoted for protection in Southeast Asian countries (000 ha) (ca. 1985)

Countries	Land area	Closed forests (% land covered)	Existing Protection Areas	Proposed Protection areas
Continental:				
Kampuchea	17,550	7,548 (43.0)	2,035	467
Lao PDR	23,080	8,410 (36.4)	-	4,721
Myanmar	65,770	31,941 (48.5)	564	739
Thailand	51,180	9,235 (18.0)	4,479	1,185
Vietnam	32,540	8,770 (26.9)	625	-
Insular:				
Brunei	590	393 (66.6)	107	10
Indonesia	181,160	113,895 (62.9)	13,787	12,810
Malaysia	32,850	20,996 (63.9)	1,326	1,438
Philippines	29,850	9,510 (31.9)	177	62

Table 7. Minor forest produce from Peninsular Malaysia (1957 & 1981) (Appanah 2000)

Produce	1957	1981
Timber	2.2 million m^3 = $364 million	10.2 million m^3 = $1.02 billion
Minor Forest Produce:		
Rattan	$74,769	$179,374
Bamboo	$26,193	$101,232
Damar	$10,528	$616
Jelutong latex	$33,911	$938
Gutta-percha	$192	-
Nipah	$84,805	$7,311
Wood oil	$122	$703
Total for MFP	$230,520	$290,174

With the conflict between the various benefits from forests, multiple-use management will become necessary so as to balance the social and environmental benefits along with ecological sustainability (Panayotou & Ashton 1992). Multiple-use management requires a full evaluation of all the forest goods and services, and this is weighed in the selection of the optimal use or combination of uses the area can be put under. The result would be, certain areas may be designated as timber forest in which non-timber goods are collected, while other areas may be managed for watershed protection with limited logging.

d. Minor Forest Produce:

The role of minor forest produce has been misplaced nowadays. In the past, many people were engaged in the collection of rattan, bamboo, damar, jelutong latex, resins, wild game, fruits and nuts. They were undervalued, never entered the cash economy, and were treated as unimportant. However, these products support a large number of people, who either collect the material for personal consumption, or sell it in the local markets for small returns. The loss of such products can upset the economic lifestyles of a large number of people in the region. In Table 7, the value of timber and minor forest produce for two different periods are given (Appanah 2000). It is obvious that in the past, minor forest produce was a valuable resource, which has been on the decline compared to timber harvesting. The figures suggest that the forest dwellers dependent on such produce cannot rely on them any more.

e. Silviculture and Logging:

Current harvesting practices using skidder-tractor methods are extremely damaging to the soils, residual vegetation, and young regeneration (Wyatt-Smith 1987, Appanah & Weinland 1990). The result is heavy siltation of waterways, and high damage to the future crop. Studies in Malaysia have shown that the damage to the future crop is not tolerable, as quite a large number of them succumb to the damage, and ultimately die (Appanah & Harun 1999). The second crop is therefore depauperate of high value commercial timbers of sufficient volume. With unplanned and excessive skidder trails, large areas of the forest become compacted and the young regeneration is destroyed. Not only are the compacted sites unable to support vegetation growth for several decades, the regeneration for the third cut is mostly lost. Several low impact methods have been tried out successfully, which include helicopter logging, mobile skyline cable system, and the long haulage ground cable system (Sasaki et al. 1999, Shamsudin et al. 1999). All of them are very promising, and should be adopted as the suitable harvesting methods. Otherwise, the future productivity of many of these forests is questionable.

In the same manner, a number of management and silvicultural practices have often been abandoned or never implemented. These include constructing of good roads, pre-felling woody climber cutting to reduce damage, protecting buffer strips of streams, and enrichment planting of degraded sites. The technologies are well developed and can be implemented with very low costs.

The estimation of growth for calculating the cutting cycles are far too optimistic, and national averages are used. This leads to very short and unsustainable cutting cycles. Appropriate local growth data are needed for ascertaining the cutting cycles.

f. Plantation Forestry:

In view of the rapid loss of natural forests, plantations have often been promoted as a better alternative to enhance timber production in the region. This has been considered the best option for countries like Malaysia, Thailand, Indonesia and Philippines where the downstream industrial capacity has far exceeded the production from natural forests. The rationale is that natural forests at the most produce about 2.5 m^3 /ha/yr of commercial timber, whereas plantations can produce annually from 10 m^3 /ha of hardwoods to 30 m^3/ha of softwoods. If the plantations are well developed, they will indeed lift the pressure off the natural forests. However, the benefit of natural forests which includes the ecological services and biodiversity may not be fully realized in plantations.

The success of eucalypts, pines and teak in the sub-tropics and dry tropics is used as evidence for their viability in the wetter regions of Southeast Asia. However, the history of plantations in the region does not appear easy and straightforward. There are numerous difficulties whether they are indigenous or exotics, and whether they are monocultures or mixed species. In Table 8, the plantation areas in the region are shown. It is obvious that hardly any of the countries have even reached 1% in area compared to the natural forest areas found in their countries. Indonesia is the only one that has so far gone aggressively into developing their plantations.

The majority of the plantations are monocultures with exotic species originating from subtropical parts of the world. In the 1970s fast growing hardwood species such as *Acacia, Eucalyptus, Paraserianthes, Gmelina*, and *Leucaena*, and the pine species such as *Pinus* and *Araucaria* were planted (Appanah & Weinland 1993). All of them have short rotations, simple stand structure, uniform timber and can be harvested at one felling. Monocultures are not without problems either.

At present, more species are being tested, particularly the indigenous species and those with longer rotations. With appropriate silviculture and hygiene, the plantations are beginning to look more promising than the initial experiences indicated. With more research, particularly in production of planting material and tree selection and improvement, the plantations would meet their initial expectations and may produce more of the industrial timber by the end of the next two decades

Table 8. Forest resources of Southeast Asian countries (000 ha) (ca. 1985)

Countries	Land area	Closed forests	Timber Plantations
Continental:			
Kampuchea	17,550	7,548	6
Lao PDR	23,080	8,410	11
Myanmar	65,770	31,941	15
Thailand	51,180 32,540	9,235	129
Vietnam		8,770	204
Insular:			
Brunei	590	393	0.5
Indonesia	181,160	113,895	1,918
Malaysia	32,850	20,996	120
Philippines	29,850	9,510	300

But most countries will still be dependent on natural forests until the plantations reach maturity. Big planting programs have to start now if that success is going to be realized. In the interim, other sources of timber have to be sought. Agroforestry programmes too offer some hope there. Agricultural wastewood, such as rubberwood and fibre from oil palm fruit bunches and trunks are important sources of wood material for countries with such extensive rubber and oil palm plantations. Already, a US$1 billion furniture industry using rubberwood exists in Malaysia.

Conclusions

The rapid loss of moist forests and their inherent biodiversity have become international issues in the last two decades. People are now arguing that the future of the planet will depend on what happens to the remaining moist tropical forests. With that concern, many international initiatives were begun. The most prominent of them is the issue of sustainable development, and therein the need to manage the world's forests on a sustainable basis. Guidelines, referred as Criteria and Indicators, have been drawn by international agencies (e.g. ITTO's Objective Year 2000) which promulgate sustainable forest management. These guidelines promote holistic forest management, and pay attention to the issues of resource security, continuity of timber flow, conservation of flora and fauna, environmental impact, and socio-economic benefits of forestry. Many countries have developed their own Criteria and Indicators (e.g. the Malaysian Criteria and Indicators: Thang 1997), and are seriously looking at using these tools for managing the forests.

In addition to that, independent market initiatives have also taken place. Nowadays, consumers in developed countries are insisting that the products originate from sustainably managed forests. This has to be ascertained by independent agencies using Certification Schemes. A number of independent organizations (e.g. the Forest Stewardship Council) are overseeing the Certification of Forest Management. Local agencies such as LEI of Indonesia (Lembaga Ekolabel Indonesia) and NTCC of Malaysia (National Timber Certification Council) are organizing the forest certification activities within their countries. Likewise, Assessment Systems to test the quality of forest management have already been developed (Appanah et al. 2000). All these movements are in their primary stage, but with proper coordination and effort, the pursuit of sustainable forest management should be achievable in the next 5 – 10 years.

Besides the above two, there are also international initiatives that are looking into global environment and biodiversity. The Global Environment Fund has been set up to assist programs in tropical countries which are aimed at saving biodiversity and the environment. Although no significant work has yet to come out of this Fund, the world is awaiting for success from such efforts. One recent move that is beginning to take off is the Carbon Bond trading. Industries that are polluting the environment, such as fossil fuel burning power generation companies, are initiating projects for planting trees and managing forests in the tropics. That is a beginning for tropical forestry certainly. It brings forth one basic message – if indeed we belong to one global village, we must invest in the common goods, and must look after it.

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Regional Scenarios in Management of Forest Resources: Latin America

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Abstract

The paper presents some general figures of the forest resources and its dynamics: amount and evolution of resources, deforestation and its causes, the general forest management situation. The paper will also emphasies on natural tropical forests.

Through selected examples like forest management by the Chiquitanos communities in Bolivia, the extractive reserves in Brazil, forest management by farmers associations in Costa Rica, forest management together by a company and a Mayagna tribe in Nicaragua, the community forest management in the Atlantic coast of Honduras, the community concessions in Guatemala and the ejidos management in southern Mexico, and the impacts of forest management oriented to the markets over indigenous peoples and local communities, are analyse. Lessons will be also extracted on the potential of forest management through local communities. The paper also give a perspective of forest management by private companies in some examples like Mil Madereira Itacoatiara in Brazil, private companies in Santa Cruz with the Bolfor Project in Bolivia, forest management by PORTICO in Costa Rica, etc. The paper will analyse some of the most important changes in the communities and in business as a consequence of forest management.

The paper analyses also the general perspectives of forest management in Latin America and will projects different scenarios and assumes the different consequences that some global initiatives and policies may have, like the Intergovernmental Panel on Forestry and the Intergovernmental Forum on Forestry, the World Commission on Forestry and Sustainable Development, the Global Forestry Programme of UNDP, the forest policy of the World Bank, the Forest for Life Initiative of the WWF/WB, international certification and the Convention on Climate Change. The paper will states the basic assumptions about conditions needed to radically improve the situation of management of forest resources.

Keywords: Forest resources, Management, Latin America.

Sustainable Forest Management In Africa : The Challenges And Issues At Stake

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Abstract

Africa has about 1084 million hectares of forests and woodlands, which for decades have been a reservoir of genetic diversity providing on a continuous basis, the needed supplies of forest products , non-timber forest products, ecological benefits and a wide range of services required by the people inhabiting the region. The regional total of forest plantations raised in Africa towards the end of the last century was about 3.64 million hectares; a figure much lower than those recorded for Asia (15.86 million hectares), and South America (6.9 million hectares). With the current rate of forest depletion at 4.0 million hectares per annum, and increasing demographic pressures and human impacts; an era of chronic wood famine is imminent in Africa before the end of the 21st century. The sustainable management of the natural forest resources in Africa can be achieved through well structured research and development programmes. Potential areas of research studies demanding attention include: studies on natural ecosystem; forest resources assessment; harvesting and utilisation of wood and non-wood forest products; and management of watershed and mangrove forests. Proper execution of the research programmes highlighted above, would ensure continuous provision of the economic and social benefits of the natural forests in the region for the present and future generations.

Keywords: Africa, Sustainable forest management, Challenges and issues.

Introduction

The tropical forest resources in Africa cover about 1084 million hectares including forests and woodlands .Throughout the last century, the forests provided a strong economic base for most countries in the continent. In addition, they have been a reservoir of genetic diversity that provide on a continuos basis the needed supplies of forest products required by the people inhabiting the region, as well as help to protect the soil from erosion, floods, siltation and a natural buffer to unexpected climate changes , as well as provide avenues for recreation and tourism .

Sustainable management and development of the natural forest resources in Africa requires urgent attention .This is because of the great influence of demographic pressures and other human impacts which have caused massive degradation and deforestation of the forest resources .

From the miombo woodlands of southern/eastern Africa through the tropical high forests of western/central Africa to the dry forest of northern Africa, it is evident that men and the environment are in a race against time , as the rate of depletion currently placed at 4 million hectares per annum (Chamshama, 1998), far outweighs man-induced regrowth or reforestation efforts. The implication is that an era of chronic wood famine is imminent in Africa before the end of the 21st century.

Considering all the above problems, it is evident that there is an urgent need for a carefully monitored programme of sustainable management, conservation and development of natural forest resources in African region This goal can only be achieved through input from active forestry research activities, improved linkages between education, training, research and policy and research capacity building .

The Need for International Action for Solving Forest Resources Management Problems in Africa

The solution to the forest resources management problems in Africa requires the need to harness appropriate relevant research and development efforts within and outside the African continent. This is because, in as much as the nations in the region are resolved and are willing to face the challenges, the handicaps in terms of increasing rate of forest deforestation and degradation, inadequate research personnel, and/or poorly equipped laboratories, low funding for scientific research and development projects, as well as unfavourable government policies do compound the problems.

The Forest Deforestation and Degradation Issues

Shifting cultivation is responsible for 70 percent of deforestation in Africa (FAO 1982). Other causes are due to unsustainable use of forest resources to meet energy, construction, cash and food needs of the rural communities.

Perhaps, a recently discovered major actor responsible for forest deforestation and degradation in Africa is industrial exploitation of oil and gas resources. Although it is not yet given recognition, it has caused extensive damage to forest lands and resources especially in the oil producing nations in Africa. (ANWORD,1999)

Although the extent of forest damage due to industrial oil exploitation in Africa is yet to be fully quantified, reports have shown that forest degradation due to oil spills and fires in Niger delta region of Nigeria can be responsible for almost 35 percent of deforestation (Dada 1999) .

WRI (1994) provided data on the status of forestry resource base for all the countries in Africa over the last decades . On the average, most of the countries have forests and woodlands occupying about up to 50 percent of the total land area, with Democratic Republic of Congo (DRC); having the largest area of land under tropical high forests . With the current depletion rate of 4.0 hectares per annum, an era of wood famine is imminent in Africa in the 21st century, if the problems of increasing deforestation and degradation of forests are not checked.

In the last century, efforts were made by various countries in Africa to boost their forest resources through the establishment of man-made plantations. Evans (1982), reported the status of plantation forestry in the tropics . Towards the end of the 20th century, Sudan and Nigeria were estimated to have raised 480,000 hectares and 370.000 hectares, plantations respectively; while Botswana and Egypt have each raised about 800 hectares. The regional total of forest plantations raised in Africa during the same period was about 3.64 million hectares. This figure was much lower than those recorded for Asia (15.86 million hectares) and South America (6.9 million hectares) within the same period. The implication of the above figures point to the fact that more forests are being cleared in Africa than established (Evan 1982) . A situation requiring urgent international attention.

The Forestry Research Issues

Sustainable management of the forest resources in Africa requires major input from forestry research. Unfortunately, the present state of forestry research is incapable of meeting this challenge. Plumptre, Dada, and Foudjet (1992), and Chamshama (1998) in separate publications reported that forestry research and development efforts have failed to make the desired impact on improving the natural forest resources in the region due to limited nature of the research and development programmes carried out in solving the problems.

The reasons that may be advanced for the above are as follows :

i. Most of the R and D studies being carried out on forestry-related problems by various stakeholders such as Universities, Research Laboratories and Institutions within the region are limited in their scope, orientations, goals and objectives ; thereby resulting in overlapping, repetition and wastage of funds, which might have been applied or used for up-grading other related programmes that can promote or support the goal of sustainable management of the natural forests in the region.

ii. The flow of information on R and D between the various stakeholders within and outside the region is rather poor.

iii. The dearth of research personnel, poorly equipped laboratories, low funding for scientific research and development projects; and government policies.

Owino (1996) in an attempt to address these weaknesses, highlighted the merits and demerits of the following models and proposed them as being suitable for improved forestry research activities and capacity building.

i. Regional models
ii. IUFRO model
iii. Centers of excellence / postgraduate institutions model
iv. International research centers model
v. Models of developed country research institutions and competitive research grant models.

The African Academy of Sciences (AAS) in response to the need for improved and coordinated research and development activities in forestry, especially in the African continent , implemented the capacity building in the forestry research programme (CBFR). as an outlet of the AAS capacity building in science and technology (AAS,1997).

Initiatives for Sustainable Forestry Management in Africa

Realising the urgent need for sustainable management of the African forests and the need to reduce the problem of deforestation , IUFRO set up a special programme for developing countries with the main goal for improving the living conditions of the rural and urban poor population. In line with the above programme, FAO , CIFOR and ICRIS group in 1998 , also recommended the need to establish a global forum or other appropriate body to bring

together forest research agencies, policy makers , funding agencies and other stakeholders that can aid sustainable management of the forest in Africa. In response to the above, a regional forum- The African Forest Forum (AFF); was initiated with the objectives for;

i. Charting and evaluating the research and the development efforts on forestry management practices in Africa.
ii. Providing guidance and initiatives aimed at enhancing sustainable development of the forests and environment .
iii. Strengthening of policy- science linkages ,and
iv. Actualising the vision for sound environmental and sustainable human development programmes for Africa, and spring board for international cooperation.

Along with the AFF initiative is the proposed African Forest Institute(AFI) which in effect would serve as a monitoring and coordinating body for AFF programmes in Africa and a linking bridge between Africa and other similar international bodies and global fora . However, the initiatives would require strong support by the international community to make the vision of sustainable forestry management in Africa realisable.

Challenges to Effective Natural Forestry Management Research in Africa

A sound forest research base is required for the sustainable management of natural forest resources in Africa. The development of such a base requires the consideration of the underlying factors which should be given more attention in the quest for developing a sustainable management programme for the forests in Africa .

Improved Linkage Between Research Needs and Formulation

There is currently a wide gap between users of research results and researchers. The consequence of this is that most of the research results have not only been sparsely used, they have largely failed to meet emerging challenges facing sustainable management of the natural forest resources in the region. The wide gap between researchers, users and policy makers have made difficult adequate considerations for research especially, when it comes to funding. Research and development efforts that are based on systematic interaction between users of research results, and researchers are those that can provide effective solutions and which can closely fit the user's need.

Research Priortization

This is an important challenge to effective natural forest research management in the region. Priority setting mechanisms at the regional and national levels are often weak or non-existence. In cases where they exist, the mechanisms are often controlled by those with little or no knowledge of forest related sciences and policy relevance.

As a result, current research activities within this region have failed to resolve pressing issues from the various stakeholders. Priority setting mechanisms that would be simple enough to be administered at the regional and national levels, and which would bear relevance to the socio-economic needs of the rural people in the region are urgently required.

Forestry Research Networking

Sustainable management of the natural forest in the region may not be realisable except the various activities and resources geared towards achieving the goals are properly harnessed through a viable cooperative R and D network.

Chamshama (1998), outlined some factors as being necessary for successful networking as follows:

(1) Structures, rules and procedures should avoid conflicts of interest.
(2) Governance should attempt to achieve a healthy balance among conflicting interests to avoid incapture of activities by a particular group.
(3) Governance should devise appropriate response to the "free rider" problem, investment in management, personnel and systems necessary in operating successful network and need to maintain accountability.

Networking would permit sharing of knowledge and skills between stakeholders within and outside the region. It can be an important option for many countries and institutions within the region to overcome resource constraints and to enable the transfer and adaptation of technology found appropriate elsewhere.

It should also have a potential of helping to build research capacity and promote sustainable use of the forest resources by the people, most especially the rural communities whose impact on the forests and environment can be devastating.

Capacity Building for Forest Research

The performance and effectiveness of a forest research institution at solving forest related problems determines the ability for undertaking research by that institution, either in cooperation with stakeholders at national or international levels.

It is only by improving current efforts in forest research capacity building in the region that sustainable development of the natural forest can be achieved. Since research capacity of most countries in Africa are under-developed; the need for improved capacity building to aid the current programme already initiated by the AAS (African Academy of Sciences), would be required to assist in the transfer of research results; to enhance the use of available knowledge; to improve networking; and to facilitate science-based decision-making at all levels. It is however expected that support provided to achieve this goal would be consistent, flexible, and output oriented.

Key Issues in Research and Development of Natural Forest Resources in Africa

The natural forest resources in Africa provide a rich variety of goods useful to the affluent industrial and poor rural communities. The range of goods and services provided by the natural forests include sawn timber and panels for construction, walls, doors and furniture; mining timbers and railway track slippers;

fuelwood as well as other non-wood forest products such as fruits, game-meat, honey, pharmaceuticals, fibers, gums, skins, waxes and oils; amenities and recreation, and soil protection.
The above forest products, and non-wood forest products provide annual earnings from export for most of the countries in the region Some important areas of research necessary for promoting sustainable development of the natural forest in the region are discussed below:

Studies on Natural Forest Ecosystem

There is need for more information on the ecological features and functions of the natural forest eco-system. In certain countries of Africa, certain tree species and eco-systems have been so heavily exploited that they have declined to a level from which it may take some time to recover. For example, certain wood species labeled "Lesser Used Species" (LUS) in Ghana (Oteng-Amoako, Ebanyenle, and Awuku,1998), have virtually disappeared in the forests of Nigeria and Cote D'Ivoire. In effect, studies would be required to determine the productive capacities of the exploited species as well as the eco-systems, and also to provide guidelines that will ensure that the level of utilization does not exceed those capacities. Currently the production capacities of most of the species in the natural forest are unknown, in some countries. Detailed evaluation of the functions of the natural forest ecosystem is necessary in order to assess the characteristics of the eco-systems and match them with the most appropriate uses.

There is the need for research on eco-system dynamics and their relationships; the effects of human activities on ecological processes baseline monitoring; and other basic eco-system species. There is also an urgent need for population studies based on the natural forest eco-system that would provide the much needed information on the ecology and functions of the natural formations. Finally, there is an urgent need to step up the current level of applied research on the natural forest ecosystem in the eco-region. This is important, if policy makers are to be given better advice on matters as to the extent the coastal wet lands can be modified.

Studies on Forest Resources Assessment and Valuation of Forest Products and Services

Many of countries within Africa, lack adequate information on their natural resources due to weak data gathering capacities, poor data retrieval and data distribution systems. The effect is that the countries lack the information base necessary for rational resources planning and management. For example, there is need for information on the extent of forest cover, the area under de-reservation or reserved protection, and the rate of its removal; as well as species inventories for the areas. Also important are information on the degraded forest areas as well as the reserved protected areas. There is need for research on the distribution of ecosystems and species in each country within the region, as well as studies on standards, technologies and techniques that will improve the planning and management of the forest resources use.

The implications of the above studies are that they would provide and aid decisions on the optimum distribution and management objectives for protected/reserved areas, and give insight on where particular conservation measures are needed and aid other aspects of planning and management. Important studies that will be required to achieve above objectives include field studies, mapping of the locations showing extent of severity of erosion, mapping of the relationship between the distribution of important, rare or threatened species in the ecosystems and potentially damaging human activities.

Studies on Forest Harvesting and Utilization of Wood and Non-Wood Forest Products

Industrial forest harvesting is responsible for most of the high rates of deforestation and forest degradation in many parts of the region. Harvesting primarily involves forest land clearing, and poor harvesting practices can deplete forest stand and site resources, resulting in forest degradation . Reliable estimates and projections of the rate of forest degradation and destruction in the region are currently not available. For more sustainable forest practices in the region, it is important to

develop studies to identify the location and severity of the problem. This can be done by initiating and coordinating reliable and comparable forest impact data on forest harvesting operations carried out in the natural forests of the region.
For sustainable use of the natural forest resources, it is important to develop experimental research and management studies aimed at promoting the lesser used wood species, development of more efficient processes and machinery/equipment for processing wood and non wood forest products, to reduce waste and incidental destruction during exploitation.

In the region, there is a great need to develop programmes aimed at promoting rural development based on production systems that enable high proportion of forest cover to be retained (Dada, 1998) and to develop systems of commercial exploitation that utilise other non-wood forest products such as drugs, gums and resins, dyes , and natural silk.

Other research areas that would require urgent attention are assessment of logging residues and their utilization potentials. Development of harvesting models for evaluating flow of logs from the forest to the mill. Such models would permit simulation of certain field actions and studies of their effects on the forest stands without damaging the ecosystem (Dada, 1998).

Equally important are studies to evaluate the annual demands by the forest products industries as well as an assessment of their annual tree removal and/or planting rates. There should also be studies on densification of forest residues and industrial wood wastes for domestic fuel .

Study on Watershed and Mangrove Forests Management

Inadequate management of the watershed due to excessive deforestation and other demographic pressures in the catchment areas of most countries in Africa have resulted in very harmful effects in most of the rural communities downstream. The flooding and gullying emanating from the above have destroyed many of the rural communities and their life-support systems as well as caused siltation of irrigation systems and reservoirs which have reduce flow rate during the dry season, causing loss of water supply and low hydroelectric power generating capacity. The above situation is a major problem currently confronting several nations in the region.

An important watershed is the Lake Chad Basin, which adjoins about four countries (Nigeria, Cameroon, Niger and Chad) within the region. As a result of decades of uncontrolled and excessive dredging and irrigation practices within and around the basin, the watershed has completely dried up. In fact on a recent Map of Nigeria, Lake Chad no longer exists.

Still worth mentioning is the on-going dredging programme of the River Niger from the Delta on the southern coast of Nigeria and along its natural course in Niger Republic. These projects have caused untold hardships and displacement of the rural inhabitants living on the banks of the river as well as massive disruption of the mangrove swamps and coastal wetlands critical to the aquatic habitat of the marine species.

The sustainable management of watershed and mangrove forests are further complicated by many competing uses. In most of the countries, decisions on their uses by policy makers are taken without due regard to the grave consequences of such actions. The major reason for this is the absence of appropriate criteria and indicators that might provide guidelines for policy makers and forests managers in their decisions amongst competing users.

Research studies on development of models for predicting use patterns and effects on the watershed and mangrove ecosystems are urgently needed. These would provide the much needed guidelines for sustainable management of the fragile ecosystems. In countries within the region where watershed forests have been severely reduced and siltation and flooding have increased; studies should be carried out to determine methods of restoring the ecosystem through selection of appropriate species to be used for reforestation. Other relevant studies that would promote conservation of this fragile ecosystem should be encouraged .

Studies on Policy, Socio-Economics, Community Forestry and Poverty Alleviation

Policy and socio-economic research for forest resources management in Africa have generally received limited attention. Hitherto, policy and economic issues were seen as being relevant only as far as production of timber from mainly forest plantations was concerned.

It is now widely recognised that the forests provide a range of non-timber forest products and ecological services to a wide range of people. There is a link between forestry and food availability. The food items include fruits, nuts, leaves, and other examples of large number of edible foods can be obtained from trees and shrubs. In fact, studies have shown in Asia, that community involvement has resulted not only in sustainable forest resource management but has also aided poverty alleviation in rural communities. Studies are therefore needed in Africa on community involvement in forest resources management, both in the protected and reserved areas.

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INTRODUCTION

This volume of Congress proceedings includes summaries of oral presentations in Group Sessions and Poster/Panel Sessions received by 31 May 2000. Minor changes may have occurred since that date. The Session moderator will mention them when opening the Session.

The following Sessions include posters:

Tuesday 8 August :

* 8.05.00. Forest fires (I). Southeast Asia
* 8.05.00. Forest fire (II). South-east Asia and other tropical regions

Wednesday 9 August

* 1.09.00. Short-rotation forestry for biomass production (II)
* 1.17.03. Tropical forest restoration (I) and (II)
* 6.03.02. Forest terminology
* 8.00.00. Environment forest science in the 21st Century
* 8.05.00. Forest fire (III). Temperate and boreal forests

If provided to the CSC in due time, corresponding poster summaries are included once in this volume, in the Session where they are presented first and additionally in the second section of the poster summary volume of the proceedings.

Special thanks to the authors for their contributions to the scientific programme of this Congress. Enjoy your stay in Malaysia.

Eric Teissier du Cros, Chairman of the CSC

Note: The summaries have been published as received by the authors and reviewers, respectively, who have sole responsibility for their content.

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Division 1
Silviculture

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1.07.00 Tropical Silviculture

Forest Destruction in Brazil and Cameroon, a Comparative Analysis of the Actors of the Deforestation Process

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To understand why forest destruction continues in the Amazon every year with a dazzling rate and why the Congo Basin is seriously threatened, the paper analyses the local context of forest dwellers and the interactions with the regional and national level. in Brazil field data from South-Para show the link between small farmers, loggers and large-estate owners at the forest frontier and their relationship with the urban centre and the different governmental levels. This context tries to describe the influence of powerful actors and their interests, which decide why the Amazon forest burns every year again. in the East Province of Cameroon, selective logging by foreign companies is the main industrial activity, provoking serious confrontations with the traditional farming and gathering practices of local people. The rent-seeking behaviour of the central government with its opaque concession policy is the main player and its links with loggers and local elites is decisive to understand the fate of the Cameroonian forest. This research uses an actors' view to show that local actors choose mostly the option of forest destruction as a result of activities of other actors at regional or national levels. This view explains why this is, from their point of view, the best and most efficient way of using their resources. The practical use of an actors' perspective is that it identifies the obstacles that local actors are confronted with and which cause the bottlenecks for the sustainable options of forest conservation, agroforestry and NTFPs. It should help policy-makers and international donors to combine more adequately their forces resulting in a sound forest management policy, and to develop instruments for forest protection adapted to the local context.

The comparative perspective enables to anticipate and to compare trends, *e.g.* the presence of Asian timber companies in both countries. It also helped to discern the different cultural and policy context and its consequences for the future of the forest. On the one hand, the booming logging industry, which is already established in Cameroon is something many Brazilian state governments want to promote. On the other hand, the empowerment of Indians and landless farmers in Brazil has already resulted in the acquirement of land for local people, while this is still the largest challenge for forest dwellers in Cameroon. Especially for international donors and policy-makers, a comparative analysis gives grips and indications to decide for new projects and which measures are strategically the most accurate in a specific context at a certain time.

Tools for a sustainable management of African closed rain forest

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African production forests are being exposed to ever-increasing pressure from logging. It should be possible to make logging compatible with sustainable management. Logging must become a real silvicultural tool followed by thinning. They represent two basic silvicultural operations designed to improve natural forest productivity. The intention is to take advantage of the growth dynamics of the trees by means of thinning operations affecting non-commercial species to balance the logging of commercial species.

Mean volume increment of 75 commercial species, whose diameter is superior to 50 cm, is included between 0,5 and 1,5 cu.m/ha/an. An optimum loggable diameter must be set for each species on technical, economic and ecological criteria. This diameter will be decided upon after analysis of the diameter structure. The loggable volume per hectare must be limited to 25-30 cu.m/ha. Beyond this threshold logging damage becomes considerable. This maximum loggable volume must take into account the growth of the stand during the chosen rotation. The regeneration shoots damaged by logging must be coppiced. After logging, recruitment of commercial species, reaching 10 cm of diameter, is about 3-5 stems/ha/an. Modeling growth, of semi-deciduous forests, shows that waiting periods of 30 years are necessary to reconstitute a stock of 2 or 3 commercial stems (diameter > 60 cm). 30 to 50 years are necessary to restore the initial stock of logged stems.

By means of a thinning operation in non-commercial species it is possible to speed up the restoration of the loggable commercial species stock and to reduce the period between two successive logging operations to around 20 years with partial restoration of initial commercial stock. in forests previously logged, logging rotation of 30-50 years is recommended, depending on the richness of commercial species stock. Systematic thinning must be banned. Selective thinning will be carried out within a radius of about 10 metres around selected future trees (diameter < 50 cm).

Some recommendations can be made for natural regeneration. For commercial species, it is important to keep seed-bearing trees evenly distributed for all species. Non logged clumps, for example, may be kept within logged plots, as can large trees. Opening up the cover should be done carefully in order to limit the spread of creepers and other undesirable adventitious plants in the holes made. Large holes in the cover often give rise to a mediocre regeneration of commercial species (except for *Okoum*, *Ayous* and *Limba*). Main damage in the regeneration occurs during hauling which must be carefully carried out and monitored.

Keywords: Africa, rain forest, management, silviculture, thinning.

The Sustainability of Short-Rotation Plantation Forests in Indonesia

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Short-rotation plantation forests for pulp production has increased significantly in the last few years in Indonesia. More than 800 000 ha plantations have been established and 13 pulp plantation projects have been approved. While many of the recently developed pulp mills have been using mixed tropical hardwood for their raw materials, woods from plantations are becoming available. The bulk of recent plantation forest is established mostly on soil relatively having inherent poor fertility and high acidity. *Acacia mangium* is the principal species to be planted due to its fast growth, high adaptability to existing site conditions and suitability of its wood for pulp and paper making. Current development of plantation forest and plantation management is discussed in great detail. This paper also presents the preliminary results of site management and productivity studies and discusses the long-term sustainability of short-rotation plantation forests in Indonesia. It is believed that the sustainability can be attained through the adoption of improved silvicultural practices including organic matter retention, attention to weed control, amelioration of soil nutrition, genetically improved planting stock and improved harvesting practices that minimise physical damage to site and that conserve organic matter, while in the mean time taking into account the social and economic conditions of local people in the management of plantation. Dispute on land ownership of the plantation must also be resolved properly.

Keywords: short-rotation plantation, productivity, sustainability, second rotation, Indonesia.

Silvicultural Principles: Synthesizing Temperate and Tropical Forestry Research

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Silviculture focuses on understanding and managing forests for human values and should, therefore, be central to any discussion of forests and society. This paper considers how silvicultural principles could be used to generate focus within the discipline, communicate with specialists from other disciplines, guide research investment decisions, and speed development of management systems for lesser known species. The paper focuses on the silvicultural principle of size-density relations and how it has been investigated in temperate and tropical forests. A review of key studies emphasizes the consistencies and contradictions of experimental results, as well as gaps in research. Applied techniques, such as density management diagrams are based on size-density relations. The extent to which these and other techniques can be adapted to different species and latitudes depends on the generality of underlying principles.

Keywords: size-density relations, competition density, self-thinning

Growth of plantation-grown *Azadirachta excelsa* (Jacobs.) three years after planting

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The growth performance of plantation grown *Azadirachta excelsa* four years after planting is discussed. The site is located in Sime Darby Plantation, Malacca, South of Peninsular Malaysia. The soil is derived from granitic rock and is classified as Rengam series (Typic Palaeudults), with sandy clay, slightly firm and compact. Formerly, the area consists of an old rubber plantation, which was manually cut and burned. The slope gradient ranges from 2 - 6 percent. The seedlings were collected from three different seed

sources: Field 2D1, Bukit Lagong Forest Reserve, Forest Research Institute Malaysia, Selangor, Central Kedah and South Thailand. Two hundred seedlings from each location were monitored. The overall growth results from Field 2D1, Bukit Lagong Forest Reserve, Forest Research Institute Malaysia, Selangor, show the best performance in terms of average diameter at breast height and total height of 11.0 cm and 11.45 m and survival rate at 78 % followed by Central Kedah; average diameter at breast height and total height of 10.2 cm and 11.20 m and survival rate at 87 %, South Thailand; average diameter at breast height and total height of 9.9 cm and 10.85 m and survival rate was 71 % respectively. There was no distinct different in term of average height from each location. An average annual diameter increment of more than 3.0 cm for the PCT was achieved for each plot.

Keywords: Growth performance-*Azadirachta excelsa*- average diameter at breast height-average height-survival rate

1.07.09 Silviculture in Latin America

The ecological basis for the management of Central American lowland rain forests: an ecoregional approach

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The broadleaved lowland rain forests (LRF) of Central America are of considerable social, economic and environmental importance to the region, and an ecoregional overview of biophysical aspects of their management for production is now both possible and timely. This review draws heavily on research carried out by CATIE during the last 15 years, concentrating on the most extensive LRF ecoregion in Central America, the Central American Atlantic Moist Forest (Dinerstein et al., 1995), which stretches from central Panama to Belize and Guatemala. Bioregionally outstanding and vulnerable from the conservation standpoint, this ecoregion is also the main source of timber in countries such as Costa Rica and Nicaragua. Frequent hurricane impacts in the centre and northwest of the ecoregion contribute to the diversity of forest types within it, as forest structure and composition in the "hurricane belt" show evidence of long-term adjustment to hurricane disturbance. Work on the north coast of Honduras indicates that the regeneration of certain particularly important commercial tree species may be dependent on such disturbance, though hurricane-impacted forests are compositionally very distinct from true secondary forest (SF) regenerating on abandoned agricultural land. Throughout the ecoregion, SF is characterised by a well-defined group of long-lived pioneer species, most with useable wood. The low elevation forests of the sector from southern Nicaragua through Costa Rica to western Panama are quite well-documented regarding local differentiation of forest types, stand dynamics and silviculture. Primary forest of well-drained soils on undulating or hilly terrain is usually dominated by *Pentaclethra macroloba*, though in northern Costa Rica, this species is infrequent in forests near the western boundary of the ecoregion. The characteristic canopy species associated with *Pentaclethra* on soils developed on old alluvial terrace are different from those of residual soils on ancient lava flows. *Pentaclethra* is also present in wetland (mainly floodplain) forests, which nevertheless show their own characteristic suite of dominant canopy trees. On both well-drained and wetland sites, forest may show marked compositional variation over short distances in relation to substrate factors. The use of existing information on forest types could greatly facilitate planning for forest management and conservation in the ecoregion.

Pentaclethra forests appear to be among the world's most dynamic tropical forests, and monitoring of stands managed for timber production indicates they are both resilient and productive. Liberation thinning produces marked increases in commercial diameter increments and under this treatment, many common commercial species show median increments in the range 0.5 - 1.5 cm yr^{-1}. Mortality rates may increase following such treatment, however; in addition, non-commercial species strongly impacted by silvicultural treatment also tend to be slow-growing, factors which may contribute to long-term decline of their populations. Mortality rates in wetland stands appear similar to those of *Pentaclethra* forest. The commercially important wetland dominant *Carapa guianensis* is nevertheless slow-growing, though it may grow faster in wetlands than on well-drained sites. *Vochysia spp.*, *Inga spp.* and *Goethalsia meiantha* are among the characteristic long-lived pioneers of SF in this sector of the ecoregion. SF in small patches on undegraded sites, with adequate seed sources, is highly productive even on Ultisols, primary forest basal area being reached in < 30 yr, and tree species of this guild may reach harvestable dbh in 15-30 yr; patterns of stand dynamics and tree growth indicate that monocyclic silviculture is particularly appropriate in such situations. Larger

SF patches, on sites degraded by activities such as cattle ranching, exhibit more complex stand dynamic patterns, however, and significant within-patch variations of site quality may become evident. SF will probably maintain a species composition completely different from that of primary forest for >100 yr.

Research-based Approaches to Sustainable Tropical Forest Management in Bolivia

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Tropical lowland forests occupy more than half of Bolivia and represent some of the largest remaining tracts of South American tropical forest outside of the Brazilian Amazon. Where access has been available, many of these forests have been subjected to highly selective logging of mahogany (*Swietenia macrophylla* King.) and a few other highly valuable species. Almost uniformly, this logging has been unplanned with little thought for future harvests. Now, Bolivia is embarking on the implementation of a new forestry law that, if successful, will bring the national forests closer to sustainable forest management. It will be important that forest management plans are based on forest research conducted in Bolivia or in adjacent countries with similar forest types to achieve sustainability. For the past six years, research in ecology and silviculture has been carried out by Proyecto BOLFOR, a sustainable forest management project located in the lowlands of Bolivia. Research during this period has been conducted in many areas, but most studies have had some common themes. These include basic research on the silvics of forest tree species to determine appropriate silvicultural treatments, testing silvicultural systems that provide for profitable and efficient harvesting while promoting regeneration, and reducing the impacts of forest harvesting and other silvicultural treatments on biodiversity. This research has provided information on the phenology, environmental preferences, growth rates and regeneration ecology of a large number of lesser-known species that may increase options for forest management and increase the value of Bolivian forests. Without this information, forest managers have conducted forest harvesting that has been inappropriate for securing the regeneration of the timber species. For example, highly selective logging has almost uniformly been applied in Bolivia, regardless of the fact that the majority of most valuable timber species have low densities in mature forests and require large disturbances for regeneration. Furthermore, pre- or post-harvesting cultural treatments, such as vine cutting, prescribed fire or release treatments, have not been applied to promote regeneration and growth of timber species. The result has been a gradual trend towards the commercial extinction of the most valuable forest tree species. Deforestation in Bolivia has occurred when forests have been degraded of their economic or ecological value through unplanned logging or the application of inappropriate silvicultural systems. Subsequently, forests have then been converted for other uses, such as agriculture, cattle-grazing, or community settlements. To prevent forest conversion, research must provide information on how to profitably harvest forests while promoting regeneration and protecting the ecological integrity of forests. An important challenge will be to disseminate the results of research successfully and promote the use of appropriate silvicultural systems in a country with little experience in forestry other than unplanned logging.

Forecasting sustainable cutting cycles in a Venezuelan lowland forest with the process-based model FORMIND2.0

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1. We simulated growth and yield of logged-over forest under different logging scenarios over a period of 240 years and compared results with an unlogged stand using the process-based model FORMIND2.0.
2. Stability and sensitivity analysis showed that the stand dynamic was simulated in a realistic range.
3. In the absence of further logging, the logged-over stand approached the stand structure of mature forest in terms of bole volume and basal area after about 50-100 years.
4. Thirty year cutting cycles with conventional logging methods and net extraction volumes of 45 and 60 m^3 ha did not provide sustainable yields under both minimum felling diameter (MFD; 35 and 50 cm, respectively) applied.
5. Only 60 year cutting cycle showed sustainable yields under both logging methods (conventional and reduced-impact logging) with the different MFDs and the whole range of net volumes extracted (30 - 60 m^3 ha^{-1}).

6. Scenarios with reduced-impact logging provided a significantly higher timber volume than under conventional logging.
7. With the longest cutting cycle (60 years), bole volume recovered to levels similar to the mature unlogged stand, while species composition differed significantly.

Keywords: functional groups, logging scenarios, simulation, sustainable timber harvest, tropical forest

Development of Preliminary Stand Growth Scenarios Based on the Relationship Among the Crown Composition, the Crown Structure and the Productivity of *Tectona grandis* and *Bombacopsis quinata* Plantations in Costa Rica

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Projects and private companies in Central America urgently need relevant information on the growth and productivity of priority species used in reforestation, such as *Tectona grandis* (teak) and *Bombacopsis quinata* (pochote). Determining production at the end of the rotation is particularly necessary in the case of advanced aged trees (over 20 years). Spatial competition among plantation trees is one of the decisive factors for adequate growth. One means of evaluating the effect of reduced competition is to monitor tree development. Research was carried out on forest plantation dynamics (study of tree development through time), identifying the composition of crown biomass as an important indicator of competition within a stand, and the effect of this competition on other growth variables. The main objective of this study is to develop preliminary forest management proposals for *Tectona grandis* and *Bombacopsis quinata* plantations to ensure high stand productivity. Models were developed for different relationships among the variables, crown composition, crown structure, growth and productivity, using information from advanced aged teak and pochote plantations in Costa Rica. The basis for the stand growth simulation models included growth and productivity information obtained from the plots measured in the field, results from stem analysis, the relationships among composition and crown structure, growth and productivity. Eight scenarios are presented for each species, using intensive management criteria of a maximum basal area of 18, 20, 22 and 24 m^2/ha, and two initial plantation densities: 1111 and 816 trees/ha. in the preliminary growth scenarios for teak, rotations periods between 25 and 28 years were evaluated, with final densities of 97 to 125 trees/ha, average diameters of 45 to 50 cm, and total average heights of 30 to 34 m. The productivity at the end of the rotation varies between 10.2 and 13.3 m^3/ha/year, yielding a total volume of 270 to 380 m^3/ha. For pochote plantations, scenarios were developed for rotation periods between 24 and 29 years, using final densities between 110 and 130 trees/ha. Expected results include trees with average diameters of 45 to 52 cm, and total average heights of 30 to 35 m, equivalent to a total volume of 220 to 331 m^3/ha, and an annual productivity rate of 9.0 to 11.3 m^3/ha/year. Cost comparisons for intensive versus traditional management practices indicate that the former requires a 25 to 33% higher investment than traditional management. The Pipe Model Theory was tested for *Tectona grandis*, confirming its use for advanced age trees of up to 46 years, evaluating the relationship between the sapwood area at the base of the tree (cm^2) and at the crown base (cm^2), with the foliage weight (kg). in the case of pochote, there is a relationship between the sapwood basal area at the tree base and the crown base with the foliage weight. in addition, for 10 to 23 year old trees, the next to last growth ring of the tree base is strongly correlated with dry foliage weight. For teak plantations, it was possible to carry out stem analysis on trees from dry zone plantations, using the clearly formed rings resulting from a marked seasonality in the area. However, for pochote it was more difficult to identify growth rings in many cases, despite the marked seasonality in the areas such as Jicaral and Samara in Guanacaste. The evaluation of growth scenarios, based on reliable data for plantation growth in the country, was a useful tool to make predictions for plantation management over time. The scenarios allow for the anticipation of future productivity and yields, based on current and potential growth in terms of basal area in the site. *Tectona grandis* and *Bombacopsis quinata* are species with medium to rapid growth, but require intensive management. The present study seeks to contribute to management strategies for these species. Recommendations include reinforcing the results obtained with more data from advanced age plantations, particularly for those older than 20 years.

Silviculture in humid lowland forests of tropical America: assessment of current practices and recommendations for future improvement

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The paper reviews and synthesizes past and current silvicultural research and practice for the management of humid primary and secondary forests as well as degraded forest lands in tropical America. This is used to derive some practical lessons to be learned and to identify successful cases and contributing factors. The analysis then focuses on the current application of common silvicultural practices in the region to assess their merits and constraints. A set of guiding principles and "best silvicultural practices" is proposed for two broad management scenarios for silvicultural work (i.e. primary logged-over forests and secondary forests). The last part addresses some ways to improve the adoption of best silvicultural practices in the region. The discussion considers, among other aspects, the potential of on-farm (participatory) silvicultural research, the market prospects for promising timber species, the incentives for forest management, and the need for revision in policy and legislation.

Tropical silviculture: where should we invest?

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Looking at the international literature, the overall perception is that tropical silviculture means plantation forestry. But plantation forestry is not the only alternative for management of forests for wood production in tropical regions. in terms of economic return in short time, no doubt that plantations are the best choice. If other values like biodiversity, environmental conservation or sound utilization of natural resources are aimed, focus should be put on management of natural forests. Very important for tropical silviculture are secondary forests, which may have two origins: overlogged primary forests or a secondary forest succession on former forest lands which were used for agriculture or pastures. Silvicultural treatments are quite distinct for this two types of forests. in the first case, normally biodiversity was not to heavy affected, but wood quality of the trees is poor. in the second case, the forests have a very simple structure, but with the absence of the valuable, slow growing tree species. Silviculture means the manipulation of the forest to achieve objectives, which may be a special product (*e.g.* wood), service (*e.g.* carbon fixation) or other commodity. For correct actions we need knowledge of a lot of relationships, between tree species (like *allelopathy*), between trees and soil organisms (like *mycorrhiza*), and between trees and animals (insects, birds and rodents). Also the growth reactions to interferences in forest structures must be known. and manipulation of the forest needs labor. Mechanization is highly developed for plantation forests, but nearly zero in terms of silvicultural treatments in tropical forests. Therefore, governments, industries and researchers should invest much more efforts in the development of tropical forest knowledge, in terms of research as well as practical applications in forest areas.

If forest certification is aimed, still more knowledge is needed. in the guidelines for certification, expressions like "minimization of changes in structure and species composition", "minimization of damages due logging operations" or "ecological functions are kept intact" are quite common and should be combined with improvement of income, for the forest workers as well as for the forest owner. But how to achieve this was never explained by practical demonstrations on the long run. Again, much expertise is required, for the millions hectares of secondary forests in tropical regions.

1.07.00 / 1.15.00 / 1.17.00 International markets for carbon sequestration from tropical forests

International Markets for Carbon Sequestration from Tropical Forests: Principles and guidelines to Ensure Beneficial Local Development and Environmental Impacts.

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Decisions taken at Kyoto in 1997 and Buenos Aires in 1998 pave the way for international financial and technological transfers to support forest-based activities that enhance carbon storage and sequestration and thus mitigate the build-up of carbon concentrations in the atmosphere. Carbon-related services of tropical forests may be more

cost-effective than emission reduction in energy projects, and various international market mechanisms being discussed could potentially contribute large financial resources for rural development and forest management in project sites.

However, there is widespread concern among the international forestry community that poorly-designed forest carbon projects could pose a major threat to the welfare of forest-dependent people, non-carbon environmental services, and sustainable management of forest resources for national development, and that successful local implementation may not be feasible.

The University of Maryland and the Center for International Forestry Research are organizing an international policy workshop in spring of 2000 to identify conditions and organizational principles under which trade in carbon sequestration services would have positive local socioeconomic and environmental impacts. Recommendations will address selection of project site, types of carbon projects, integration of management with national and regional forest and environmental strategies, mechanisms for distribution of benefits among local people, and incorporation of local interests in project planning.

A presentation based on workshop recommendations will be presented at the proposed IUFRO Group Session, followed by comments from two expert panelists, and then broader discussion. Possible panelists are Dr. Jagmohan S. Maini, of the UN Secretariat of the Intergovernmental Forum on Forests and Dr. Roger Sedjo of Resources for the Future. The presentation will be revised in the light of this discussion, and submitted for publication in a leading environmental policy journal. A policy brief will also be published and disseminated widely by CIFOR.

1.09.00 Short rotation forestry for biomass production

The Status and Future of Short-Rotation Woody Crops in the U.S.

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Short Rotation Woody Crop production systems, involving rotations of 10 years or less, reached a commercial production level of approximately 55,000 ha in the United States by 1999. Hybrid poplars and cottonwoods dominate, but willows, sycamore and sweetgum are also being planted. This wood is produced almost entirely as fiber for pulp and paper and fibreboard. The majority of the commercial production exists in the Pacific Northwest and Southern portions of the U.S. New activity for fibre and energy crops is occurring in the North Central and Northeastern U.S. Experience shows that early success of commercial ventures depends greatly on the existence of well-integrated research programs incorporating breeding, physiology and silviculture and close partnerships between industry, government and academia. Research on short rotation wood fibre crops is in a very active phase and production levels are anticipated to increase. Recent policy decisions by the U.S. government will provide additional research funding and incentives for production of woody crops for energy in addition to fibre.

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Productivity and Sustainability of Wastewater Irrigated Tree Plantations

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Keywords: Wastewater; Biomass; Sustainability; Short rotation; Nutrient sequestration

The utility of tree plantations for the disposal of wastewater has been well established and continues to be investigated throughout Australia, particularly with respect to: the profitable reuse of wastewater, rather than simple disposal; the sustainability of land use under wastewater irrigation; the silvicultural management of plantations to achieve specific objectives such as the production of high-value sawlogs; and the optimisation of nutrient sequestration and water use.

A major concern with wastewater irrigation is the fate of nitrogen (N) and phosphorus (P) in the environment since these nutrients can cause pollution of surface and groundwaters. Municipal wastewaters treated to primary or secondary level often contain greater amounts of these nutrients than can be sequestered by the trees at the rate of irrigation needed to meet the water requirements of trees, particularly in semi-arid environments. While

P will not usually be a problem in the short to medium term, particularly on soils with high P adsorption capacity, there is always potential for leaching of N (as nitrate) to groundwater.

Fast growing trees initially accumulate significant amounts of N in foliage, but the net N requirement of the plantation declines after canopy closure, and as N is recycled through the decomposition of litter and internal translocation. Therefore removal of N and other nutrients by plantations can be maximised by growing trees in short rotations (*e.g.* <6 years). However, such rotations may compromise water use, and also limit the potential products to biomass fuels rather than higher value wood products.

A second concern with wastewater irrigation arises from the often high concentrations of sodium (Na). Therefore, long-term irrigation has the potential to deleteriously affect soil structure through changes in soil chemistry, and ultimately reduce the productivity of the site and its utility for wastewater disposal.

A wastewater irrigated, short rotation coppice trial was established at the Goulburn Valley Region Water Authority (GVRWA) Shepparton Wastewater Treatment Complex in 1993, with the aim of determining whether the long-term irrigation of tree plantations with wastewater is sustainable within alternative silvicultural treatments, by measuring changes in soil properties, the input of water and nutrients in wastewater, tree growth, sequestration of nutrients and salts in trees and soil, and monitoring groundwater depth. The trial incorporates comparisons of coppice rotation length (3, 6 or 12 years), planting density (1333 or 2667 sph) and tree species (*Eucalyptus globulus* or *E. grandis*).

During the first six years of the planned 12-year experiment, growth rates and biomass production in this trial are amongst the highest reported in Australia with mean annual increments of up to 40 m^3 ha^{-1} yr^{-1}. During this period up to 550 kg ha^{-1} of N was accumulated in the above-ground biomass. However, some marked changes in soil properties were apparent within the first three years, including significant loss of carbon (C) and N, and increases in the sodicity of the surface soil.

A Study on the Pollen Morphology of Six Sections in Subgenus *Salix* L. (Salicaceae)

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The pollen morphology of 15 species, 2 varieties and 1 forma belonging to 6 sections of the subgenus *Salix* was investigated by means of light and scanning electron microscopy. From a pollen-morphological point of view, subgenus *Salix* is stenopalynous. Species from six sections have been distinguished on the basis of pollen morphology, and a key for their identification using pollen is presented. Based on pollen morphology, *S. jessoensis* (section Subalbae) is the most distinct of the species studied. Species of section Humboldtianae appear to be the most evolved in this subgenus with a closer relationship to section Amygdalinae than any other section of this subgenus.

Keywords: *Salix*; Salicaceae; pollen morphology

Short Rotation Forestry in Korea

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Keywords: short rotation forestry, fuelwood, biomass, caloric value, *Robinia pseudoacacia*, hybrid poplars

Short rotation forestry in Korea has started since late 1950s and 1960s when Korean Government initiated establishing fuelwood plantations for rural village dwellers. Most of the planting woody species for fuelwood were fast-growing *Robinia pseudoacacia*, *Pinus rigida*, *Populus sp*ecies and *Lespedeza* species, which show good sprouting and adaptability in various sites.

Started in 1959, the total area of fuelwood plantation to be needed was 1.2million ha, based on a total of 2.4 million households. Of these 1.2 million ha, 400,000 ha from existing forests to be used for fuelwood production and the other 800,000 ha to be established by artificial planting. However, the target for the establishment of fuelwood plantation was revised to be 643,000 ha due to failure in plantations. The total area of 643,000 ha for fuelwood was successfully established in 1977, of which 127,000 ha done by IBRD loan project.

In 1980s, research on short rotation intensive culture has started to examine the biomass production by planting densities and species. Tree species for testing were *Populus alba x P. glandulosa, Populus nigra. X P. maximowiczii*, *Robinia pseudacacia* and *Alnus* species. Planting densities examined ranged form 10,000 trees/ha to 40,000 trees/ha. Caloric values, sugar and ethanol contents were also compared for 27 hardwoods and 3 conifers, of which the highest values were shown by *Populus* and *Morus* species. Among the planting densities at nursery sites, the density of 40,000 trees/ha showed the highest above ground dry matters of 20 tons/ha/year from *Populus alba x P. glandulosa* and *Populus nigra x P. maximowiczii*. However, at hillside sites, the density of 4,000 trees/ha exhibited the highest dry matters of 7.7 tons/ha from *P. alba x P. glandulosa* compared to densities of 1,000, 2,000 and 3,000 trees/ha.

In 1978, *Robinia pseudacacia* was planted at various planting densities of 3,000, 6,000, 9,000 and 12,000 trees/ha in the hillside mountain area to test the biomass production for 18 years. During the period, 6-year, 9-year and 18-year rotations were applied for all of the densities. Under 6-6-6-year rotation, the density of 9,000 trees/ha showed the greatest biomass production (37.5 tons/ha), while that of 12,000 trees/ha did the best (60.9 tons/ha) under 9-9-year rotation. Under 18-year rotation, the density of 3,000 trees/ha exhibited the best production (85.8 tons/ha). The greatest total biomass production (108.4 tons/ha) was shown by the density of 9,000 trees/ha under 9-9-year rotation for 18 years.

A survey of short rotation willow growing in Sweden

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This paper presents an evaluative study of short-rotation willow plantations for energy purposes in southern and central Sweden. The results are presented statistically and in Geographic Information Systems (GIS). Willow growing is described according to owner characteristics, farm type, size, land use, willow area and management. Since the two issues of how to increase the share of renewable energy and how to reduce surplus crop production are relevant in many countries, realistic predictions about potential energy-crop growers are needed. Better knowledge about the adoption patterns of willow production in Sweden during the early 1990s could help policy makers, in Sweden and in other countries where short rotation energy forests are being considered, to design effective energy and agricultural policies and to identify target groups for information campaigns. Commercial willow plantations in Sweden expanded in the early 1990s when two main policy decisions were made. First, the implementation phase of a deregulated food policy between 1991 and 1996 made subsidies available for planting willows and for fencing. Second, environmental and energy taxes on fossil fuels increased considerably in 1991, improving the competitiveness of biofuels in the energy market. Data about the 1000 farms in southern Sweden with a farming area of more than 2 hectares and with more than 0.1 hectares under willow cultivation were obtained from the 1995 Farm Register compiled by Statistics Sweden. For comparison, a stratified sample of 535 non-willow farmers from the same geographical region was also used. A postal survey was also conducted of a sample of the willow-growers. The willow growers in southern and central Sweden, were growing about 13,000 hectares of willows in 1995. in relative terms 2% of the farmers in the region grew willows on 0.5 % of the total area of arable land. Willow growing is most common in regions where biofuel use (*e.g.* of residues from logging and forest industries and imported biofuels) in district heating plants is already high. Willow plantations are generally common on large farms and on crop-producing farms. Willows are less common on small farms and on farms with many animals. The survey questions concern information about the willow growing farmer, motives for planting willows, willow plantation management and harvesting, economic aspects and evaluation.

Turkish Energy Forestry for Sustainable Forest Management and Energy

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Much of the world today is well on its way towards creating an unsustainable environmental situation. It is still possible to solve some of our environmental problems in a efficient and perhaps even a cost effective way by utilising suitable, located forest land and former agricultural land for energy, fibre and timber production. At the same time, some waste products of the community can be added into the cycle again. Biomass production for energy purposes through the cultivation of fast growing, broad-leaved trees will result in an ecologically sound and economically viable crop in Turkey. in this way, unproductive land can be converted to productive energy plantations where wood is harvested as a crop and used for energy purpose and industry. The importance of biomass in Turkey today is indisputable since the traditional biomass fuel wood, charcoal, crop residues and dung are still a primary cooking fuel for some parts in Turkey. For a variety of reasons like rising prices of oil and growing population, biomass fuel might not longer supply the demanded needs. At the same time the shortage of local biomass are increasing. Therefore, the establishment of fast growing plantations would have multipurpose. There is a need to collect and analyse prior experiences in local wood production and consumption in order to design efficient measures to reach the desired situation of local control, cost and the efficient use of energy from biofuels.

Forest land in Turkey constitutes 26.5% of the country, that is about 20.7 million hectares. 12.8% of Turkey is covered by productive forests and the remaining 13.8% is degraded land. Turkey has about 4 million hectares of land subject to the activities of energy forest establishment. The coppice rehabilitation projects have been commenced especially in east and southeastern Anatolia regions since 1978 to control degradation, to rehabilitate and to make the degraded coppices land reproductive. With the realization of project objectives, new job opportunities will be created as well as supplying animal fodder in the region.

The gap between wood production and demand will reach 3.5 million m^3 in per year. If necessary actions are not taken, the shortage in wood production will be even more serious. Thus, the establishment of industrial plantations with fast growing species such as poplar, willow, *Eucalyptus*, *acacia*, alder and oak species are of great importance. Until 1998, energy forest activities with coppice regeneration was undertaken on an area 517 000 hectares and production of fire wood is used for heating and cooking purposes.

A specific goal is to increase the use of wood and wood based residues for energy generation increased at combined heat and power generation plants being established by private sector in locations where coppices and natural forests are available by 2003.

Keywords: Energy forestry, forest management, sustainable environment and energy, power

Sustainable Management of Abandoned Farm Lands for Energy Forestry Using Domestic Nitrogen-fixing Tree Species

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Keywords: Alder species (*Alnus* sp.), biomass production, nutrient cycling, cultivation methods energy forestry, short-rotation forestry

In transition countries the volume of agricultural production has fallen considerably over recent years. in addition to agriculture, a large number of important changes have also occurred in forest management and energetics. A need has arisen for the compilation of new economically and ecologically justified agricultural and silvicultural recommendations and sustainable management systems.

Estonia is situated in an intermediate zone between the boreal coniferous forest and the deciduous, broad-leaved forest. Forests cover more than 47% of the total area, in 1992-1996 some 30% of arable land was left uncultivated. With the exception of oil shale deposits, Estonia does not have any major sources of fossil fuels, and a substantial proportion of such fuels must therefore be imported. To ensure the energy supply and improve the environmental conditions a programme of converting boilers from fossil fuels to domestic biofuels was started. The results will help to optimise land utilisation by choosing soils suitable for the cultivation of alders (particularly grey alder energy stands), thereby in a natural way making such areas fertile with the future objective of returning the areas to agricultural use or of cultivating conifer stands.

Purpose of the work was to create yield tables and to determine the rotation period for alder stands as energy forests depending on forest site types. A second objective was to investigate nutrient cycling in alders and thereby their effect on soil fertility. As alders are in symbiosis with actinomycete Frankia microorganisms, which fixate aerial nitrogen and the nitrogen content of alder leaves is therefore high, it can be presumed that the cultivation of alders will have a positive effect on soil fertility.

Silvicultural, ecological and economical aspects of the management of grey alder (*Alnus incana*), hybrid alder (*Alnus incana* x *Alnus glutinosa*) and black alder (*Alnus glutinosa*) stands are analysed. Different cutting and regeneration systems are examined. For the development of rational methods of afforestation of abandoned agricultural land by alders, the experimental plantations were established where various planting materials were used. in order to find out the influence of alder forest, grown as energy forest, on the surrounding environment, above all on soil, and its ability for uptake of chemical elements, as well as to evaluate the possible loss of nutrients after felling and the removal of trees from the place of growth, the concentration of basic nutrients in different plant fractions was analysed annually.

Short Rotation Forestry in Europe

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Short rotation forestry (SRF) in Europe has a long tradition and originally aimed at providing a supply of fuel, fodder and convenience wood, usually by means of coppice systems. The main genera involved are *Populus*, *Salix*, *Eucalyptus*, *Robinia*, *Betula*, *Alnus*, *Castanea* and *Quercus*. Eucalypt is confined to the Mediterranean parts of Europe, whereas willow and birch mainly are found in the northern parts. SRF systems both are employed in forestry and agriculture and have integrated functions in agroforestry, shelterbelt- and environmental applications such as vegetation filter systems. Modern SRF has developed towards an industry which needs large volumes and a continuous supply. Consequently the focus is on species with a high initial growth rate and breeding programmes are directed towards resistance or tolerance against pathogens. With the actual range of final products in mind (biomass for energy purposes, paper pulp, particle board, veneer, construction wood) a wide range of growing systems has been developed, ranging from densely planted willow coppice (2x104 stools ha^{-1} and harvested each 2 to 4 years) to widely spaced single-stem poplars (100 stems ha^{-1} and harvested after 25 years). Major developments of European SRF during this century are envisaged in the fields of specialised high quality products and in the field of bioremediation. The increasing amounts of sewage sludge, slurry and other organic waste products from the society form an excellent resource for biomass production by means of SRF.

Comprehensive silviculture and development strategies for pulpwood plantation in China

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In pace with the growing economy and population, and improvement of the living standard in China, the demand for paper and paper products will increase continuously, while wood as the main raw material in the pulp industry is decreasing gradually. Development of fast-growing, short rotation plantations for pulpwood production, which are highly productive through adopting sustainable forest management in relatively small areas of forest land, can make a significant contribution to wood supply. This will replace wood supplies from natural forests in response both to economic development and environmental problems. The status of the silviculture for pulpwood plantation in China is reviewed and its development strategies are discussed as follows:

1) According to the selection of appropriate afforestation species, and the estimation of productivity for pulpwood purposes, the pulpwood bases will be properly planned.

2) Under the guidance of the principle for sustainable forest management and forest ecosystem management, plantation establishment is focused on specific goals of industrial use, i.e. fast growth, high productivity, superior quality, stability, and high profit. Based on systematic research of tree improvement (careful selection of tree species and genetically improved materials with superior vigour, fibre property, and pest and disease resistance), site control (suitable site quality and the maintenance of high soil fertility), stand density control (rational initial density and thinning technology) and economic considerations, the intensive silvicultural technologies will be promoted.

3) Based on clonal selection and vegetative propagation with commercial utilization, optimal combination of the site and clones, the ecological stability and adaptability and genetic variation of pulpwood properties are studied, and the comprehensive cultivation system for clonal plantation will be perfected for development of large-scale clonal forestry.

4) The development avenues towards integration of forest management and the pulp industry will be explored in relation to the Chinese situation, and the pulpwood raw base for a relatively stable supply to

the industry will be established, simultaneously with reasonable development on resource use and finance.

5) Aided by the geo-information system and advanced forest technology, the information management system for pulpwood bases will be set up to serve as the basic tool of planning, management and decision-making, and gradually to make the development of pulpwood plantations sustainable.

1.15.04 Agroforestry

Why Use Agroforestry in European Mountains?

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Keywords: Agroforestry, Europe, mountains, silvopastoral systems

As far as agricultural products are concerned, the context of high economic competition in West Europe has led to the abandonment of the less productive plots of land. This has been particularly the case for the mountain areas throughout the region. As agricultural products were the main economic resource for those mountain areas, one important result has been out-migration of population. There is then a trend towards a desertification of mountain areas, as people fail to look after the rural space. Abandoned plots of land are rapidly colonized by a dense shrubby vegetation and afterwards by a closed forest. However, mountain areas are an important tourist attraction, which is not an insignificant income source. However, tourists often give preference to opened landscape and pastures. There is consequently a need to manage the rural space and landscape.

Agroforestry - the association of an agricultural production with tree culture on the same unity - is a possible way to maintain a rural activity, diversify the production and look after the landscape in the mountain areas. in particular, silvopastoral systems - the association of grazing animals with tree culture- are well adapted. Animals maintain extensively the vegetation to a low level, providing an opened landscape. At the same time, the trees provide an additional income to the farmer through timber, fire wood, forage, honey, and other products.

Experiments were undertaken with two silvopastoral systems: the plantation of forest trees in pasture and the opening of dense forests or brushwoods to grazing animals. in both cases, only a low number of trees were planted or kept to allow sufficient grass production to support the flock. Experimental details are presented.

Data were collected for the two kinds of silvopastoral systems for ten years including technical, ecological and economic characteristics and performance. Results of experiments and farmer evaluations are presented. Both silvopastoral systems have proved feasible and interesting from an economic point of view. Grazing animals are really a cheap mean of maintain an opened landscape. On-going research is analysing how those silvopastoral systems can fit into the farmers' exploitations and particularly what are the economic and environmental consequences of introducing trees.

Computer-Based Data-Management Technologies in Agroforestry

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The past decade has witnessed dramatic progress in the use and deployment of computers for rapid and efficient acquisition, management and analysis of data to support development and dissemination of land-use technologies. This paper will evaluate the developments of computer use within agroforestry, discuss the potentials and suggest future directions in this exciting approach to research.

The major computer-based tools and methods in land-use system research are database management systems (DBMS), decision support systems (DSS), geographic information systems (GIS), and computer modeling. DBMS's are used for the input, storage and retrieval of relational data. With the development of the CD-ROM and the Internet, access to and distribution of large amounts of data have become easier. Databases have been developed containing information related to natural resources such as climate, tree species, and soils. These databases provide information that can be used by planners and managers in making land-use decisions. Decision support systems integrate data (often obtained from a DBMS) with decision criteria or rules to provide users with decision options in planning, implementing, and managing different land-use systems. DSS's have been developed to provide advice in several forestry and other land-use activities; e.g.: timber management of national forests, pesticide application in field-crop cultivation, and management of citrus production. Widespread access to satellite imagery, remote sensing equipment and other sampling equipment has allowed for the development of GIS's to aid in land-use management. GIS's are DBMS's designed to capture, store, analyze, and display data from a spatial point of view. GIS's have been used in evaluating appropriate land uses, the development of precision farming, and in planning agricultural or forestry systems. Computer modeling takes advantage of the computer's ability, often using linear programming techniques, to evaluate many different scenarios (different levels and combinations of inputs to a system) with a minimum of effort. Models have been developed to determine optimum levels of fertilizer required in different agricultural production systems and to understand the growth of trees to more effectively manage production.

Recent developments have seen these technologies applied to problems relating to agroforestry. One of the first such systems was the United Nations University (UNU) Agroforestry Expert System (AES). The UNU-AES is a type of DSS that provides management options for alley cropping under specific conditions in the tropics and subtropics. in response to the need for appropriate information relating to agroforestry tree species, the International Centre for Research in Agroforestry (ICRAF) developed the Multipurpose Tree & Shrub Database (MPTS). This DBMS contains first-hand, site specific information as well as secondary data on over 1000 multipurpose tree species. Other databases have also been developed to provide additional information about potential and current agroforestry tree species. GIS systems have also been developed to aid in the adoption of agroforestry. For example, a GIS-based agroforestry research tool was developed to determine the appropriate agroforestry systems that might be adopted in certain regions in sub-Saharan Africa. One system that models a rubber-cacao agroforestry system in Brazil was developed to bioeconomically simulate a 40-year cycle. The system explores different scenarios to achieve optimum production and profit levels. Modeling efforts in a variety of agroforestry themes have also produced interesting results. As each system is reviewed, its intended audience (farmers, land-use decision-makers, researchers) and end-use (research, development, decision-making) will also be discussed.

Agroforestry in Malaysia

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Keywords: Agroforestry, Malaysia, New Agriculture Policy

Agroforestry as a land use, is getting prominent in Malaysia. in 1999, the government launched the New Agriculture Policy with agroforestry identifies as one of two strategic approaches to meet the challenges in the agriculture and forestry sectors. in the New Policy, the agroforestry approach is aimed at addressing the increasingly scarce resources including land and raw material availability with agriculture and forestry viewed as mutually compatible and complementary. The integration of agriculture and forestry is also aimed to create a larger productive base for both sectors. This paper discusses various strategic directions, action plans and recommendations on the agroforestry approach in the New Agriculture Policy.

The Effects of Population Growth and Agricultural Intensification on the Forest Resource of Central Honduras, 1970s-1990s: A Community-Scale Analysis

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Keywords: Agricultural intensification, deforestation, hillsides, Honduras, population and environment

The effects of agricultural intensification on forest cover, use and management are of major concern for forest policy and planning, particularly in tropical countries with high rural population growth. International evidence suggests that the relationship of forest cover with population growth and agricultural intensification is not linear. Population growth from low population densities typically leads to forest clearing for extensive agricultural production. But once continuous cultivation becomes the norm, further population increases often result in improved management of remaining forests and on farm tree-planting to meet subsistence needs and new market opportunities, as well as greater action to protect locally important watersheds.

However, our understanding of when and how this process occurs--for different population densities, types of farming systems, physical environments, and policy contexts-is limited. Most insights into these relationships have come from statistical analysis of macro-level changes in agricultural land and forest use. More sophisticated understanding and analysis of the nature, processes and impacts of forest land use and management under various types of agricultural intensification has been lacking. Such analysis is constrained by lack of detailed data that would permit joint analysis of changes over time in agricultural economies at the local level, and associated changes in forest cover and management.

This case study attempts such an analysis, for the Central Hillsides of Honduras, for the period from the mid-1970s to the mid-1990s. By comparing the processes and impacts in 48 communities with varying geographic, demographic, and economic characteristics and varying local governance arrangements, the study sought to identify the impacts of regional economic trends and public policies on forests at the local level. Six pathways of agricultural development in the region (stagnation of basic grains, expansion of basic grains, horticultural intensification, coffee expansion, forestry specialization and non-farm employment) had distinct determinants of economic change, distinct patterns of land and forest product use, and different concerns about local forest resources.

Aggregate tree cover declined only slightly in the coffee, forestry and non-farm employment pathways (which account for three quarters of regional land area), despite rapid population growth, as annual crop production became more intensive and less important to livelihoods. Forest cover declined significantly in the other three pathways, as area in annual crops expanded due to high-value vegetable markets (horticultural pathway), extensive production systems (the basic grains pathways) and cropland degradation (basic grains stagnation pathway).

Findings suggest that the impacts of agricultural intensification on forest resources depend on initial resource conditions and the type of intensification. Resource scarcities relative to population and agricultural development policies have greater impacts on forest conditions than do forest policies. The latter need to be targeted by agricultural pathway. The observed variations in land use dynamics raise concerns about the reliability of macro-scale analysis for predicting forest cover change or informing policy action.

1.17.01 Rehabilitation of mined lands

Reclamation of post-mining landscapes in Eastern Germany - The largest environmental protection project of Europe

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In East Germany an area of more than 1'000 square kilo-metres was consumed by strip mining and open pits. With the transformation process from a planned economy to market economy in East Germany most of the mines had to close down. The lignite or brown-coal mining had destroyed the landscape: By removing the over-burden the micro-organisms, vegetation, and animals, were lost. Particularly in the 70th and 80th the mining was carried out so intensively, that the reclamation did not keep up with the area devastated by mining. The political leaders had other priorities and so the state run mining companies did not receive the funds for remediation and reclamation.

The remediation is particularly difficult as the overburden consists of sand and gravel and hardly any topsoil. in the dumping areas a new covering soil need to be established and the interrupted nutritional chains have to be build up again to bring back plants and animals. in addition the residual pits are forming dangers to man and nature that appear from the physical properties of the pit slopes. The dump areas are geotechnically not stable. Over long distances the banks tend to slide down suddenly.

The East-German example demonstrates drastically what enormous problems occur, if active mining and land reclamation is not integrated. in order to be able to tackle such a task, a huge amount of various sorts of support was needed. So a first Administrative Agreement for a 5 year action program was signed in December 1992 which was extended in 1997 for another five years until the year 2002. According to this new agreement, now up to 1.2 billion DM is allocated from the Goverment yearly.

The funds are provided for safety-measures in the disused open-cast mines restoration of the water-balance, and rehabilitation and land reclamation.

In early spring of 1999, the program is well established as Europe's largest environmental program, and after more than 8 years of intensive work, progress can be documented in many ways.

Some achievements of the program are shown below. Area of waste-land and dump-areas to be reclaimed (without water-areas) 65.370 ha accomplished in early 1999
- reclamation of forest 27.280 ha
- reclamation of agricultural land 11.590 ha
- natural revegetation and controlled succession 5.760 ha

Total reclaimed area 44.630 ha

New ecosystems are established in order to bring the post-mining landscape on the path leading towards a sustainable development and achieve as well the desired future land use.

In the year 2002 in many areas that looked - for miles and miles - like a lunar landscape at the time of reunification in 1990, you will find many new lakes with water of bathing quality and you will also see thousands of acres of young forests and new agricultural land and areas protected for wildlife, and in some areas it will already be difficult for a laymen to tell that the area once had been mining land.

The impact of industrial pollution on the vegetation of Northern Siberia

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Northern regions of Eurasia and North America are predominantly occupied by forest-tundra ecotones with considerable diversity of landscapes. Along with hydrothermal conditions, their appearance is largely governed by the presence of permafrost and is considered to be "one of the most pronounced boundaries in the landscape regionalization of the Earth". The biological components of forest-tundra ecosystems are extremely vulnerable to climatic changes and anthropogenic pressures. The so-called "land of small sticks", which is the local name for such landscapes, is characterized by larches that are less than 1 m high and branches which grow near the ground, protected by snow cover. 10-meter high trees grow in the valleys, while mosses, lichens, shrubs and dwarf shrubs occupy the concave uplands.

The natural resources of the Russian Lower Arctic, such as polymetal ores, gas, oil and coal, are intensively developed, often without due regard to certain features such as historical sites, as well as consideration of the importance of ecosystems. The Norilsk industrial region demonstrates one of the more serious conflicts between nature and society today. Norilsk is the largest town of the Polar Regions. Nowadays it is the largest center of mining and non-ferrous metallurgy in Russia, which is based on the locally available rich deposits of copper, nickel and coal. in recent decades, the town has also become the largest center of industrially-caused air pollution in the Arctic. Sulphur dioxide and heavy metals are of particular concern. About 2 million tons of sulphur and 60,000 tons of heavy metals enter the atmosphere of this area each year.

Current research is focused on the impact area of the Norilsk mining and Metallurgical Industrial Complex (Arctic part of Eastern Siberia). High emissions of sulphur dioxide and heavy metals, as well as the extreme climatic conditions of high latitudes, have caused large-scale degradation of the surrounding ecosystem.

The results of this investigation are based primarily on field studies of the vegetation cover. Toxic effects are most pronounced at the local level, in the vicinity of plants and industrial centres where pollution accumulates in the ecosystem and enters the biological cycle. It is in such extreme natural conditions, with fragile structural and functional links, that the effects of industrial impact can rapidly be seen in the state of the ecosystem.

Ecology of Post-Mining Landscapes - Fundamental Principles

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Surface mining has a severe impact on landscape ecology. At many places, reestablishment of ecosystems is impeded by extreme site conditions.

Restoration of sustainable ecosystems resembling the situation before mining or rehabilitation towards designed systems with predefined goal functions requires complex knowledge based on an ecosystem approach, particularly if seminatural systems shall be recreated, *e.g.* by directed succession. Unfavourable physico-chemical site factors often must be actively compensated by rehabilitation measures, displaced target organisms must be brought back onto the sites. Areas designed for agricultural or forestry use must be rehabilitated considering the future perspectives of the users, i.e. interactions with socio-economical questions have to be considered if successful recultivation shall be achieved.

Knowledge can be extracted from mined land rehabilitated during this century, *e.g.* by means of chronosequence studies. Natural succession processes on post-mining sites starting from "point zero" are not only unique events in cultivated landscapes, they help understand natural ecosystem dynamics - far beyond the actual post-mining landscape.

Results from a number of research projects will highlight the various aspects and the scope of development of the ecology of post-mining landscapes using as an example the lignite mining district of Lower Lusatia in eastern Germany. Based on chronosequence approaches and long-term observations, a concept of ecosystem development on minesites was developed integrating various aspects potentially altered on former minesites and compared to ecosystems on natural, undisturbed sites: pedogenesis and organic matter transformation, natural flora and fauna succession, water and element budgets.

However, so far the dynamical aspects of ecosystems on former minesites are still not understood well enough to predict their long-term future development. Novel methodological approaches are needed to extend our knowledge and meet the demands of decision makers and land managers.

Forest Rehabilitation in the Baltic Region - The Oil Shale Study Case

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The Estonian oil-shale field is the largest commercially exploited oil-shale deposit in the world. It contains over 60% of explored reserves exceeding 6600 million tons. The mining of oil-shale was started in 1916 and its total output exceeds 770 million tons of shale. Presently, 6 underground mines and 4 open pit mines are in operation. All the operating mines are located in north-east Estonia, i.e., in the central and eastern part of the deposit. in this area, the overburden reaches ranges 0-70 m due to gentle southward dipping of Ordovician strata. Mining in pits started to spread intensively in 1959 when excavators with a scoop volume of 15-20 m^3 came into use to remove surface. Pits are used in digging up to depth of 40 m with a total area of 23 thousand hectares. If oil-shale is deeper than 50 m underground mining is used. Nowadays around 50% of oil-shale is mined in pits. Until 1999 around 11700 ha was mined. The reclamation order of exhausted oil-shale pits was determined by the Estonian government as early as 23 November 1923. The planned afforestation of oil-shale pits began in 1960. More than 365 ha of experimental stands are planted on smoothened oil-shale pits to ascertain the most suitable tree species and bushes (all together 52 species have been used), cultivation methods, cultivation times and most suitable planting material sizes. The physical and chemical characteristics, water regime, microclimate and natural vegetation growth on these areas of land have been studied. From 1978 to 1980 128 permanent sample plots were established in experimental and productive stands. The growth and development of different tree species is studied after every 5 to 10 years, as are the initial density of trees depending on the species, the need for thinnings, vegetation and soil formation processes.

As of 1 September 1998 there are 8374 hectares of forest stands planted on smoothened oil-shale pits. 85% of them are pine stands, 7% are birch stands, 4% are spruce stands and 2% are larch stands. Other species make up around 2% of the cultivated area. Fire and insects endanger spread monocultures of *Pinus sylvestris*. Pine stands need thinning at a young age. *Larix europaea*, *L. sibirica*, *L. kurilensis* and *Betula pendula* show quite good growth on calcareous soils. They exceed pine stands of the same age (25-30 years) by 4 to 7 metres in height. Larch stands with an initial density of 1200 - 1800 plants per hectare, and birch stands with an initial density of 3000 - 3500 plants per hectare (2 year old seedlings) do not need thinning at a young age. in very rocky areas (rocks compromise 50-70%) *Alnus* spp. are more suitable to promote the soil formation processes.

Trees and bushes are also suitable for cultivation of oil-shale chemical industry residual formations like ash plateaus and coke-ash heaps with height up to 100 m. Experiments have been carried out there with 28 species. Fertilising with N and P fertilisers is necessary. in alkali conditions *Betula pendula*, *B. pubescens*, *Alnus glutinosa*, *A. incana* and *Populus trichocarpa* showed the best vitality.

Native Tropical Forest Rehabilitation: A Case Study from Brazil

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Keywords: Amazonia, biodiversity, mine reclamation, native species, reforestation, tropics

Restoring productive, self-sustaining tropical forest ecosystems on surface mined sites is a formidable challenge that requires the integration of proven reclamation techniques and reforestation strategies appropriate to specific site conditions, including landscape biodiversity patterns. Restorationists working in most tropical settings are usually hampered by lack of basic information on the wide variety of native tree species that characterize these forests as well as insufficient understanding of the ecology of disturbance and natural recovery that can aid in the design of effective restoration programs. A notable exception to this is the forest restoration program developed since the early 1980s by a Brazilian bauxite mining company operating at Trombetas in Par State in central Amazonia. A systematic nursery and field research strategy was used to develop a reforestation program based on mixed plantings of more than 70 native primary forest tree species. This technique has been used to replant about 100 ha of previously forested minelands each year over the past 15 years. Research in recent years has evaluated this approach and other, generally simpler, techniques used at a smaller scale at this site in terms of post-plantation biodiversity development and other indicators of restoration success or sustainability. The results of these studies have shown the overwhelming importance of careful site preparation and topsoil handling/replacement practices in determining both future productivity and biodiversity of developing forests irrespective of the complexity of the planting design used. Beyond this, study results show that the inclusion of a wide variety of forest species, particularly later successional species, is very important for long-range restoration success due to limitations on natural recovery processes that inhibit seed dispersal and subsequent colonization of many primary forest species. Many of the lessons learned at this site have implications for the design of mineland rehabilitation and forest restoration programs worldwide.

Ecosystem development on post-lignite mining sites: element budgets of false-time series

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The post-lignite mining landscape in Lusatia is dominated by sandy substrates of tertiary and quaternary sediments. Lignite and pyrite contents of varying amounts can result in extremely phytotoxic site conditions. To establish pine stands on these sites, large amounts of CaO were used for amelioration. These forest ecosystems virtually start very close to the "point zero" of development, especially with regard to soil development, plant-soil interactions, and establishment of biogeochemical cycles. The development of these ecosystems at 2 - 60 years old pine stands on two typical substrates in a "false-time series" approach was studied. Water and element fluxes in different ecosystem compartments along these chronosequences were measured, analyzed with respect to differences between substrates, and compared to pine ecosystems on non-mined sites of the region. Main objectives were to identify the dominating processes and temporal trends in ecosystem development and to use flux budgets as an indicator for ecosystem functioning.

Soil solution compositions indicate very high spatial and temporal dynamics. Over time sharp depth gradients are formed due to amelioration and soil forming processes. Soil solutions are mainly composed of Ca, Al, Fe, and SO4 depending on soil pH and pyrite content. Dynamics in lignite-free sands are much less pronounced and show overall lower concentrations.

The results reveal fundamental differences of element budgets between the two substrate types due to their different geochemistry. The fluxes of almost all elements under investigation at lignite and pyrite free sites are similar or even lower compared to a non-mined site which can be explained by low weathering rates of the dumped material consisting mainly of quartz and low atmogenic input rates. in contrast, the lignite and pyrite containing sites show very high dynamics of initial development induced by substrate composition and are characterized by high element flux rates and intensive transformation processes, i.e. changes and redistribution of element pools.

The following processes could be identified as dominating factors in soil formation at the lignite and pyrite containing sites - Prite oxidation resulting in the release of large amount of acidity, sulfate, and iron, intensive weathering of primary minerals within the substrate releasing considerable amounts of Al, Ca, Mg or K depending on the specific mineral composition of the substrate, and precipitation of secondary salt and mineral phases like gypsum or oxides, hydroxides and sulfates of alumnium and iron.

Since pyrite oxidation can be a rather fast process depending on its control by chemical or microbial oxidation, a pyrite-free zone is developing from the surface to increasing soil depths over time.

- Leaching of easily soluble or labile secondary salt and mineral phases like gypsum, anhydrite or epsom salt. Over time this zone develops down the profile, too, forming a zone free of pyrite and salts.

- Both processes are affected by the amelioration measures taken in recultivation practice. Large amounts of lignite ash are incorporated in the topsoils resulting in an input of high amounts of Ca and Mg, but also to a lower extent sulfur. This of course introduces a large acid neutralization capacity compared to the substrate-internal buffering and also enhances formation of gypsum and other sulfate salts like MgSO4 that is leached very fast in high amounts from the profiles. The raising of soil pH on the other hand induces precipitation of Fe - and Al - oxides/hydroxides.

The chronosequence approach to study "false-time series" of post-mining sites has proven to be a very useful tool to identify dominating processes on the ecosystem level.

Biodiversity and The Role of Arbuscular Mycorrhizal Fungi for Enhancing Tailings Revegetation at PT Freeport Indonesia.

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The PT Freeport Indonesia Company mill is presently processing about 150,000 tons of ore (Gold and Cupper) per day of which about 3% becomes ore concentrate. The remaining 97% is discharged into the Ajkwa River watershed in the form of tailings, and settles out in the Ajkwa Deposition Area (ADA), which currently covers an area of approximately 133 km^2.PT Freeport Indonesia has an intensive program to rehabilitate tailing deposition area by establishing vegetation cover. However, the proposed target is difficult to be achieved, due to several major constraints which are related to the unfavorable environmental conditions existing at the tailing sites. The succesful establishment of trees in these unfavorable tailing conditions may be enhanced by introducing the effective and selective AMF by inoculation of the seedling in the nursery. The novel functions of arbuscular mycorrhizal fungi (AMF) as biofertilizer inoculum for improving growth and health of plants and as an agent for bioremediation of heavy-metal contaminated soil are recognized. A limited survey of local arbuscular mycorrhizal fungi species was conducted in ADA areas at the Maurujaya Reclamation Research Center (MRRC), Mile 21, PT Freeport Indonesia. Representative soil and root samples were collected from different rhizosphere plants. Using standard methods, the roots were stained and the AMF spores were extracted from the soil, isolated, and identified. Selected AMF isolates were also cultured using devised test tube methods and mass produced on pot cultures. The local AMF isolates which were obtained in culture, were tested for their ability to increase the early growth of host plant grown on tailings as a substrate.

Among the 43 identified plant species grown on tailings, the root systems of 39 species (90%) are colonized by AMF. These data show that mycorrhizal associations are needed for plants to successfully adapt to growing conditions on tailing deposits. Among the pioneer tree species, the rhizosphere of *Macaranga mappa* contained high AMF species richness. Thus enhancing early establishment of this species by re-cultivation are expected can enhance the improvement population of indigenous AMF. Based on spore propagule counts, twelve spore types included in three genera of *glomalian* fungi (i.e. *Glomus*, *Acaulospora* and *Sclerocystis*) were found in the sites (early sere succession). Three other common genera, *Gigaspora, Scutelospora* and *Enthrophospora*, were not found at the sites. Results from pot experiments shown that among the local AMF isolate tested, Isolate MRRC-4 and MRRC-46 gave the best results. These isolates can significantly (P.05) enhance the biomass of host *S. grandiflora* grown on tailing by 453% and 326%, respectively, compared to the controls. They can also consistently improve the biomass of *S. grandiflora* grown on control ultisol soil by 123% and 95%, respectively. Isolate MRRC-46 and MRRC-4 has yet to be identified, however, both isolates form intensive mycelia around host plant root systems. This mycelial network may be important as a chelating agent and in nutrient absorption, and thus can facilitate plant establishment on tailing sites. This paper will review the novel function of mycorrhizal arbuscula for tailings rehabilitation, and provide a step by step protocol how to develope and used this mycorrhizal inoculant as a clean technology for rehabilitation and bioremediation of contaminated tailings at PT. Freeport Indonesia.

1.17.03 Tropical forest restoration

Restoration of a Sri Lankan rain forest: An eight year review of experimental trials

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In the moist tropics much research has demonstrated that many late-seral tree species of the rain forest do not establish well on forestlands that have been cleared for agriculture and subsequently abandoned. This is most acute for the site-specific and shade-tolerant timber trees of mixed-dipterocarp forests in southeast Asia. For the last ten years we have been testing the use of Caribbean pine (*Pinus caribaea*) as a nurse for establishing rain forest timber trees. We selected 9 species of trees and 4 non timber species in two experimental sets of treatments that created microsites for planting seedlings within and adjacent to experimental openings within 20 year old pine plantations. Initial results after two years revealed that planting within the centers of canopy openings (photon flux density of 22 mols m-2 d-1; approximately 50 % of open conditions) that were 8 m wide provided conditions for greatest growth. in these circumstances seedlings grew between 3 and 15 times faster in height, depending upon species shade-tolerance, as compared to conditions beneath the closed canopy of *Pinus* (3 mols m-2 d-1; approximately 7 % of open conditions). Seedling planted in the full open had very high mortality during the first year and exhibited the poorest growth. The more shade-intolerant species showed greater response increases in all measures (dry mass gain, leaf area increase, height growth) than the more shade-tolerant species. Mortality of all species was higher in the *Pinus* understory, but this was most significant for the shade-intolerants. Results after eight years were the same but with greater differences between treatments. Seedlings planted in openings were growing at nearly 2 m yr^{-1} in some of the species, while growth of seedlings beneath the *Pinus* canopy was not more than 25 cm yr^{-1}. For the non timber species, two were lianas (cane, medicinal climber), one was a ground orchid with ornamental value, and one was a herbaceous shrub (cardamom). After two years all four species grew best in the edge microsites of the canopy openings. in these circumstances cardamom yielded 50 g plant-1 yr^{-1}, cane grew over 1 m yr^{-1}, the medicinal liana grew over 50 cm yr^{-1}, and the ground orchid produced the greatest number of flowers (25 per plant yr^{-1}). Results from these experiments have been used to construct planting guidelines for the various species tested along with an economic valuation (using NPV, net present value) of optimum species combinations for restoration on formerly cleared lands that have been reforested with Caribbean pine.

Underlying Causes of Deforestation and Forest Degradation and Constraints against Rehabilitation Efforts in Ghana

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Sustainable development of the forest resources of with the active cooperation of all stakeholders including rural communities is one of the important objectives of the forest and wildlife policy of Ghana. However achieving this objective cannot be possible without addressing the problem of deforestation and degradation. It is estimated that about 32% of forest reserves have been degraded. While there are no records for the areas outside reserves it is assumed that more than 75 % of those areas are also degraded. The major contributors to the deforestation and degradation are the people in the rural communities. While rural communities are blamed for contributing to the problem of deforestation and degradation discussions on these problem focus mainly on the activities which have contributed to the problem. However the rural communities are driven undertake those activities because of certain factors. Therefore to solve problem of deforestation and degradation and thus help in the sustainable development of the forest resources in Ghana these underlying factors and efforts that motivate rural communities need to be identified and remedies found for them. Deforestation and degradation in Ghana have been attributed to fire, unsustainable farming practices, logging and mining. Farming for instance has led to the loss of whole forest reserves. Efforts were therefore made to stop the encroachment of more reserves by farmers. Thus one of the first action that was undertaken was the eviction of the farmers living in the degraded reserves. Unfortunately this met with stiff resistance from the farmers with the result that the action was not successful.

Also in spite of the fact that deforestation is continuing efforts have being made to rehabilitate some of the degraded forests through taungya, enrichment planting and plantation establishment. Taungya and enrichment planting were tried and abolished. Plantation establishment, which is continuing, however involves only the use of mainly exotic species and in the past did not involve the local communities.

This paper therefore takes a look at the problems of deforestation and degradation as well as rehabilitation by discussing the underlying factors that motivate deforestation and degradation. It also discusses the reasons for the resistance put up by the farmers towards their eviction as well as the reasons for abolishing taungya and enrichment practices as well as the use of mainly indigenous species for plantation establishment.

The paper makes suggestions for actions that can provide solutions for the underlying factors that contribute to deforestation and degradation and measures to overcome that will enable the farmers living in the forest reserves contribute to the rehabilitation programme. It also makes suggestions on the appropriate methods for rehabilitating forests degraded through different direct actions.

Forest restoration for biodiversity conservation in Northern Thailand

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Restoration of degraded forest ecosystems for the conservation of biodiversity requires development of different methods to those currently used for commercial forestry. Research must cover a much broader range of indigenous trees species, instead of focussing only on those of economic value. Ecological criteria, such as ability to shade out herbaceous weeds and attract seed-dispersing wildlife, must be emphasized when selecting species for planting. Furthermore, processes of natural forest regeneration must receive greater consideration, to develop effective silvicultural strategies.

This paper will present a synthesis of research findings aimed at developing ecologically effective and socially acceptable methods to restore degraded, seasonally dry, tropical forests within conservation areas in northern Thailand, where the primary aims of management are biodiversity conservation and watershed protection. Seasonal drought, fires and heavy human impact present special challenges to the restoration of such forests.

The results of a research program to screen nearly 400 native forest tree species for their potential usefulness in forest restoration programs will be presented. The program included studies of the seasonal cycles of seed production of mature trees in undisturbed forest as well as experiments on seed germination and seedling growth under nursery conditions. The relative importance of various criteria considered for species selection will be discussed, including: seedling performance; ease of propagation; ability to shade out weeds; ability to foster regeneration of other tree species; inhibited natural seed dispersal and rarity. Initial results will be presented of planting trials using mixtures of 30 native forest tree species and testing various silvicultural treatments, such as fertilizer application, weed control and mulching.

A program to test the applicability of new methods developed by the program within a hill tribe community living within a national park has also been initiated. A community tree nursery was constructed within the village and community members have participated in nursery management, tree planting, weeding, fire control and monitoring the success of planted plots. On the basis of the experience gained during this program, the challenges of introducing local communities to new methods of forest restoration will be discussed.

Rehabilitation of degraded Tropical Rain Forest by enrichment planting of endemic species in a forest of Sabah, Malaysia

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The valuable timber from tropical rain forests around the world is an essential resource often used to meet the demand for economic development in the local societies. Most tropical rain forests are able to gradually recover from a selective harvest. But repeated harvest too early in the secondary forest and/or wild fires can call for rehabilitation plantation to speed up the recovery process. The main objective of this effort is to improve biodiversity. Planting and tending tree seedlings of old growth species in the degraded forest is supposed to facilitate migration and reestablishment of fauna and flora belonging to the natural forest. in the current study, located to Sabah, we investigate the feasibility of rehabilitation planting in a secondary tropical rain forest degraded by harvest and the 1983 wild fire. Under the canopy of a Macaranga- dominated pioneer forest more than 30 Dipterocarp species, some non-*Dipterocarps* and fruit trees are planted using two different plantation concepts i.e. line and gap plantation. The study also includes tests of different techniques for seedling and wildling production and different regimes of shade adjustment in the pioneer vegetation overstory. in the first phase, starting in 1998, 4500-5000 ha will be planted in a 5-year period.

The main result so far is that gap plantation is cheaper than line plantation. The reason being that only five compass lines need to be cleared compared to ten for line plantation. Gap plantation appears to give the new Dipterocarp forest a more natural structure since the seedlings are more irregularly spaced than after line plantation. Seedling survival was similar following the two plantation concepts exceeding 85 % after three months.

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Transformation of degraded farmer forests into managed semi-natural forests in Eastern Paraguay

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50 years ago, more than half of Eastern Paraguay (about 160.000 km2), was covered with subtropical lowland rainforests. Today the forest cover is about 10 to 15 %. All residual forests have been exploited selectively once or several times. There are no primary forests left. As a consequence of the rapid deforestation in the last few years the discussion over how to maintain the residual forests has arisen in political circles and in public. The approach "maintaining by managing" is favored.

Nearly half of the paraguayan population assures her economical existence by managing small-scale farms with an extension of 20 ha. or less. These farms are caracterized by a strongly marked mixed production system: Food-crop cultivation, cash-crop cultivation and livestock-breeding. Generally the farms include small forests which are used without any management-plan and later on - when degraded and economically unattractive - converted into agriculture.

Until today there is no systematical investigations available on how to manage these residual small-scale forests and what economical impacts on the farming system a sustainable management might have. The investigation project was initiated in September 1998.

The aim of the investigation is to assess the potential of rising farmer's income by the integration of sustainable forest management in the farming mixed production system.

The investigation is carried out as an integrated On-Farm-Research-Project in the bufferzone of the National Park Ybycu¡, situated 150 km. south-east of Asunción. in all stages of the project, which are described in the following, a high level of active participation of the farmer families is required:

- Development of adjusted forest management concepts. The management concepts should be compatible with

- the target(s) of forest production (fuelwood, construction wood for subsistency, comercial timber, non-wood forest products) determined by the farmers themselves.

- the farmer families personal, technical und financial abilities to carry out a forest management.

- the natural conditions of the residual forests for a sustainable management. To respect these general conditions in the first instance was necessary a socio-economic assessment. Elements of the Participatory Rural Appraisal were used. Afterwards the forest ressources have been inventorized in three case-study farms.

Both, the socio-economic assessment and the forest inventory, showed, that to cover the forest product needs of the families in the long run, on-farm small reforestations are necessary as a complement to the management of the residual forests.

- Implementing the forest management concepts and the reforestations/enrichment By putting into practice the forest management it is possible to recognise and resolve technical problems and to assess the real costs and benefits of the initial silvicultural activities. This project stage will be finalised in the current year.

- First evaluation of the economic impact of the forest management With the cost-benefit assessment of the initial forest activities in combination with a simulation of future forest growth and future cash-flows a first evaluation of the economic impact on the farming-system of sustainable forest manegement should be possible. The economic evaluation will be carried out in the year 2000.

It is expected, that the results of the investigation project give practical assistance to the owners of small-scale forests and to the forest extension agencies. It is also expected, that political decision makers, for the purpose of promoting small-scale forestry, get additional arguments based on scientific results, e.g. in the discussion about subsidies for forest activities.

The Potential Role of Plantations on the Rehabilitation of Native Forest Biodiversity in Degraded Hilly Areas of Bangladesh

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Keywords: Plantation, Rehabilitation, Biodiversity, Degraded areas, Bangladesh

The natural forest loss and degradation of forest lands in Bangladesh are proceeding at an unprecedented rates eroding the biological diversity and prospects for sustainable economic development of forest resources. About 0.67 million ha hill forests rich in both floral and faunal diversity and another 0.73 million ha Unclassed State Forest (USF) areas alone in the Chittagong Hill Tracts are shrinking and degrading mainly due to agricultural expansion, shifting cultivation, encroachments, land alienation and over exploitation. Considering the magnitude of deforestation and slow growth of the existing natural forests, artificial plantation programs are getting priority day by day and there is an increasing evidence that forest plantations may play a key role in harmonizing long term forest ecosystem rehabilitation. in the past, the poor yielding heterogeneous natural forests were in the gradual process of conversion into plantation forests through clear felling and artificial regeneration with desirable exotic and indigenous tree species. Reforestation activities are also being continued in depleted and barren areas. The catalytic effect of tree plantations on native forest succession under a variety of degraded sites may be obtained and plantation forests can have the same functions as secondary forest stands.

The paper describes the necessity of the gradual conversion of the degraded hilly areas to a prospective plantations of suitable tree species which will ultimately save the natural hill forests of several hundred economically important species of both the plants and animals. The denuded hills of Chittagong, Chittagong Hill Tracts, Coxs Bazar and Sylhet Forest Division areas comprising a vast land resource of the country can neither be kept unproductive barren nor can be allowed to be abused by the peoples. As early as these denuded hills are brought under permanent forest cover by afforestation of suitable tree species, the better benefit will be derive by the local people and the nation. The depleted hilly areas which can sustain only forest crops, have been suggested to be sought under afforestation programs with valuable tree species. To restore the former biodiversity of the forested area, monocultures will be discourage whereas, emphasis should be given to indigenous species. A proper species-site matching mechanism and mixed plantations of diverse end uses should be given priority. Participation of local peoples in plantation establishment, management and protection will also enhance the activities of tree planting programs instead of shifting cultivation or jhum cultivation. Participatory approach and jhumia rehabilitation program will be given emphasis in an aim to rehabilitate the nomadic jhumia families and to improve their economic conditions with the restoration of native biodiversity over the denuded hilly areas.

Restoration of the Native Understorey Vegetation in the Plantation Forest Areas of Chittagong University Experimental Plantation Area

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Keywords: Restoration, Native species, Understorey vegetation, Plantation forest, Species composition

The degraded natural forest areas of Chittagong University experimental plantation area was in a gradual process of conversion in to a productive plantation forest through clear felling the existing natural vegetation and then followed by artificial regeneration. Both the exotic and indigenous tree species are getting preferences in the plantation programs in an aim to restore the degraded sites to a vegetation cover with valuable timber species. The native vegetation cover also emerged with the growth of the artificial plantations which restore the partial biodiversity of the original ones. The present study was an aim to survey the native understorey vegetation by random quadrat method in different years plantation. Mixed plantations of *Acacia auriculiformis*, *Albizia procera* and *Cassia siamea* of 1982 showed the presence of 36 different species in comparison to 21 species only in *Eucalyptus camaldulensis* plantations. of these, 15 understorey species are common in both the mixed and eucalypt plantations, whereas 21 species are solely present in mixed plantations and 6 species in the eucalypt plantations only. The index of similarity (Is) of ground vegetation in both the plantations is 0.36. The dominant species in both the plantations are *Clerodendrum infortunatum, Eupatorium odoratum, Lantana camara*, *Microcos paniculata* and *Vitis* *assamica*. Similar survey in the 1984 mono-plantations of *Artocarpus chaplasha*, *Swietenia macrophylla*, *Acacia auriculiformis* and *Eucalyptus camaldulensis* showed that the presence of understorey vegetation was 34, 33, 33 and 32 respectively indicating that the mono-plantations of the different species did not significantly influence on the restoration of the native understorey vegetation. *Clerodendrum infortunatum*, *Crotalaria saltiana, Eupatorium odoratum, Ichnocarpus frutescens, Lantana camara*, METLA*stoma malabathricum*, *Microcos paniculata* and *Syzygium fruticosum* are common species found in all the plantations. Similarly 1987 *E. camaldulensis* and *A. auriculiformis* plantations showed the presence of 32 and 26 understorey species respectively. of the species, 18 are common in both the plantations.

The study also revealed the presence of maximum understorey species (36) in the 1982 mixed plantations and lowest (21) in the *E. camaldulensis* plantations. The presence of understorey species in plantations also depends on the initial field preparation practices, even the initial cultural practices. The previous vegetation of the site, planting spacing and also the surface soil conditions determine the intensity and species composition of the plantations. The proper species mixing in suitable sites and the initial silvicultural treatments may restore the native understorey vegetation which will ultimately conserve the valuable native biodiversity in artificial plantation areas of the degraded hilly areas of the country.

Comparative ecological study of natural forest, man-made forests and grass lands for developing sustainable forestry in Sakaerat, Northeastern Thailand

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Keywords: restoration of forest, man-made forest, biomass, net primary production, plant species diversity

Man-made forests could play a crucial role in the process of restoring forest ecosystem to a region. However, we have not yet clearly evaluated the role and significance of man-made forests in this process. At Sakaerat, in northeastern Thailand, various stands of exotic and indigenous tree species have been established on grass lands during an re-afforestation project conducted jointly by Thailand and Japan (JICA). The goals of the present study were to evaluate the present status of re-afforestation in terms of the role of man-made forests in restoring the forest ecosystem and to develop suitable forest management systems capable of enhancing the forests on a sustainable basis. We studied biomass, productivity, and the plant species diversity of man-made forests composed of exotic species (*Acacia mangium*, *A. auriculiformis*, *Eucalyptus camaldulensis*) and indigenous species (*Xylia kerri, Dalbergia cochinchinensis, Pterocarpus macrocarpus*) and compared with those from neighbouring natural forest (dry evergreen forest) and grass lands (*Imperata cylindrica*, *Neyraudia reynaudiana*) in 1998 and 1999. The results were as follows:

1) By 13 years after planting, exotic man-made forests had accumulated above-ground organic matters levels 20 to 30 times as great as the *Imperata cylindrica* grassland and 1 to 1.8 times as great as the natural forest, whereas indigenous man-made forests accumulated 6 to 17 times as much above-ground organic matter as the grassland and 0.3 to 0.9 times as much as the natural forest. Much larger biomass developed in the exotic stands than in estimated seral forests during secondary succession from *Imperata cylindrica* grassland to dry evergreen forest; these values were approximately equal for indigenous stands and the seral forests.

2) The leaf biomass in the man-made forests ranged from 2 to 5 ton/ha. This range of leaf biomass was the lowest measured thus far in various types of forests.

3) The annual above-ground biomass increments in the man-made forest were 1.4 to 3.7 times as high as the increment measured in *Imperata cylindrica* grassland. The annual net primary production in exotic man-made forests and indigenous man-made forests were, respectively, 1.2 to 1.8 times and 0.6 to 1.1 times as great as the level in natural forest. The low level of leaf biomass, combined with high turn over rates of leaf mass, was found to have enabled exotic species stands to attain high level of net primary production.

4) More plant species with various life forms became established in man-made forests of exotic and indigenous species than in grass lands; the values range from 62 to 82 plant species per stand. Among the plant species established in the stands, seedlings and saplings of forest tree species accounted for 29 to 40% of the total. A noteworthy thing was almost no invasion of *Imperata cylindrica, Neyraudia reynaudiana* in the man-made

forests. in Sakaerat, the occurrence of surface fires decreased greatly after establishment of the forest stands. This could be a result of the disappearance of these shade-intolerant grasses under the stand canopies, since such grasses are a major source of fires. Preventing surface fires could, in turn, have allowed tree seedlings to become established within the man-made forests. in this context, the small leaf biomass in the stands created enough shade to prevent invasion of the two grasses and to provide a suitable light environment for seedling establishment.

From these results, it appears that re-afforestation helped the ecosystem to accumulate large amount of biomass and fix large amount of carbon in a relatively short time because of high net primary productivity, and accelerated the forest succession from grass land to natural forests by increasing the stocking of advance growth of indigenous species in the stands. Based on these results, we discuss suitable management systems for promoting forest succession and for enhancing the quality of forests on a sustainable basis.

Participatory restoration of a degraded landscape in Kerala state, India with indigenous forest tree species of commercial potential

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While there is increasing pressure to transform more of unproductive landscapes in India into productive areas by the introduction of exotics like *Eucalypts* and Acacias, a pilot scale experiment was conducted to restore such a wasteland using indigenous forest tree species, the products of which are of commercial demand in the Indian System of Medicine. With the active participation of the rural beneficiaries, ensured by Participatory Rural Appraisal (PRA) method, the land capability, vegetal cover and adverse factors which operate in the ecosystem rendering it degraded and unproductive, were understood and an area of 12 ha was adopted for development under the scheme. Species selection for artificial regeneration was also accomplished through PRAs, where, acceptability to the people and the environment were the priorities and long-term returns on a sustainable basis, the economic doctrine. The tree species, thus selected for the restoration programme, are Aegle marmelos (L.) Correa, *Caesalpinia sappan* L., *Oroxylum indicum* (L.) Vent., *Pterocarpus santalinus* L.f. and *Saraca asoca* (Roxb.) de Wilde, the last three among them very rare or endangered due to over-exploitation of their medicinal products vis-a-vis degradation of their natural habitats. The restoration component of the programme involved procurement of seeds, establishment of nursery, raising seedlings of the six species in sufficient numbers, field planting them and monitoring their survival and growth rates. The data generated during each of the phase were analysed and is presented in the paper to conclude on the success of the rehabilitation programme. in the nursery, Aegle marmelos and *Caesalpinia sappan* recorded maximum germination rates, whereas, in the case of outplanted seedlings, better survival and growth were observed for *Caesalpinia sappan* and Pterocarpus santalinus. The programme also generated direct employment to the beneficiaries during its nursery and planting phases, and created awareness among them on alternate economically potential, indigenous species for restoration of unproductive and degraded sites in the place of exotics - not eco and etho-friendly. Moreover, the strategy evolved for the intervention and transfer of technology pertaining to the nursery and plantation aspects of the species were so designed to facilitate the beneficiaries to undertake such rehabilitation activities in future, in similar areas with same or similar species, ecologically suitable and economically viable.

Development of Wasteland Through Tree Plantation in Chattisgarh Region

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Plantation of multipurpose trees (MPT) species play an important role in restoring productivity, ecosystem stability and biological diversity to degraded lands. The choice of Plantation species is likely to influence both the rate and trajectory of rehabilitation process. in chhattisgarth region where entisols (red laterite) and inceptisols dominate which have negligible productivity; there is a need to find ways to increase productivity by including wood perennial. Out of the total geographical area of 144018 sq. km nearly 20 % area is under red laterite soil, commonly known as bhata soil. Due to poor waterholding capacity, available field moisture and very poor nutrient status of these soils, the productivity is extremely low. Beside the low productivity the problem of soil erosion is predominant in the uplands. in order to conserve the soil and increase productivity, the tree plantation programme was undertaken. Both forest tree species and horticulture tree species viz., *Albizia lebbeck, Dalberiga sissoo, Gmelina arborea, Pongamia* *pinnata, Albizia procera, DendroCalamus strictus, Azadirachta indica, Anacardium occidentale, Annona squamosa, Emblica officinalis, Psidium guajava* and *Zizyphus mauritiana* were planted either as block plantation or as energy plantation. The survival and growth performance after 4 to 6 years of plantation revealed that many of the tree species could be planted in red laterite soils of chhattisgarth region. Among the tested species *Eucalyptus tereticornis, hardwickia binata, Leucaena leucocephala* and *Emblica officinalis* out performed in block plantation. Growth and biomass of bole, branches, leaves and fruit after 7 years of plantation were assessed. The highest growth performance and biomass production were in order, *L. leucocephala* > *E. tereticornis* > *A. procera* > *D. Sissoo* > *A. indica* > *H. binata* > *T. arjuna*. The variation in soil properties at different depths of soil under different tree species was also studied. Increased levels of nutrients (N, P and K), moisture content and organic carbon varied in different species and nitrogen fixing trees, in general, showed higher nutrients. Moisture and nutrient, contents decreased with depth. The results are discussed in the light potential of introduction of exotics in comparison to indigenous species.

Seed and seedling demography of an alien tree species Bischofia javanica in a subtropical island forest of western Pacific

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Bischofia javanica Blume (*Euphorbiaceae*), indigenous to southeast Asia, was introduced into Bonin Island in early 1900's as a timber tree. On Bonin Island, a small Japanese island in the western Pacific, it became established in the natural forest replacing native tree species and assumed dominance in the local forest as a canopy tree or an emergent at maturity. It is competitively replacing the preferred native species of which 73% are endemics occurring in highly valued conservation areas. These endemic species and the native forest biodiversity are being seriously threatened by *B. javanica*. Conservation measures to control *B. javanica* is being considered. But the ecological behaviour of this species is not well known. The aim of this study is to clarify the ecological traits which confer an advantage in the regeneration of *B. javanica* over native species. We investigated the early establishment of *B. javanica* including seed fall, seedling emergence, and seedling survival both in the field and in greenhouse experiments. Seed fall of *B. javanica* occurs mainly from December to February and shows considerable yearly variations. A large number of seed (about 2400/m^2) was observed in the autumn of 1995 (mast year) but for the next 3 years, very few seed were produced. To evaluate seed longevity in forest soil, we buried seeds in forest soil and checked their viability at regular intervals over 2 years. About 7% of the seeds with pulp and 3% of the seeds without pulp buried in forest soil were still viable after 2 years. This suggests that *B. javanica* forms short-term seed banks that will be exhausted in a few years without the input of newly fallen seeds. Mortality of seed produced in the autumn was quite low resulting in high seed germination in the following rainy season (middle May to June). This initial flush of germination produced a dense carpet of seedlings (mean 210/m^2), but low numbers of seedlings continue to emerge for several years. Many seedlings die after 2 months (in mid-June to July) from wilting, and to a lesser extent, from damping off and herbivory. Compared with *B. javanica*, seedling emergence and persistence of native species were much lower under forest shade. Large numbers of seedlings and saplings of *B. javanica* also dominated most forest gaps indicating a competitive advantage over other species in disturbed sites. This is supported by findings in greenhouse experiments where *B. javanica* seedlings showed capability of high growth rates in both high and low light environments. It appears that *B. javanica* seedlings have the ability to occupy gap openings and reach maturity more quickly than native species. Based on findings of this study, *B. javanica* can be characterized by its high seed output, low seed mortality, a large annual seedling emergence from newly dispersed seed and short-term seed bank. It is also capable of high seedling survival by maintaining high growth rates both in gaps and under canopy shade. It is likely that these regeneration traits contribute to the success of *B. javanica* in the juvenile stage and to the over-abundance of this invasive species on the island. Forest management to control *B. javanica*, therefore, will only be effective by combining the removal of adult trees with reducing the seedling population to a very low level. *B. javanica* can persist in the shaded understorey but can not reach maturity without canopy openings. By eliminating the sapling population in gaps would reduce the further spread of *B. javanica*. Suppressing its natural increase in the juvenile stage is probably the most ecologically and economically effective means of maintaining long-term control over large areas.

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2.01.00 Physiology of tropical and temperate trees

Within- and among-provenance variability of *Pinus ponderosa* seedling response to long-term elevated CO_2 exposure

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Among- and within-provenance variability in growth and physiological performance of *Pinus ponderosa* Dougl ex P. Laws seedlings were investigated in response to ambient or elevated atmospheric carbon dioxide (ambient + 175 µL L^{-1} or ambient + 350 µL L^{-1} CO_2) for sixteen months. Among-provenance variability was studied with bulk-collection sources from five different physiographic regions of California. Within-provenance variability was examined with three half-sibling families from a common physiographic locale.

Regardless of source, stem volume increased at ambient + 175 µL L^{-1} CO_2, however, further increases in CO_2 to ambient + 350 µL L^{-1} resulted in a variety of stem volume responses with about equal numbers of sources showing either no change or slight increases. Physiological responses to elevated CO_2, including decreased efficiencies of photochemical transfer (Fv/Fm), no change in stomatal conductance, and increased photosynthetic and water-use efficiencies, were consistent among half-sib families. This limited survey shows little within-provenance variation in CO_2 effects on seedling physiology. The within- and among-provenance variability in growth response to CO_2 indicates differing genetic control of carbon acquisition and allocation mechanisms among sources of *Pinus ponderosa*. Understanding the extent and source of intraspecific variation in growth and physiological responses to elevated CO_2 is a critical need in developing management strategies for future atmospheric environments.

Ecophysiological studies at the Top of a Lowland Rain Forest Canopy in Southern Taiwan

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Diurnal patterns of photosynthesis, transpiration and stomatal conductance of five species were measured in a lowland rain forest of Nanjenshan in southern Taiwan from 1995 to 1997. These physiological measurements were taken at the uppermost canopy of *Ficus benjamina*, *Machilus kusanoi*, and *Michelia compressa*. Those at the middle canopy were monitored only in *Ficus*, and those of understory species were represented by *Psychotria rubra* and *Aglaia elliptifolin*. Under moderate weather conditions seasonal courses of net photosynthesis in the uppermost canopy of the *Ficus* tree showed a positive correlation with leaf temperature. However, when leaf temperature exceeded 33°C and leaf-to-air vapor pressure deficit exceeded 2.5 kPa, net photosynthesis as well as stomatal conductance declined. Low temperatures in winter and high temperatures in summer inhibited net photosynthesis as well.

Photosynthetic photon flux density (PPFD) was found to be the major environmental factor affecting primary photosynthetic productivity of plants in Nanjenshan forest. Usually, diurnal courses of both net photosynthesis and transpiration followed the variation patterns of PPFD. Diurnal mean PPFD and net photosynthesis in the upper canopy of the Ficus tree were 643 µmol photon m-2 s-1 and 6.94 æmol CO_2 m-2 s-1, respectively. Comparatively, measurements at the middle canopy were only 14% and 30% and those of understory species were only 3-6% and 7-11% of the upper canopy values. The photosynthesis productivity of Ficus, Machilus and Michelia were 10.8, 11.2, and 11.7 g CO_2 m-2 day-1, and their transpiration rates were 1.30, 1.51, and 1.53 kg H2O m-2 day-1, respectively. Net photosynthesis at the uppermost canopy measured at 9 am, or mean net photosynthesis measured at 8 am and 10 am, had significant linear correlation with the diurnal carbon gain. This suggests that short-term measurements of photosynthesis, performed at periodic intervals in the morning, can be used to predict the daily leaf carbon gain in a lowland forest tree.

Dependence of biomass formation on carbohydrate content in the leaves of *Populus tremula*

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Several vegetation models suggest profound changes may occur in the boreal forests with a doubling of atmospheric CO_2 and global temperature rise. These forest responses may result from changing competitive relationships among species (Solomon, Cramer, 1993) and increases in the wood production capacity of deciduous trees (Kellom et al., 1995). Results from FGM calculations indicate that the competitive ability of several deciduous tree species that occur in Estonia could increase significantly with rising temperatures in association with increases in their biomass in the forest ecosystem (Mandre, Klysheiko, 1996). Leaf orientation, display and anatomy and branch type of *Populus tremula* (aspen) have suitability for enhanced CO_2 acquisition with climate change suggesting an increase in the relevance of aspen in Estonian forests.

Knowledge of carbon allocation processes is essential for understanding tree growth; however, such knowledge of the mechanisms and controls of carbon allocation are generally lacking. Carbohydrates are necessary for the growth and biomass formation of a tree, and we have determined the carbohydrate content and nutrient status of aspen leaves in relation to their location in the canopy.

The canopies of aspen trees (n = 12 in each year) were sampled from ten equal horizontal layers. Canopy foliage was obtained from all canopy layers at the end of the leaf growth period in 1987-1994. The specific leaf mass (mg m-2) and the dry matter distribution (%) increased, whereas, the area of leaves in a canopy layer (m^2) decreased with increase in canopy height. On average aspen leaves contained 10.3% soluble sugars and 1.7% starch on a dry mass basis. The lowest content of non-structural carbohydrates was usually found in the lower canopy layers. Beginning from mid-canopy the carbohydrate content showed an upward trend. The content of non-structural carbohydrates varied with position of the leaves in the different canopy layers and with the N, P and K contents in the tissues, reaching a maximum in the upper canopy layers. Leaves of the upper canopy layers had 15-20% more soluble sugars and 30-40% more starch than the lowest canopy layer. The content of hemicelluloses in aspen leaves fluctuated between 40-70 g kg^{-1} and seemed to be higher in mid-canopy. Regression analysis showed a strong relationship between the specific leaf mass, leaf area and the percent carbohydrate content of foliar dry matter.

Biomass and morphological characteristics of aspen were related to the carbohydrate content in leaves. The relatively large differences in carbohydrate concentrations in different canopy layers of *Populus tremula* suggests that leaves have differing abilities to assimilate CO_2 from the atmosphere. Enhanced growth and acclimation of photosynthesis of several *Populus sp*. were also shown by Ceulemans and Isebrands (1996) for elevated CO_2 conditions. These results suggest the possibility for expansion of *Populus tremula* in Estonian forests with projected changes in environmental conditions.

Photosynthetic characteristics of tropical trees and their ecological significance in climate changes

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Tropical forests may contribute a large proportion of the photosynthetic CO_2 uptake by terrestrial ecosystems. However, the CO_2 fixation contribution of tropical forests is still unclear for its quantitative amount. Consequently, it is difficult to predict the ecological role of tropical forests in regional and global CO_2 budgets. Some studies suggest that tropical forests are significant carbon sinks, but others reveal that some tropical forests (Amazon) can be CO_2 sources, especially during dry seasons. Without further detailed understanding of the physiological characteristics of tropical trees, it would be difficult to quantify the contribution of tropical forests in the global carbon budget.

In this study, we evaluated whether tropical tree species show any particular physiological characteristics in CO_2 uptake that differ from the evergreen tree species of temperate forests. We surveyed photosynthetic data for tropical tree species from literature, and measured photosynthetic characteristics for some typical tree species in the Pasoh Forest Reserve, Malaysia. Particular attention was given to seedlings of tree species from South East Asian tropical forests, since knowledge is still rather limited for this region among tropical forests of the world.

We found that tree seedlings from tropical rain forests tend to use light efficiently under low photosynthetic photon flux density conditions, whereas their canopy leaves, exposed to direct sunlight, tend to show a higher resistance to photoinhibition in comparison with the majority of temperate tree species. By examining the effects of various environmental factors on photosynthetic parameters, we found that sunflecks may contribute to a larger proportion of leaf carbon gain for tree seedlings in tropical rain forests than in temperate evergreen forest species. We also note that the high CO_2 concentration in forest floor enhanced leaf carbon gain of tree seedlings.

Our results suggest that we need to account for physiological differences between temperate and tropical trees in model predictions of their contributions to leaf carbon gain. We propose a set of parameters for characterizing the differences in photosynthetic responses between tropical and temperate trees, which may facilitate model prediction of climate change impacts on the global carbon budget.

A Correction Coefficient for Dealing with Variation in Sapflow with Position in Sapwood

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Sapflow sensors were used to investigate the variation of sapflow velocity in the sapwood of *Eucalyptus globulus*. Sapflow velocity was measured sequentially at 5 mm intervals across the sapwood by moving two probe sets simultaneously on two opposite radii. A second probe set was placed in a fixed position at right angles to the first set. Sapflow velocity ratio was defined as the velocity of each moving sensor divided by that of the static sensor. The ratio at each position was constant but varied across the sapwood. The variation was high and implied a need for large numbers of sensors for accurate determination of sapflux. To overcome this necessity, a correction co-efficient was determined for use in conjunction with a fixed sensor probe set. The coefficient was calculated as a weighted average of the velocity ratios obtained with depth in the sapwood.

2.01.17 Vegetative propagation

Recent Advances in Mass Propagation of *Acacia mangium*, *Acacia mangium* x *A. auriculiformis* hybrid and *Acacia crassicarpa* by Tissue Culture

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Keywords: *Acacia mangium*; *Acacia crassicarpa*; *Acacia mangium* x *auriculiformis* hybrid; micropropagation; forest plantations

Acacia species, and more specifically *Acacia mangium*, have become major plantation tree species in South-East Asia during the last two decades, particularly in Indonesia and Sabah. These fast-growing species are mostly used for pulp production but their wood can also be used for general construction, furniture, particle board as well as plywood. During the past few years and in the context of an increasing demand of superior plant materials by local forest companies in Sabah, the Plant Biotechnology Laboratory Project has carried out micropropagation studies on the three major plantation species of Acacias: *A. mangium*, *A. mangium* x auriculiformis hybrid and *A. crassicarpa*. The cloning of superior genotypes is more appropriate in the case of *A. crassicarpa* compared to *A. mangium* since the genetic variability is known and often observed to be much higher within and between progenies in *A. crassicarpa* than in *A. mangium*. in the case of *A. mangium* x *auriculiformis* hybrid - that is known to have a better growth than the *A. mangium* pure parent species - vegetative propagation is currently the only way of propagation since propagation by seeds from bi-specific orchards still remains not feasible at the present time. Although the micropropagation method allows the cloning of superior adult *Acacia* genotypes in a shorter time than conventional methods of propagation, especially in the first stages of the long rejuvenation process, the combination of both in vitro and conventional methods of propagation is the most cost-effective and appropriate strategy to be applied for large-scale afforestation programs.

Micropropagation protocols and appropriate culture media were developed for each of the three *Acacia* species studied. Our tissue-culture experiments were mainly focused on the improvement of the multiplication rate through axillary budding and the in vitro rooting ability of the axillary shoots obtained. The protocols were initially developed from juvenile materials (seedlings) and then adapted to mature genotypes. The in vitro introduction of shoots directly collected from mature trees was shown to be successful since responsive and contaminant-free cultures were obtained on specific introduction media for all species. The next step consisted in defining a suitable methodology for maintaining selected genotypes under intensive micropropagation for long periods of time. The multiplication rates varied strongly between and within each of the three species, except for *A. mangium* in which no genotype effect was found among the clones tested. Conversely, clonal differences were observed for adventitious rooting ability in *A. mangium* and *A. crassicarpa* but not in the *A. mangium* x *A. auriculiformis* clones studied. Overall, *A. mangium* displayed a weaker potential for in vitro root formation from microshoots than *A. mangium* x *A. auriculiformis* and *A. crassicarpa*. Ex vitro acclimatization of in vitro rooted plantlets in nursery was also less successful for *A. mangium* compared to the hybrids (50% and 90% respectively). A very low percentage of recovery (5 to 10%) was obtained in the preliminary acclimatization experiments performed on *A. crassicarpa*.

Prospects of tissue culture for improving teak plantations

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Keywords: *Tectona grandis*; clonal propagation; tissue culture; teak clones; forest plantations

Teak (*Tectona grandis*) is a high quality timber valued for the attractiveness and durability of its wood. Increasing lack of available natural resources has resulted in a step up of reforestation programs on teak. The conventional means of propagation is through the use of seeds. However, this source is limited by availability and germinability of seed lots and further, by variability in the growth and performance of the derived plants. Methods through vegetative propagation aiming at the production of improved planting materials have been investigated. The propagation of selected clonal materials is of importance owing to the obvious gains that can be derived in terms of growth yield and superior wood characteristics as well as for traits that confer resistant to pests and diseases.

Within the joint project between Innoprise Corporation and CIRAD-Forêt, in addition to the issuance of rooted cuttings at the nursery level, a technique has been developed for the in vitro propagation of teak. Using the tissue culture protocol, it is now possible to select and introduce any outstanding or "Plus" tree for mass multiplication regardless of its age. The technique also allowed the germination and multiplication of seed lots that are hard to come by or show low viability in the nursery. Using a sole multiplication/elongation culture medium with minimal hormone addition, an exponential multiplication rate of 3 to 4 microcuttings per plantlet can be obtained at every six to eight week cycle. Spontaneous rooting occurs in more than 80% of the microcuttings and in the acclimatization phase, more than 90% survival is seen. The protocol incorporates the lowest costs possible, simplicity, and ease of manipulation, thereby making the propagation of selected teak clones highly feasible.

The success of the protocol has so far resulted in the transfer of more than 200,000 micro-shoots to the nurseries and subsequently to the field for further testing. Genetic materials comprising of fourteen different origins used in various trials are being maintained in the laboratory and will be used in future deployments depending upon their field performance. The propagation of clones from such a broad genetic base is definitely compulsory for the the technique to be broadly and effectively applicable.

To date, commercial activity involving the sales of materials to local and overseas planters has been undertaken by the project on a small scale. in view of the successful results obtained from the transfer of plantlets overseas, the use of this technology for setting up superior quality teak clonal plantations in even more distant countries appears to be very promising.

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Local Biotechnology Project "Development of micropropagation technology for high quality trees"

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Keywords: Micropropagation; Tissue culture; *Larix, Pinus, Quercus, Prunus, Zelkova*

The forest biotechnology research project was carried out with support from the Forestry Agency of the Ministry of Agriculture, Forestry and Fishery, Japan from 1986 to 1996. The cooperative research group consists of 18 prefectural research institutes (Hokkaido, Akita, Gunma, Saitama, Ishikawa, Aichi, Gifu, Mie, Wakayama, Tottori, Hiroshima, Ehime, Kochi, Fukuoka, Kumamoto, Ohita, Miyazaki, Kagoshima) and 1 national research institute(FFPRI). In this project, proper micropropagation techniques were developed for *Larix* hybrid, *Cryptomeria japonica, Chamaecyparis obtusa, Pinus thunbergii, Pinus densiflora, Diospyros kaki, Quercus acutissima, Quercus serrata, Quercus phyllyraeoides, Castanea crenata, Zelkova serrata, Prunus verecunda, Prunus jamasakura, Prunus spachiana* forma *ascendens, Betula grossa* and *Melia azedarach.*

Mass propagation of *Larix* hybrid using shoot primordium liquid culture system and direct rooting system of *Prunus* are prospective newly developed techniques for practical application of micropropagation for high quality trees. Micropropagation by axillary shoot culture of *Zelkova serrata* has high potential for commercialization because of its high value in the market. Tissue culture system of a 850 years old natural monument *Prunus* tree was developed. Following these successful achievements, new local biotechnology project « Development of preservation and propagation techniques of useful forest resources using biotechnology» has started from 1996. This 8 years long project group consists of 14 prefectural research institutes, 1 private company and 1 national research institute(FFPRI) and is supported financially by the Forestry Agency, Japan.

Private Sector Forestry Research - A Success Story from India

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Keywords: *Eucalypts*, Clone, Productivity, *Casuarina*, Genotype

Almost the entire 76 million ha recorded forest area is owned and managed by the State Governments in India. Forestry research, by the State Forest Departments and various Forest Research Institutes, is mostly funded by the Government. Legislation for *sui generis* protection for breeder's rights is still pending, and there is no mechanism for certification of seed of forestry species or registration of clones. There is no wonder, therefore, that there is little incentive for private sector investments in forestry research.

Despite many constraints, ITC Bhadrachalam has been implementing a major research and development project since 1989 with a view to improving the productivity and profitability of plantations and making farm forestry an attractive land use option.

Starting with cloning of 64 candidate plus trees (CPTs) of *Eucalyptus tereticornis* and Mysore Gum during 1989, more than 500 CPTs have been cloned so far. Based on their comparative performance in field trials, 72 promising, fast growing and disease resistant clones, with productivity ranging between 12-44 cum/ha/yr. under rainfed conditions, have been identified. Several hybrids have been developed through controlled pollination between selected best `Bhadrachalam' clones of *E. tereticornis* and other species of *Eucalyptus*. Hybrid seedlings with good heterosis have been cloned. These hybrid clones are under field evaluation.

In vitro propagation, a viable alternative for the continuous supply of planting material for recalcitrant tropical forest trees

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Key words: tropical trees; in vitro propagation; acclimatisation; plantation.

Natural regeneration of forest trees is poor because of sporadic seed production and most of the species produce recalcitrant seeds that are intolerant to desiccation, so that their genetic diversity can not be preserved in conventional seed banks. Concerted efforts must therefore be made to evolve methods for mass multiplication of forest trees, their conservation and cloning of superior genotypes for use in tree improvement programme. During the last decade, significant progress has been made in the propagation of fruit and forest trees through *in vitro* culture technology. For clonal mass propagation, through *in vitro* culture, from shoot tip and nodal explants of mature trees, we have established protocols for some tropical trees e.g. *Artocarpus heterophyllus*, *Artocarpus chaplasha*, *Azadirachta indica*, *Gmelina arborea* and *Elaeocarpus robustus*. Small twigs were collected in spring season from coppiced branches of selected trees and protocols have been established for their mass clonal propagation. The techniques consisted of four major steps. 1. Establishment of *in vitro* cultures from rejuvenated tissues, 2. Induction of multiple shoots from individual explants, 3. Rooting and 4. Acclimatisation. For culture establishment, multiplication and rooting Murashige and Skoog's (MS) nutrient medium was used. Explants of different species showed different responses when cultured on MS medium supplemented with various concentrations and combinations of cytokinin, auxins, casein hydrolysate and coconut milk. Polyvinylpyrrolidone (PVP) was required to overcome the effects of phenolic compounds secreted from the explants. Depending on species, 65-85% cultures produced shoots. For multiplication newly formed shoots were subcultured to fresh medium designed for each plant species, and 15-20 shoots per subculture were obtained through several subcultures. Well developed shoots were rooted by implanting them on root induction medium. For acclimatisation four to six-week-old regenerants were transplanted into sterilized soil and compost (1:1) and covered with transparent polyethylene sheets misted three times per day. After 3-4 weeks the plantlets were transplanted singly in polyethylene bags containing sand, soil and compost (1:1:1) and kept under indirect sunlight. After 8-10 months they were transplanted in the open field where 70-85% plants survived. The technique is feasible as viable alternative for the continuous supply of planting material for recalcitrant trees as well as for the conservation of forest gene resources.

2.02.00 / 2.08.00 Future of breeding and plantations in a sustainability-oriented world

Dynamics of nutrient budgets during coniferous plantation development: Interest for sustainable management recommendations

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This paper aims at (1) showing the nead of chronosequence studies in forest ecosystems; (2) presenting contrasted situations of nutrient budgets calculated for representative coniferous plantations from France, semi-extensively managed, where risks of soil nutrient depletion linked to silviculture is high; (3) discuss the causes for contrasting results; (4) Evaluate the sustainability of different forest management scenarios.

Material and methods

Two chronosequences of three stands were used to study the dynamics of nutrient budgets. Input-output nutrient budgets were calculated as: Total atmospherical deposition + Release of nutrients from soil mineral weathering- Biomass removal - Deep drainage.

The sites: i) Aubure (Vosges) is a chronosequence of three stands of Norway spruce (*Picea abies* Karst.) 20-, 40- and 90-year old, planted on acid sandy soils developped from a leuco-granite. The elevation is 1100 m, rainfall 1500 mm and mean annual temperature 6-C. Stands are Mg and Ca deficient. ii) Vauxrenard (Beaujolais) is a chronosquence of three stands of Douglas-fir (*PseudoTsuga menziesii* Franco), 25-, 45- and 65-year old, planted on an acidic and desaturated soil, previously cultivated, developped from a rather rich volcanic tuff. The site elevation is about 750 m, mean annual rainfall 1000 mm and mean annual temperature 7-C. The stand mineral supply is correct.

Results and discussion

Aubure: The mean annual nutrient budget is negative for all elements, and the nutrient budgets calculated for the three development stages (three stands) are also always negative. in the young stands, the budget deficits are link to the high biomass incorporation and drainage losses are low. in the older stand, the deficit is similar but mainly linked to drainage as biomass incorporation is low in this declining stand. Norway spruce planted on a very poor soil, acidified by atmospheric deposition take advantage of soil nutrients during the young stages of stand development, but its nutrient status progressively decrease in relation to the its shallow rooting, and drainage losses increase.

Vauxrenard: The mean annual nutrient budget is strongly negative for all elements, but the deficits of the budgets decrease with stand-age to become more or less nil in the older stand (apart for Ca which is always few negative in the 60-year old stand). The deficit is strongly link to drainage losses which were attributed to two factors: i) the Douglas-fir is not the native vegetation for the site and a new organic matter equilibrium is going on and ii) the previous land occupation by agriculture induced a high nitrifying activity which cannot be compensated by nitrate uptake by Douglas-fir. The over-loading of NO_3-N induced a strong excedent of protons leading to cation losses associated with the mobile nitrate. Atmospherical deposits increase the phenomenon but is not the main driving force.

Sylvicultural consequences of these contrasting situations are: at Aubure, the nutrient budget is always negative, indicating that there is no management possibility other than liming and fertilization to restore the soil quality. At Vauxrenard, the nutrient budget tend to be equilibrate for rotation length longer than 60 years and a biomass harvest limited to stem (with bark), indicating that the soil fertility would stabilize for a rotation time longer than 80 yrs.

Conclusion

Nutrient budgets are dynamic, therefore chronosequences studies are needed to evaluate forest sustainability. Soil fertility may or may not stabilize when increase the rotation length, depending on soil type, pollution climate, previous land use and stand adaptation to site conditions.

Tree breeding and Plantations in Europe: a regional situation report

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As a reaction to the more and more artificial environment of humans and some bad experiences with human impact on nature there exists an increasing scepticism against manipulation of nature in the European society. This scepticism is not restricted to the public but can be found in the forestry society as well. Often non reflected comments like: “natural regeneration is always better than plantation” or “tree breeding is against nature” can be heard. As soon as such ideas and feelings become more general, they have implications on funding.

With the assistance of colleges from 25 European countries the situation of tree breeding and tree plantations in Europe was evaluated. The results are presented in the first part oft the paper.

Tree breeding is regarded as important in nearly all European countries. The main emphasis of tree breeding is on pine and spruce, followed by oak, poplar, larch, ash, Douglas fir and wild cherry. Altogether 25 tree species are included into breeding activities. Seed orchard establishment ranges before testing of stands and clonal propagation. Medium intensity tree breeding is prevailing and only in three countries aggressive tree breeding is done. There is a higher concern about forest tree breeding among foresters than in the public. Since only 40 % of the tree breeding programs are on a secure financial base, this must have implications on funding.

Natural regeneration plays a very different role in the different countries, ranging from zero to 85 %. Afforestation of marginal farmlands plays an important role in most of the European countries with a total annual surface of slightly above 200.000 hectares. There exists a trend to favour close to nature forest management. in competition situations protection of nature is mostly favoured in funding as compared to tree breeding. in spite of this the climate towards forest tree breeding is neutral or supportive more than hostile. The last situation occurs only in three countries.

in the majority of the countries tree breeding is handling the conservation of forest genetic resources as well. Therefore tree breeding programs take into consideration the conservation as an integral part of the programs.

A majority of the colleges (16 out of 25) think that a self - imposed ethical code how to use improved material would be useful or necessary. This is especially true for the use of genetically modified organisms.

In a second part the rationale basis for the field of tree improvement in Europe is outlined. Lines of compromise to solve the conflicting situation between future need for wood as a raw material and protection of biodiversity are discussed, e.g. how far a certain area of intensive plantations with genetically improved material could help to conserve natural forests.

Situation and results of breeding and plantation forestry in the American Southeast

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Forest genetics and tree breeding have made significant contributions to forest productivity and plantation programs over the last 50 years in the southern U.S., where forests comprise more than 50% of the land cover and supply 53% of the timber harvested in the U.S. The southern pines are the most commonly planted species, with about 11 million hectares in plantations. The South plants approximately 1.2 billion seedlings annually, 80% of which are loblolly pine (*Pinus taeda L.*) seedlings and 20% are slash pine (*Pinus elliotti var elliottii Engelm.*) seedlings, and virtually all planting stocks are genetically improved seedlings from seed orchards. Productivity improvement from forest genetics has helped to provide a reliable, ecologically sustainable, and economically affordable supply of wood. The N.C. State University-Industry Cooperative Tree Improvement Program has completed 44 years of genetic improvement for loblolly pine in the southern U.S. The impact of the tree improvement on forest productivity has been substantial through the two cycles of breeding, testing and selection. Trees grown from seeds of first-generation seed orchards have produced 7-12% more volume per acre at harvest than trees grown from wild seed. Genetic gains from second-generation seed orchards over the first-generation are estimated 14-23% additional for rogued seed orchards. Genetically improved stock has also lower infection from fusiform rust, typically 20%-25% below the unimproved seedlots. With additional improvements in quality traits (stem straightness and wood quality), the realized genetic gains in value should be much greater.

Plantation forestry is generally acceptable by public in the southern U.S. because tree planting has been a common practice since 1930 in the region. Forest planting, harvest, and manufacture of forest products provided greater economic returns to the land and more employment opportunities in the region. About 90% of forest land are owned by private land owners and forest industries, and only 10% are in public ownership. Furthermore, short rotation of pine plantations, good management practices for environmentally sensitive areas, limitation on harvesting area, and other self-imposed regulations have all contributed to the public acceptance of plantation forestry. Research demonstration and public education are also important for people to understand that intensively managed plantations are the most effective strategies to meet future demands of wood products without increasing pressures on old-growth and ecologically sensitive forests. Improved wood production on limited commercial lands will reduce the logging pressures on natural forests. By increasing wood production per hectare in plantations, rather than by managing more hectares of forest, genetics, in combination with intensive silviculture, can and will provide better opportunities for the use of natural forests and forest lands for conservation and recreational purposes. Results from two-cycles of loblolly pine breeding strongly suggest that high-yield plantations by genetic improvement can contribute significantly to the conservation and recreational purposes. Results from two-cycles of loblolly pine breeding strongly suggest that high-yield plantations by genetic improvement can contribute significantly to the conservation and sustained use of forest resources.

Introduction and Conclusions of the Beijing consultation 1998

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The future contribution of forest genetics to sustained management of global forest resources was the subject of a Division 2 consultation held in Beijing, China, 22-29 August 1998. The objective was to reach a consensus on directions and priorities for research in forest genetics and tree improvement at a time when critical financial support for long-term tree improvement research has declined while worldwide demand for wood and fiber production is continuously increasing. in setting priorities, it was recognized that a balance will be needed between long-term genetic improvement research and short-term research focused on the new technologies.

A major research focus will be the genetic background of the adaptive potential of forest trees. This will require the testing of phenotypic variability and plasticity in trees over time in diverse and changing environments, using suitable process-related markers. Research on genetic diversity should be integrated with research on forest ecosystems and conservation of genetic resources, particularly in relation to expected global environmental change. More information will be needed on the genetic consequences of mode of reproduction, breeding and gene flow mechanisms and population structure and size.

There is evidence that properly managed breeding can maintain or even increase genetic variation relative to natural populations and at the same time maximize wood production and reduce the logging pressure on natural forests. in breeding and gene conservation research, the order of priority should be (1) species of current high socioeconomic value; (2) species with clear potential or future value and (3) species of currently unknown value. Gene conservation must be part of silviculture in managed natural forests. New information will be needed of the effects of different forest interventions on adaptive genetic variability in forest ecosystems varying from mature natural stands to fiber farms.

In view of future demand for forest products, tree improvement will continue to be a key factor in sustainable forest development. However, it will be necessary to demonstrate to the forest constituency and the general public that wise management of forest resources with a strong focus on genetic improvement is fully compatible with genetic conservation, and that it is an integral part of the overall maintenance and enhancement of biological diversity. Tree improvement research deserves long term commitment by the public sector in cooperation with private agencies, supported in developing countries by international and non-governmental agencies.

Global Situation of Forest Tree Breeding: An Overview

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The first known document on tree breeding is dated 1749 by the Marine command concerning choice of seed source for *Quercus robur* (pedunculate oak) grown for ship construction. Since then many steps have been made in the management of forest gene resources.

Forest genetics include two major and complementary topics: forest tree improvement/breeding which aims at providing forest reproductive material (provenances, seed orchards, clones) to users, and forest genetics which refers to the science bringing basic information for breeding and gene conservation. Tree breeding is based on two fundamental prerequisites: variability and heritability.

Variability studies among and within species started 150 years ago and have reached full expansion during the second half of the 20th Century. For certain species and in several parts of the world this basic effort still needs to be done with a very simple idea in mind: choosing the right provenance reduces loss due to abiotic and biotic factors, and may provide as much as 30% gain in volume production. Advanced breeding based on detailed knowledge on trait heritability and other genetic parameters may double or triple this figure. Selection and improvement traits are usually classified in 4 groups: adaptation to abiotic factors, resistance to biotic factors, growth and yield, and quality. According to species use and growing conditions in each region, the right strategy and the right traits have to be chosen.

The opposition to exotics and genetic improvement in parts of the " western " world should not be generalised. Forest tree improvement has a long way to go. However the decreasing public financial effort devoted to classical breeding should be channelled and gradually replaced by private recurrent funding or long term contracting with national agencies. Regional networking is suggested whenever common efforts are possible.

Classical breeding should not be opposed to biotechnologies. Both are needed and are interactive, particularly on advanced breeding schemes.

2.02.00 / 2.08.00 Genetic variation

Diallel Crossing in *Pinus cembra*: II Analysis of Genetic Variation at the Nursery Stage

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A 10 x 10 full diallel was made in a native population of stone pine (*Pinus cembra L.*) from high elevation, to provide information on the genetic variation and inheritance of important breeding traits. in October 1991, seeds were sown in individual polyethylene pots, in spruce humus. The families, including self-pollinated parents and a mixed open-pollinated control, were arranged in a randomized complet block design with four replications and 12 seedlings per plot. Fifteen traits were measured during nursery testing. in addition, weight of 100 seeds and the cotyledon number were assessed prior and after sowing, respectively. Computer analysis of a balanced modified full diallel using the SAS program produced the results presented below. The most important result was that significant ($p<0.05$) and highly significant ($p<0.01$; $p<0.001$) differences occurred in all 17 traits for general and specific combining ability as well for reciprocal effects. Maternal effects were significant in 13 traits, including diameter and total height. This suggests that the traits are controlled by nuclear (additive and non-additive) and extranuclear genes, and by nuclear x extranuclear gene interactions. Additive and non-additive genetic variances accounted for 25% and 27% for total height at age six and 14% and 22% for root collar diameter at the same age. These figures indicate that both variances were important for growth traits within the tested population. Parents were found with significant general combining effects for growth and other traits. Narrow-sense heritability estimates at family level varied between 0.150 to 0.675 for cotyledon number and lamma shoots, respectively with 0.453 for total height at age six (H.6). By selecting the best 10 to 40 families, a genetic gain in H.6 of 10.6% to 5.5% could be achieved. An extra genetic gain could be also made by individual within family selection. The improvement of growth by using both additive and non-additive gene effects should be possible.

Gene Flow within and among Populations: A Review of Methods and Results from Temperate and Tropical Forest Trees

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Gene flow is a key determinant for the distribution of genetic variation within and among populations and thus of outstanding interest both for population geneticists and managers of forest (genetic) resources. Gene flow of plants is mainly mediated by the transport of pollen and seeds. Forest trees species use a great variety of vectors for the transport of their genes and consequently differ widely with regard to their systems of gene flow. Experimental efforts to study gene flow in forest trees have concentrated on the distribution of genes through pollen; much less is known about gene flow mediated by seeds.

Gene markers are the main tools to directly study gene flow and its effect on the genetic structures of populations. Most marker-based studies simultaneously investigate aspects of gene flow via pollen and the mating system of tree populations since both elements of the genetic system of a species are closely interrelated. Uniparentally inherited markers are powerful tools to study gene flow on a large geographic scale. Biparentally inherited markers are mainly suitable to study gene flow within populations but are also widely applied to estimate gene flow parameters such as the number of migrants among populations (Nm). Moderately variable, biparentally inherited gene markers like isoenzymes can be used in order to estimate and compare frequency distributions of marker alleles in the pollen clouds of single seed trees. Major shortcomings of frequently used methods to study gene flow and mating system parameters are a limited variability of marker loci and the violation of model assumptions made in order to estimate crucial parameters.

Most studies on gene flow have been conducted on temperate, wind-pollinated tree species. Results from experiments in closed forests dominated by a single conifer species indicate that pollen of single trees is mainly effective within a distance of less than 100 meters. However, this still implies that hundreds of trees may contribute to the genetic effective pollen cloud of single seed trees as suggested by the homogeneity of pollen allele frequencies in plantations of Norway spruce (*Picea abies*). The importance of long-distance pollen transport over many kilometres has been demonstrated for spatially isolated clonal seed orchards mainly in Scandinavia.

Most tree species are zoogamous and occur in low density in tropical forests. Much less is known about their systems of gene flow, although experimental research on these species has intensified during the past decade. Results from high-density populations of teak (*Tectona grandis*) indicate that pollen movement is mainly confined to near neighbours for this insect-pollinated species in northern Thailand. *Pterocarpus indicus* occurs in medium to low density in tropical forests of Southeast-Asia. An investigation of a population on Luzon revealed considerable amounts of effective pollen movement over distances of several hundred meters. Comparable results were also reported for several trees species of the new world tropics. Pollination by animals turns out to be a very efficient mechanism to ensure efficient gene flow and outcrossing even for species typically occurring in low density.

Efficient gene flow promotes genetic variation within the offspring generation but results in decreased genetic differentiation among subpopulations. Thus, gene flow enhances the evolutionary adaptive potential of populations but tends to decrease the opportunities for the maintenance of local adaptations. It is suggested that future research interprets gene flow as a crucial aspect of the adaptive system of forest tree species, concentrates on endangered, mainly tropical species and takes into consideration the importance of gene flow through seeds.

Using Shoot Growth Patterns to Select Desired Genotypes and understanding adaptation of *Pinus brutia*

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Shoot elongation patterns of *Pinus brutia* have been studied, with the objectives of (i) further understanding the adaptation mechanisms of species, (ii) to aid better selection of desired genotypes and (iii) accelerating the breeding programs. Six natural populations each of ten open-pollinated families were sampled. Data were collected from a provenance-progeny trial destructively. Annual height increment was partitioned to fixed growth (spring shoot) and free growth (summer shoots) and contribution of each one to the annual height increment was measured. Shoot traits of six (ages 7 to 12) consecutive ages were regressed on growth traits at ages 13 and 17 at the same site and at age 18 at another site.

Populations and families did not differ in fixed growth, but they varied in their free growth and in number of flushes except age 10 (significance level ranged from 0.042 to 0.001). Middle elevation populations of the species range had greater annual height increment and free growth cycles than the populations from distal part of range. Second and later free growth cycles were the major cause of the annual height growth differences among and within populations. This was also supported by significant correlations between free growth observed at early ages and height growth at age 17. The coefficients ranged from 0.32 to 0.45.

Linear regression models using the free growth as explanatory variables at ages 7 and 12 and fixed growth at age 12 explained 84% of the variation in height growth at age 13. Whereas number of flushes observed at ages 7 to 12 at one site explained 26% of the height growth at age 18 at another site.

Populations and families from the low and high elevation range had more conservative growth strategy, which is characterized by less free growth and less flushing, but mainly depending on the fixed growth. Favorable environment in the middle elevation range of the species may have favored genotypes with opportunistic growth strategy, making more free growth. Free growth cycles can be used to screen fast growing genotypes as they have an opportunistic growth strategy. in contrast, genotypes showing more conservative shoot growth pattern may be favored for poor and extreme sites, as they have evolved to avoid frost in higher elevations and drought in coastal regions. The differences in shoot growth pattern of the species reflect its adaptation to a wide range of environments, suggesting that shoot growth patterns should be considered when gene conservation strategies are developed.

Inbreeding owing to isolation restricts regeneration in a vulnerable species growing on isolated small islands in Japan

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The effects of inbreeding, owing to isolation and small population size, on regeneration of a vulnerable tree species *Pinus armandii* Fr. var *amamiana* (Koidz.) Hatusima in Japan were studied in relation to gene conservation. Wind-pollinated cones were collected from 11 trees growing on two isolated islands, Tanegashima and Yakushima, and mature seeds and undeveloped ovules were extracted from each cone. The average number of seeds and ovules per cone was 20.4 and 64.0, respectively. The content of seeds were investigated by using soft X-ray photography and were classified into sound seeds with normal embryo, unsound seeds with abnormal embryo or endosperm, and empty seeds with no embryo. The percentages of unsound and empty seeds were 1.7% and 83.8% respectively, but that of sound seeds was only 14.5%.

The seeds were sown in a growth chamber under controlled condition and the number of normal seedlings and mutant seedlings as well as survival rates were investigated. Germination rate was only 3.9% for all mature seeds and 0.2% for sound seeds with embryo on the average. Abnormal seedlings with yellow or white needles and morphological mutants appeared frequently, but some of them disappeared within a few weeks after germination. These results indicate that small populations and isolation of individuals reduce the chance of outbreeding and increase the frequency of inbreeding. Controlled pollination was applied to restore seed quality and to confirm the effects of inbreeding and outbreeding on regeneration. Eight trees were selected and four of them were used as female trees and the others as male trees. Cross-pollination was carried out between islands, between isolated trees growing on the same island and between trees growing within a small area. Self-pollination was also carried out on trees with a lot of male and female strobiles. Mature cones cross-, self- and wind-pollinated were collected from those trees. Many sound seeds were obtained from cross-pollinated cones; 10.1 times as many as that from wind-pollinated ones. However, no distinct difference was found between self- and wind-pollinated cones in the average number of sound seeds per cone. in cross-pollination, the number of sound seeds per cone was not different among four trees used as a male. This indicates that coefficient of relationship among individuals is not so high that it affects seed quality.

As many trees of this species have already disappeared by felling or insect damage and most of them are isolated in this island, it is hard for female strobiles to get enough pollen from others naturally. From results obtained in our experiments, it is necessary to improve seed quality by controlled pollination and to grow seedlings from those seeds to assist the conservation of this vulnerable species.

Factorial crossing design in *Picea abies L.*: genetic variation in dry matter distribution between components in full-sib families

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Keywords: *Picea abies*, narrow and normal crown, hybrid, heterosis, combining ability, dry matter.

Four selected parents of each of two narrow and normal - crowned *Picea abies L.* were used in two separate factorial mating designs. The research was performed to asses the genetic variation within an between the two groups of hybrids. Nine traits were measured at age 4, as follows: total length of stem (TLS), total number of branches (TNB), length of leader root (LLR), total number of roots (TNR), total dry matter: of stem (TDMS), of branches (TDMB), of needles (TDMN), of roots (TDMR), and dry matter of total seedling (DMTS).

Factorial analysis produced the results presented below: ANOVA indicated highly significant ($p<0.01$; $p<0.001$) differences among female effects for TDMS, TDMB, TDMN, TDMR and DMTS for narrow x normal crowned hybrid and no significant for any trait in normal x narrow crowned hybrid. Differences among male effect were significant ($p<0.05$) for DMTS and highly significant ($p< 0.01$) for TDMB and TDMN in narrow x normal crowned hybrid and significant ($p<0.05$) for TDMS and TDMN in reciprocal hybrid. Male x female interaction effects were significant ($p< 0.05$) only for TDMB in narrow x normal crowned hybrid. Positive significant ($p<0.05$; $p<0.01$; $p<0.001$) g c a effects were founded in the female parents for all traits in narrow x normal crowned hybrid and no significant in normal x narrow crown hybrid. No significant s c a genetic effects were found in both types of hybrid families.

Both high - and mid - parent heterosis were negative for all traits in narrow x normal crowned hybrid but positive for all but one traits (TNR) in normal x narrow crowned hybrid. Highly significant phenotipical correlation were found between TDMS on one hand, and TDMB, TDMN, TDMR and DMTS on the other hand in narrow x normal crowned hybrid but in reciprocal hybrid the TDMS was significantly correlated with TDMN only. Also highly significant correlation were found between TDMN and TDMR and between TDMR and DMTS in narrow x normal crowned hybrid and insignificant correlation in reciprocal hybrid. The dry matter of all seedling components was greater in normal x narrow crowned hybrid than in reciprocal one.

Optimum Breeding Generation Interval Considering Build-up of Relatedness

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A key problem in forest tree breeding is at what age selections should be made to maximize genetic progress. Conventional treatment of optimizing generation interval may take *e.g.* age-age genetic correlation, breeding time lag, cost and investment interest rate into account.

One among the most important disadvantages with short generation interval is the build-up of relatedness at each generation turn-over. in the present study this is taken into account. The genetic progress is formulated as group merit, which is a weighted average of gene diversity (group coancestry is average coancestry and also loss in gene diversity) and breeding value. Group merit progress per year can be compared over a range of selection ages, and optimum selection age can thus be identified. Hypothetical and real materials were used to demonstrate the effects of relatedness as well as its interaction with other factors on generation interval. Relatedness and breeding time lag increased optimum selection age while strong age-age genetic correlation and large breeding population size favored early selection. Optimal selection age increased as the weight for relatedness increased (equivalently gene diversity become more important). Consideration of relatedness may increase the optimum selection age compared to many suggestions in literature. in order to reduce risks of inefficient early selection, a reasonable high genetic juvenile-mature correlation and sufficiently large breeding population size are required.

2.02.00 / 2.08.00 Genetic improvement

Hybridization dynamics between two southern beeches (*Nothofagus spp.*).

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The occurrence of natural hybridisation between forest tree species increases the genetic variation of the ecosystem and therefore must be taken into account in the management and use of its genetic resources. Hybridisation dynamic constitutes an evolutive process from which less has been experimentally proved because of the difficulty for the unequivocal determination of species specific gene markers. The fulfilment of the prerequisites for the origin of inter-specific hybrids (*e.g.* contact of the species involved, overlapping of flowering dates and cross-compatibility) takes place between two southern beeches (*Nothofagus nervosa* and *N. obliqua*) in the template Subantarctic forest of southern South America. Morphological (leaves margin and vein pilosity), phenological and growth traits and allozymic heterocigosity showed the first significant evidences of hybridisation in two years old seedlings of free pollinated families of *N. nervosa*. Hybridisation rates varied between 0 and 80 % among families and differ also among years. Most of the juvenile (up to three years old) hybrid individuals showed also a significantly higher growth rate than that of the "pure" half-sibs. Through the utilisation of three allozymic gene markers a mainly unidirectional hybridisation (*N. nervosa x N. obliqua*) was found. The autofecundation rate was estimated in about 6 %. in the first analysis of the families two gene loci (Adh and Pgi) appeared to have species specific alleles with fixation in monocigous state for each species. An additional analysis of adult trees was done in different populations of the natural forest in order to confirm the allele specificity found in the seedlings. Hundred trees of each species were analysed in pure isolated populations where the gene flow from the other species could be considered as less unlikely. The specificity and fixation of the marker alleles was confirmed. in the sympatric zone around 180 individuals, 100 from each species were also analysed. The genetic inventory confirmed the heterocigous pattern of the hybrids which appeared in about 7 % of the cases.. More than 95 % of the hybrids were masked in *N. obliqua* phenotypes from which only one third were previously suspected to be hybrids based on their bark morphology. The proportion of hybrids in the analysed open pollinated families was bigger than that found in the adult trees of the natural forest suggesting the occurrence of natural selection against them. The speciation process between these two southern beeches is likely to be taking place in the last phases of pre- and post-cigotic incompatibilities.

Norway spruce breeding for growth and adaptedness

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Sustainable forest tree breeding requires that improvement in one aspect does not lead to deteriorated performance in other aspects. in a long-term perspective, it is crucial that the breeding considers adaptive traits along with other economic traits such as growth or timber quality. Previous experiments in Sweden with one-year-old Norway spruce (*Picea abies* (L.) Karst.) seedlings indicate that progenies from improved seed orchards are more prone to early-autumn frost damage than progenies from unselected natural populations of the same geographic origin. The purpose of this study was to investigate if improved and unselected material differs in level of climate-related damage also after several years in the field, and how this difference is related to the differences in growth.

We compared growth and adaptive traits in progenies from phenotypically selected plustrees, allocated as grafts in seed orchards, and from natural populations of Norway spruce. The study comprised six field trials located in central Sweden. Subsets of up to 114 open-pollinated families from plustrees, originating from central Sweden, were compared with 18 natural populations from Sweden, the Baltic states and Belorussia. The trees were 9-14 years old when measured. Plustree progenies were 11 to 28% taller when compared with unimproved populations from the same geographic area. The plustree progenies had lower frequencies of climate-related damage such as ramicorns, doublestems and frost damage in all of the field trials. Family-mean correlations were negative between damage frequency and height, i.e. tall families were more free from damage. Transfer of populations from south to north resulted in increased growth compared to that of local populations. The best populations, from Belorussia, were almost as high as the plustree progenies. Belorussian populations had, on average, lower frequencies of frost damage and ramicorns than the other populations and the plustree progenies. Spruces from Belorussian populations are characterised by late budburst, thus they are more resistant to early summer frosts. However, they are likely to set bud and harden later in the summer than spruces of central Swedish origin. At one particular occasion with an early autumn frost, Belorussian spruces were more damaged than any other test sort. Plustree progenies were least damaged also at this occasion.

The lower autumn-frost hardiness in seed-orchard material previously observed in one-year-old seedlings is not reflected in overall damage level for the field-grown trees. The explanation might either be that one-year-old seed-orchard seedlings show temporary effects of *e.g.* improved seed physiology, or that autumn-frost hardiness is not relevant for climate-induced damage in the field in southern and central Sweden. The observation from the single occasion with an early-autumn frost argues for that the effects are temporary. Thus, the results indicate that both growth and overall adaptedness to climate are improved in the selected families.

The Slovenian Forest Gene Bank

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Forests cover 53% of Slovenia with the total growing stock of 208.5 million (106) m^3. Sustainable management of forests on the basis of their multiple functions and co-natural orientation of forest management have long tradition, due to the large Karst area, in which already 400 years ago no clearcutting could be allowed as it would have resulted in degradation and erosion of deforested land. The regulatory framework for the protection and management of forests in Slovenia is based on the Forest Act from 1993. It determines the protection, silviculture, exploitation and use of forests as renewable natural resources with the aim of ensuring their co-natural and multi-purpose management in accordance with the principles of protection of the environment and natural values, long term and optimal functioning of forest ecosystems, enabling all their functions. The basis for forest management are programmes of development of the Slovenian forests, forest management plans and detailed silvicultural plans. According to the Slovenian Forest Act from 1993 all forests are managed in a co-natural way, which can be classified as Category VI of the IUCN management categories: 'protected area managed mainly for the sustainable use of natural ecosystems'. From these special protection is given to the Forest Reserves (10% of all forest areas in Slovenia, IUCN category I). Most forest stands are regenerated naturally, only 1/10 th are regenerated by nursery seedling material, while seeds are mostly collected from yearly re-acknowledged seed stands. Therefore no special attention is given to ex situ conservation of forest genetic resources in Slovenia. A limited number of seed orchards have been established in Slovenia about 15 to 30 years ago. These seed orchards are not used for seed production and their future is questionable. International provenance tests have been established for silver fir on 4 research plots, for Douglas fir, for Austrian pine (9+8 provenances) and for beech (31 provenances). Tests of offsprings were established for Norway spruce with 10 provenances. S small living archive of Slovenian clones of poplars exists at the Institute's grounds. The forest seed bank comprises predominantly Norway spruce seed accessions. The main part of the Slovenian Forest Gene Bank is represented by the seed stands. The register includes 409 active seed stands, covering 2313 ha. of these 271 (1821.8 ha) are conifers, 138 (491.1 ha) are broadleaf seed stands. Yearly control of the seed stands, where seed collection is supposed to take place is the main task by staff from the Slovenian Forestry Institute, while revisions are made every ten years. The main concerns in the last few years are linked to preparation of new legislation (according to EU directives & OECD scheme), preparation of the Central Information Data-Bank on the Slovenian Forest Gene Bank, which will be available through the INTERNET and linked to the geographical maps, and to revisions of the regions of provenances in comparison to seed units (based on phytocenological associations, altitude and ground rock types) and with respect to the newly established tests of offsprings.

Incorporating Wood Density in Breeding Programs for Softwoods in Europe

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In European forests rotations are getting shorter, the proportion of juvenile wood in the stem of harvested trees is increasing, and the quality of European softwood is decreasing. One way to compensate for this is to genetically improve wood properties, especially those of the juvenile core.

In many European countries, wood collected from a given stand and even a given tree may be used for a variety of end products. The wood properties which affect end product quality vary from one product to another, and relationships between wood properties and adaptation, growth and form traits are variable. Tree breeding takes many years, while industrial processes change rapidly. It is therefore difficult to define selection objectives for wood properties that are general and constant over time. in this context, the main reason for incorporating wood traits in tree breeding programs should be to avoid unfavourable correlated responses in wood properties when selecting for improved adaptation, growth and form. Computing genetic gains for wood properties is not a priority. Instead, estimates should be made of the co-variation of wood properties with the adaptation, growth and form traits that are the main concern in breeding programs. Wood density is widely regarded as a key trait in determining wood quality, and when measured on a fine scale it is strongly correlated with the properties of many end products. Wood density is generally more highly heritable than growth traits, but the genetic variation of wood density is low and it is sometimes unfavourably correlated with growth and adaptation traits. The most comprehensive data on wood density are computed from microdensity profiles. Progress in computer science has made possible the utilisation of statistical and modelling tools for more efficient use of these data. in this context, we propose original methods, in order to: 1) study the volume growth - wood density relationship, 2) increase description efficiency of within-ring density models, and 3) measure within-tree density heterogeneity from density profiles. Results show that there is a significant clonal effect on the ring density and ring width relationship. This clonal effect is very strong for Douglas-fir and much smaller for Norway spruce. This result suggests that there are selection possibilities at the ring level for Douglas-fir for genetic entries (clones) combining quite fast growth and high wood density. But for Norway spruce, there is a need for finer studies at the within-ring level. Such studies raise the question of the cambium reaction to within-growing-season climatic events: is there genetic variation for the tree reaction to, for example, climatic stresses? What is the consequence of such a genetic variation on basic wood properties? It is possible to simply and objectively describe homogeneity of wood density. There is a highly significant clonal variation for most of the homogeneity traits. Furthermore, very high individual and clonal coefficient of variation let expect high genetic gain when selection is conducted on these traits.

The Domestication of *Acacia mangium*

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Acacia mangium has in the past 20 years become the most widely planted timber species in South East Asia. in 1997, a Malaysian company decided to invest in a project to produce improved genotypes for commercial planting, within a time frame of 3 years. This paper presents the case history of the project from the perspective of the scientists involved in this program of accelerated domestication. The program involved the selection and assessment of candidate plus trees, propagation of candidate plus trees, development of pollination and hybridization techniques, testing of hybrids, analysis of growth and form, genetic diversity analysis and the start of a genetic map.

Genetic resources and breeding of *Pinus caribaea* in China

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Pinus caribaea (*Pc*), the most important commercial softwood tree crop in the tropics of China, will become an increasingly important source for softwood fiber for pulp and timber. Plantation area of the species is currently over 50 thousands ha and expected to reach 100-150 thousands ha by the year 2010. The history of introduction and domestication of Pc can be divided into three stages chronologically: species (variety) trials in the early 60s (Cuban variety) and the early 70s [varieties *hondurensis (Pch)* and *bahamensis (Pcb)*], variety/provenance trials in the early 80s and range-wide provenance/progeny trials in the early 90s. Two provenance/progeny trials were established in China using 121 open-pollinated families (14 provenances) of *Pcb* and 217 open-pollinated families (16 provenances) of *Pcc*, respectively through international collaborations. All these experimental populations constitute the base populations of the two varieties.

Significant genetic variation was found in growth traits and pest resistance among the three varieties and among provenances within each variety except Pcc. There was also large family variation within provenances of Pcb. Superior varieties/provenances were identified for different site conditions, Pcc is suitable for the lowland tropics and southern tropics and Pch suitable for inland mountain areas with better provenance from Poptun. However, in Leizou Peninsula, where the tip moth is severe, Pcb (better provenances from Abaco and New Providence) and Pcc are better than Pch.

An extensive population genetic study on natural and exotic populations of Pcc and Pcb, employing isozyme markers, was conducted in order to detect and quantify the patterns and extents of genetic changes in the genetic structure and mating systems of populations that have gone through different domestication schemes. There was significant genetic difference between the two varieties and population differentiation was much larger in Pcb than in Pcc, attributable to the fragmented distribution of Pcb. For Pcc, both single and multi locus estimates of outcrossing rate were significantly less than 1.0 in the island population (Isles of Pine) but in the mainland population (Cuba Island) and the seed orchard, indicating that stronger inbreeding exists in the island population. The small differences between single and multi locus estimates suggest that inbreeding detected be caused by true selfing rather than consanguineous mating. The Chinese material, used as Pcc, differed substantially from the natural populations of both Pcb and Pcc as revealed by either isozyme or cpDNA markers, proving that it is a distinct taxa or hybrids or mixture of seeds. This striking result suggests that breeding program of Pcc in China should be replaced with newly introduced genetic materials.

During the mid 70s, 12 grafted seed orchards or seed stands of Pcc were established in Guangdong and Guangxi provinces using materials selected from the first introduction. Seed production of these was very low, ranging from 8 to 50 kg/ha on year to year basis. Seed production of early-introduced trees peaked in the early 80s, facilitating large-scale plantings of Pcc. Hybrid breeding of Caribbean pines started from the early 80s, mainly by crossing between Pcc and P. *elliottii*. Hybrid of P. *elliottii x* Pch introduced from Australia showed excellent growth performance. Potential of other hybrid combinations among the varieties and *P. elliottii* needs to be further studied in future. The need for continued efforts on genetic improvement on the Pcc and Pcb and their hybrids to adequately conserve and wisely use the genetic resources was recognized.

2.02.00 / 2.08.00 Future of breeding and plantations in a sustainability-oriented world 2

Virgin Forests and Industrial Tree Plantations

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Virgin forests can be regarded as a unique depositary of genetic resources and perfect regulator of environmental conditions. The idea of a particular role and significance of virgin forests and the necessity of their conservation as a property of the Earth biota, has become common in social consciousness. in high latitudes of northern hemisphere virgin forests are mostly preserved in Russia and Canada. These forests are underproductive(low-yield), usually timed to permafrost soils and are quite vulnerable as ecological systems. The researches carried out in different countries(including Russia) and wide practical experience show that timber cutting in virgin and natural forests can be replaced by timber production at special industrial tree plantations. This can offer great advantages, especially from the point of view of ecology, ethics and economics. The report will be based on the results of large-scale experiments in planting and growing of spruce(*Picea abies* L.) and pine(*Pinus silvestris* L.) industrial tree plantations in the north-west of Russia. These experiments have been carried out during a period of 25(twenty five)years. During this research the following data was obtained: expedient localization of these plantations depending on climatic and soil conditions, the problems of territory arrangement, optimized according to the wood growing conditions methods of soil cultivation, scientifically grounded rate(regime) of forest stands density in their age dynamics, activities for taking care of the plantations, possible timber increase (6-8 m^3 per hectare a year), turnover of cutting(50-60years), the power of additional carbon flow obtained from the atmosphere(2-2,5 tons per hectare a year), etc. It has also been shown that millions of hectares of land can be used for growing industrial tree plantations in Russia.

On the basis of the data published in different countries it is considered advisable on the behalf of IUFRO to send the following suggestions to UNO:

a) to organize ecological reserves of global significance on the territories where virgin("ancient") forests are still preserved;

b) to attract authority and material(financial) resources of the world community to the matter of organization of the above mentioned reserves and to the necessity of transferring timber production to the industrial tree plantation areas before the end of the forthcoming century.

These suggestions have to be put forward on the agreement with the governments of the corresponding countries.

2.04.01 Conservation and management of forest gene resources

Investigations of an oak of unknown origin

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An unusual oak of unknown origin growing near Zadar, Croatia is called the "Green oak". This tree produces hermaphroditic flowers and flowering is not synchronized with other oaks in the vicinity. The tree has been classified as a putative a hybrid between *Quercus cerris L.* and *Q. ilex L.*, *Quercus viridis* Trinajsti‘. However, this classification is probably not accurate, as a hybrid between a species where acorns mature in the second year (*Q.cerris*) and a species where acorns mature in the first year (*Q. ilex*) has never be verified. To investigate the origin and taxonomic position of this tree, we conducted comparative investigations in wood and leaf anatomy and morphology of flowers and pollen among the "Green oak" and specimens of *Q. cerris*, and *Q. ilex* using a light microscope combined with digital image analysis and a scanning electron microscopy. The hairs of all three oak species were examined using several histochemical reactions and scanning electron microscopy, and the DNA content of nuclei was measured. Volatile compounds of the leaves were determined using gas chromatography. The results of these investigations, and the origin of the "Green Oak"are discussed.

Keywords: *Quercus*, hermaphroditic flowers, hybrid, wood anatomy, leaf anatomy

Data Base on Genetic Resources of Woody Species in the South Forest-Steppe of Russia

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Genetic resource data for numerous woody plants species of the south forest-steppe of Russia (united into the Central Chernozem Region (CChR) and includes Belgorod, Voronezh, Kursk, Lipetsk, Orel and Tambov oblasts) were collected in the database (Pas-op) that was formated by FoxPro 2.6 for Windows. The data base represents an area consisting of the Central Chernozem Region (CChR), which includes Belgorod, Voronezh, Kursk, Lipetsk, Orel and Tambov oblasts. The data base consists of 14 files interconnected as a single informational space.

Presently, the database contains s 2521 records concerning conservation resources of the CChR gene pool. Represented in the data bases are: 23 genetic reserves, 18 clone archives, 7 provenance trials, 1935 plus trees, 6 plus stands, and information about other genetic resources. There are 18 object names in conjunction with the conservation of the gene pool of CChR forest species.

Data base information can provide different characteristics about the primary forest species in the CChR. Characteristics on individual species, the areas of the objects location, and genotype of individual trees are examples of the information within the data base. The data can now used by various statistical packages, electronic tables and text editors. This possibility enabling the use of the information materials in different combinations.

Keywords: Russian forest-steppe, data base, computer software, genotype, statistics

Establishment of Genetic Resource Data Bases for Forest Flora

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The ubiquity of personal computers and efficient software has become the basis for wide use of data bases in different fields of knowledge. The information is searchable and quickly processed. There is also an opportunity for active exchange of data among specialists. The utilization of such information is increasing with expansion of the Internet.

Data bases of forest genetic resources undoubtably will have a significant role in forestry. The term "genetic resources" is defined here as biological material with useful or potentially useful genetic information of available. Very often genetic resources are forest plots or individual trees, isolated for the conservation of the gene pool. in Russian forestry, genetic resourse data bases can include: gene reserves, plus trees, stands, forest seed orchards, clonal archives, and progeny tests.

A list of indices, defining an object of a genetic resource is more often determined by proper methodic design That`s why compiling of the index list does not arouse any difficulties for a programmer. However, with a great number of different objects, the necessity for creation of a system for database control appears.

Uniformity in species names and corresponding codes are critical for successful widespread use of a genetic resources data base. For information exchange with other resarchers it is important to come an agreement with scientists about coding of table fields. The following principles are suggested for coding species names: 1) the International Code of Botanical Nomenclature should be accepted as a methodological basis of taxon division., 2) scientific names of taxonomic groups should be in Latin, and 3) a common international coding of species names should bea common international coding of species names should be established.

Files were developed to contain taxon of any class of a species up to division. For the formation of databases, correlation tables connecting coinciding fields are used. Hierarchy of the files was provided by indicating of the taxon in one of the code fields. Another database program was written to keep different indices, describing genetic resources, in one unified file. All the files were interconnected as a common information space and represented thousands of infomration bits about the gene pools of forest species.

Keywords: forest species, data base, computer software, genetic test, taxon

Pollen Cryopreservation Studies on some Tree Species in the Indian Forest Ecosystem

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Forest genetic resources are described as a heritable material contained in tree species ,which may have economic, scientific and social value for the local inhabitants. Pollen has been identified as a source of diversity that can be used in conservation strategies of forest tree germplasm. For precise monitoring of gene flow through pollen procedures need to be developed for long term storage through cryopreservation. *Emblica officinalis* Gaertn., *Cassia fistula* L., *Cassia marginata* Roxb., *Millingtonia hortensis L.*, *Elaeis guineensis* Jacq. and *Pandanus fascicularis* Lamk. were chosen for study. Four species have medicinal value and two species are commercially important. *Emblica officinalis, C. fistula* and *C. marginata* are widely distributed in dry deciduous forest of southern and northern India, while *M. hortensis* and *E. guineensis* were introduced to India from Burma and W. Africa, respectively. *Pandanus fascicularis* is a profusely branched small tree distributed in India, commonly found in the western plains. Protocols for collection, cryopreservation and cataloguing pollen of these species were developed in this study. Pollen collection and extraction procedures were optimized, based on type of inflorescence, pollen production patterns, and physiological characteristics of study species. Viability was assessed by pollen germination using the hanging drop technique for all species except E. guineensis, where a modified cellophane technique yielded superior germination frequencies. Optimum pollen germination was obtained in modified Brewbaker and Kwack's medium, consisting of different concentrations of sucrose, supplemented with inorganic salts. Feasibility of pollen for cryogenic preservation was tested by immersing pollen samples sealed in laminated aluminum pouches in liquid nitrogen (-196°C) for about one hour. pollen was then germinated in vitro, and found to have comparable germination rates to fresh pollen samples. As a result, experiments on long term storage of pollen were initiated and are presently in progress. The results indicate that cryopreservation of pollen could provide the basis for the establishment of a conservation repository of nuclear genetic diversity.

Keywords: conservation, genetic resources, forest trees, genetic diversity

2.04.02 Genetics and traits

The physiological genetics foundation of *Liriodendron* heterosis

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Heterosis in *Liriodendren* interspecific hybrids, and fixation and utilization of the hetorosis, were studied in this doctoral dissertation using principles and methods of genetics, breeding, physiology, biochemistry, anatomy and biostatistics. The main results are as follows:

1. One-year-old hybrid seedlings of plus-crossing, minus-crossing, backcross and F1-crossing showed universally notable positive growth heterosis. Growth characters of seedlings had extremely significant difference among families and expressed great variation among individuals of family. Growth condition of backcross families was particularly excellent. Thus, family selection, individual selection and utilization of backcross and F2 hybrids have tremendous potential.

2. Having many advantages in photosynthetic area, photosynthetic time, leaf blade structure and resistance of water stress, reciprocal hybrids possessed photosynthetic capacity superiority over parents.

3. The decrease in rate of relative water content, chlorophyll content as well as protein content and increase rate of RNase activity in leaf blades under water stress were *L. chinense (*Hemsl.*) Sarg.* > *L. tulipifera Linn.* > *Plus crossing F1* > *minus crossing F1. L. chinense (*Hemsl.*) Sarg.* was severely damaged by short water stress. Reciprocal hybrids displayed super-parent heterosis of resistance to water stress. Direct evidence from 3H-Gly labeling under water stress proved both that RNase genes of parents and hybrids were expressed in translation level as well as RNase were synthesized de novo and that intensity of RNase gene expression was *L. chinense (*Hemsl.*) Sarg.* > *L. tulipifera Linn.* > *Plus crossing F1*> *minus crossing F1*. Indirect evidences from protein synthetic inhibitor under water stress indicated that RNase activity increase of parents might be involved in cytoplasmic mRNA translation and RNase release, activation and/or synthesis of chloroplast and/or mitochondria, but RNase activity increase of hybrids might originate mainly from cytoplasmic mRNA translation, not from chloroplast and/or mitochondria.

4. Reciprocal hybrids had higher stomatal apparatus density; larger stomatal apparatus opening and more developed vascular system contrasting sharply with parents.

5. The hybrid clones presented great variation of cutting root forming ability among adult and young hybrids. The variation range of cutting root forming ability of young hybrids was much larger than that of adult ones. The root forming ability of basal stem sprouts of adult hybrids was powerful.

Fertility variation and its effect on genetic diversity over generations in finite populations

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Keywords: fertility variation, status number, group coancestry, inbreeding, gene diversity, reference population

Gene diversity and inbreeding over five generations are simulated considering fertility variations and population sizes in finite populations. Gene diversity of seeds is influenced by differences in fertility among parents and their relatedness. The overall relatedness can be described as group coancestry. The fertility is expressed as a standardised measure of fertility differences among individuals. Fertility variation causes faster accumulation of relatedness and reduces the effective number (status number) of the seed crop.

Status number (Ns) is defined as half the inverse of group coancestry. Group coancestry is the probability that two genes in a gene pool are identical by descent, and it can also be interpreted as an average of relatedness or as a lost of gene diversity. Group coancestry of the present generation is the expected inbreeding (F) of the following if individuals mate at random and if they are equally fertile. Inbreeding, group coancestry, status number and gene diversity are all relative to a conceptional reference population with an infinite number of unrelated and non-inbred individuals. A small status number means a reduced gene diversity of seeds, because Ns expresses the accumulated genetic drift from the same reference population to which the concepts inbreeding and coancestry refer. The build-up of coancestry and inbreeding during successive generations is potentially a major problem when dealing with small populations (such the breeding populations). The consequences can be predicted, evaluated and monitored in this study.

For the idealised random mating population, relative status numbers (Nr = Ns / N) decline to 0.50, 0.33, 0.25, 0.20 and 0.17 for five consecutive generations, respectively. Also, the variance effective population sizes (Ne(v)) were estimated as infinity over generations when all genotypes had equal fertility. All calculations were made for the constant population sizes over generations where the populations were derived randomly from the zygotes of the seed crop. The importance and magnitude of fertility variation and population size on this decline has been studied. Gene diversity decreased faster as the fertility variation increased. But the effect of fertility variation on gene diversity was not linear.

Predictions over five generations shown that group coancestry and inbreeding accumulated fast, and the status number and variance effective population size decreased remarkably in the first generation shifts. The accumulation of inbreeding and group coancestry was faster and higher when the fertility variation was larger. The loss of gene diversity was proportional to the fertility variation and to the size of the population. The gene diversity was maintained high when provided the breeding population size was reasonable. Long term breeding programs that use small population sizes and low status effective numbers may lead to a loss of gene diversity and do not provide a sustainable long-term breeding strategy. This study helps us to understand how large numbers are required to maintain reasonable gene diversity.

Networking in phenological monitoring for commercial timber species in Peninsular Malaysia

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Keywords: Networking, phenological, seed, planting materials and procurement.

Many of the commercial timber species in Peninsular Malaysia particularly the indigenous tree species are irregular and unpredictable fruit bearers. Cyclic mass fruiting which usually occurs once in six to seven years, often resulted in sudden availability of huge quantities of seeds over a short period. This situation, coupled with the short storage life of the seeds, requires close monitoring and phenological observations, to avoid loss of potentially good seeds.

A phenological monitoring and reporting system via network of district forest offices is being developed to serve as a tool to enable timely collections of seeds. Phenological plots have been established and phenological monitoring teams formed in each state of the Peninsula to undertake regular observations and monthly reporting to the Forestry Department Peninsular Malaysia Headquarters. The monthly summarised reports will provide a good overview of flowering intensity and amount of fruit crop available throughout the Peninsula. These will be made available to State Forestry Departments for more effective planning of post-collection activities such as transportation, processing, storage, sowing and distribution.

A Forest Genetic Resource Information System (FORGRIS) was developed under the Malaysian-German Forestry Planting material Procurement Programme to centralise phenological information. It is a computerised management tool for the storage and retrieval of a broad range of information on forest genetic resources. This includes an up to date information on resource types; selected plus trees; monthly phenological monitoring as well as seed collection, handling and storage; nursery practices and distribution. FORGRIS comprised six main components from which information can be retrieved namely: Resource Register, Tree Register, Phenological Monitoring Register, Seed Register, Nursery Register and Distribution Register.

At the same time, efforts towards development of infrastructure and manpower are continually being upgraded. Skills of officers in the fields of tree climbing; seed collection technique and handling; storage and phenological observation are further improved through training. A prototype vehicle known as Mobile Seed/Seedling Chamber was developed to assist in the collection and long distance transportation of planting materials. The Existing forest nursery in Lentang, Pahang is being upgraded to become a Forest Planting Material Procurement Centre. in addition to the development of storage facilities for recalcitrant seeds, the Centre will plan and co-ordinate activities related to procurement of planting materials in Peninsular Malaysia. The Centre will also conduct training and research on large scale handling of planting materials, seed testing and documentations.

- Resource Register stores data on the different resource types, genetic information of the population and description of the site.
- Tree Register stores information on selected trees including botanical and common name, phenotypic description, location and site.
- Phenological Monitoring Register contains information on phenological observation of flowering and fruiting of every selected mother trees, as well as general observation within the phenological plot.
- Seed Register contains information on collecting, processing, testing and storage of seed.
- Nursery Register contains information on the production of all nursery-grown planting stock. This includes pre-treatment, sowing, germination and potting of plants.
- Distribution register holds information on distribution of planting materials and keeps the different identification of resource, seed and nursery. It links the information of the origin and handling of the planting materials with the planting site.

Characteristics and inheritance of male sterility of *C. japonica*

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Genetic male sterility is a useful trait in plant breeding, especially in angiosperm crops such as corn, onion and carrot. We found a male sterility *Cryptomeria japonica* trees in Japan. Pollen of *C. japonica* is one of the major causes of pollinosis in Japan. We carried out this research in an attempt to male clear the characteristic and inheritance of this male sterility. Microsporogenesis of the male sterile tree proceeded meiosis, however, the microspores collapsed under they were separated from pollen tetrads in locals, resulting in complete male sterility. Most likely, ethylene was responsible for male sterility expression. Mating of male-sterile *C. japonica* and elite *C. japonica*, as well as backcross seedlings of male-sterile trees, were carried out. The seeds from male-sterile *C. japonica* were germinated in an incubator, and grown in a greenhouse. The seedlings were treated with 100 ppm gibberellin in early July 1995, to promote the formation of male flowers. in January 1997, all of the seedlings of elite *C. japonica* produced pollen in its male flowers; however, pollen had not developed in 55 out of 120 backcrossed seedlings. This evidence indicates that the heredity model of male sterility in *C. japonica*, is nuclear genetic male sterility controlled by a pair of recessive genes.

2.09.00 Seed physiology and technology

Use of halogens in controlling deterioration of some tropical tree seeds

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Keywords: *Acacia* catechu, *Pongamia pinnata*, *Shorea robusta*, storability, germination, ageing, vigour.

Halogen treatment of seeds is a powerful tool for controlling seed deterioration in field crops. An attempt was made to use this simple technique during storage of seeds of forest tree species. The most significant results were obtained with sal (*Shorea robusta*), khair (*Acacia* catechu) and karanj (*Pongamia pinnata*). in all cases, halogen treatments extended seed storability, with high germination and vigour in laboratory and field tests.

Sal is one of the most important timber species of the tropical regions and the seeds are an important source of edible oil and butter. The rapid deterioration of these recalcitrant seeds creates several disadvantages for raising planting material as well as for butter extraction. Khair is the chief source of katha and cutch, is a useful timber and fodder species and produces good quality charcoal. Other parts of the tree have a number of medicinal uses. Khair produces good crops of seeds almost every year, but the seeds are very delicate and damaged even by a slight fire. They are also subject to insect attack, and do not store well for more than 6 months, far shorter than other leguminous seeds. Karanj is another multipurpose tree species, the wood being used for making agricultural implements and as a source of pulp. The seeds are valued for their non-edible oil, but they store poorly.

In this study, khair and karanj seeds were collected from the TFRI campus and used immediately. Sal seeds were collected from a natural forest and transported to the laboratory the same day. All seeds were exposed to chlorine and iodine vapours for durations ranging from 4 to 65 hours. Khair and karanj seeds were subjected to accelerated ageing at 100% RH at 420C for 8 days to simulate storage effects. Germination tests were carried out on top of germination paper at 300C in a BOD incubator. Following laboratory testing, selected treatments were field tested. Simultaneously, membrane permeability was studied by measuring the electrical conductivity, dehydrogenase activity and total sugar content of the seed leachate. Treated sal seeds were stored at room temperature, 150C and 80C for 15 days, then sown in the nursery.

Sal seeds treated with chlorine vapour had enhanced storability and tolerance to lower storage temperature. Exposure for 65 hours gave 30% germination in the nursery, even after 15 days storage, while untreated seeds did not germinate. Chlorinated seeds also exhibited increased vigour and faster completion of germination. Iodination had no promotory effect. For khair seeds, the maximal beneficial effect in the laboratory was observed by chlorination for 24h, which also improved the germinability before ageing. Other durations of chlorination and iodination did not have a promotory effect on non-aged seeds. The effect of 48h exposure to chlorine was especially evident by increased germinability of aged seeds. Greater membrane integrity of 24h and 48h chlorinated seeds was demonstrated by lower electrical conductance of seed leachate and reduced leakage of sugars. Therefore, these seeds were subjected to field trials. Following chlorination for 24h, germination in unaged seeds increased to 36.52% compared to 23.75% for the control, and 7.5% for the 48h treatment. Also after 24h treatment, total biomass was 4.37g compared to 3.94g and 3.33g for the control and 48h treatment, respectively. Promotory effect of the halogen treatments was more evident in the aged seeds. Germination percentage, root and shoot lengths of seedlings, total biomass, collar diameter and nodulation were highest in the 24h treated seeds. Even though the germination of the aged seeds decreased as compared to the non-aged, there was an increase in the total biomass of the seedlings, thus demonstrating the beneficial effects of this methodology. Karanj seeds showed a positive correlation between the conductivity of leachate, leakage of sugar, dehydrogenase activity and germination of aged seeds after 24 and 48 hours of chlorination and iodination respectively.

Thus, halogenation has the potential for utilisation as a low cost, simple technique for enhancing tree seed storability even under ambient field conditions.

Introduction of Genetic Resources and Improved Forestry Seed Production in Madagascar

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Keywords: *Eucalyptus*, genetic improvement, seed orchard, smallholder plantation

Forest products supply more than 86% of the Malagasy domestic energy consumption. Production in the natural forest has decreased and no longer satisfies the local demand of fuel-wood and timber for the ever-growing population. of the 750 exotic species already introduced in arboreta, *Eucalypts* and pines originating from summer rainfall areas have been the most productive. The introduction of *Eucalyptus robusta* and *E. camaldulensis* early in the 20th. Century was particularly successful. These two species now produce more than 1 million tonnes for the yearly fuel-wood supply of Antananarivo. But successive crosses within narrow genetic base populations have resulted in local land races with severe inbreeding depression. Local seed sources cannot match plantation requirements that need 250 kg of eucalypt seeds every year.

For the past 20 years, FOFIFA with Cirad-Forêt has conducted a hardwood genetic improvement programme (funded by the European Union between 1993-97). The main objective is to supply smallholders with locally-improved varieties for a range of wood products. The first step was to introduce new genetic resources for several species to build both the base and breeding populations. Because of the huge ecoclimatic diversity and the range of desired wood products, numerous improved varieties had to be developed simultaneously. Thus, a multiple-population breeding scheme was implemented for several species. Within each population, the improvement strategy was as follows: i) progeny-provenance trials for genetic diversity assessment (base population), ii) selective thinning retaining the best trees within the best provenances or progenies (generation 1, Seedling Seed Orchard 1), iii) harvesting of the open-pollinated seeds for the second generation seed-orchard (SSO 2) and to implement the second cycle of recurrent selection. The seeds produced in the SSO are used for breeding as well as the deployment of varieties. The broad genetic base of the seeds produced by the SSO matches the required plasticity for smallholder plantations with poor silvicultural practices.

Forest plantations are currently established in several ecoclimatic conditions, from the dry South (450 mm of annual rainfall) to the wet East coast (2500 mm), from coastal savannahs to 1600 meters above sea level. Nine contrasting sites were chosen for SSO establishment. To match the actual demand as well as promote poorly-known species, 9 *Eucalypts*, 7 acacias and 8 miscellaneous species were included. The most important ones were: *Eucalyptus camaldulensis*, *E. citriodora, E. cloeziana, E. grandis, E. maculata, E. microcorys, E. resinifera, E. robusta, Acacia auriculiformis, A. crassicarpa, A. mangium, Casuarina equisetifolia, Grevillea robusta* and *Prosopis juliflora*. 5 000 open-pollinated progenies belonging to 400 provenances and 25 species were introduced between 1988 and 1998. Most were collected from their respective natural areas. Seed lots were tested in a complete randomised-block design encompassing several provenances of the same species with 16 tree plots. The high planting density, i.e. 2500 trees per hectare, allowed the combination of provenance testing (at least for initial growth) and orchard objectives. Four to five successive selective thinnings resulted in a final stocking of 80 to 150 trees per hectare at six to seven years old. Thinnings are implemented on the basis of individual tree value, but aim to preserve a broad genetic diversity. Trial replications across several sites permitted a combination of provenance-progeny and genetic-environment interaction assessments, as well as the production of locally well-adapted improved seeds. Last but not least, the 50 SSO already established (70 ha) are used as demonstration plots to promote the use of poorly-known species and improved varieties. Since 1997, new planting programmes have been partially supplied with seeds produced in SSO. Besides the traditional *E. robusta* and *E. camaldulensis*, new species such as *A. mangium* and *E. maculata* (for poles and sawn wood) are now sought after by smallholders.

Forest Tree Seeds at the End of the 20th Century: Major Accomplishments and Needs

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Keywords: seed production, storage, desiccation, longevity, dormancy, testing

Based on the State of Knowledge Report for Research Group 2.09.00 (Seed Physiology and Technology) this paper reviews developments and accomplishments, indicates what remains unknown, and suggests directions for research during the early years of the new millennium. The main focus is on tree seed production, storage and longevity, and seed quality testing and nursery performance. It is pointed out that although conservation efforts are underway, a 1998 estimate declared 10% of the world's tree species as threatened with extinction.

Seed orchards and other tree seed production areas have been developed for numerous economically-important forest species, but the bulk of tree seed crops continue to be derived from wild plants in natural stands. Forest tree seed biology remains poorly researched for many species, but advance-forecasting of good crops is possible in some. However, erratic crop production, uncontrolled insects and diseases, and the need to make collections at the right time to ensure maximum germination and vigour, plus correct post-harvest handling, remain priorities for most species. in general, seed processing methodologies can now eliminate all (or almost all) unfilled seeds, but only one method (a Swedish development) applied to some conifers separates live-filled seeds from filled-dead ones. Despite these difficulties, large increases in tree seed production, particularly in species and provenances selected for desirable attributes, are going to be needed to meet the challenge of successful forest regeneration worldwide. Collaborative efforts to determine more-appropriate species, and to improve production of genetically- and physiologically-improved seeds, are underway in some regions, but these probably need to be broadened. Seed storage, to combat sporadic crops and stabilize supplies to nurseries, remains a major research issue. Three broad classes of seeds, based principally on their desiccation tolerance and sensitivity to low temperature, are now recognized. So-called "orthodox" and "recalcitrant" seeds are opposite extremes of a continuum between which lies a broad spectrum of seeds with "intermediate" storage-behaviour characteristics. The report outlines a number of major findings concerning the causes and reasons for desiccation tolerance. A complex suite of mechanisms is involved, and further research is required to resolve all the components into an integrated system. One notable factor is that, unlike orthodox seeds, cell organelles in recalcitrant seeds remain differentiated and actively metabolic, and vulnerable to any amount of dehydration. Seed dormancy, common in orthodox seeds and some temperate non-orthodox seeds, but rare in tropical species, increases the complexity. Predictions of tree seed longevity are still largely empirical, but data is slowly accumulating. For operational forestry and germplasm conservation, especially for hard-to-store materials, major research efforts continue to be needed.

Even the better moist-chilling treatments to overcome seed dormancy require weeks or months to apply, often only work on some seedlots, or some seeds within a lot. Seed moisture control during chilling produces more rapid, synchronous germination, permits seeds to be cold-stored in a non-dormant state for 1 to several years, is used operationally for several conifers and, when combined with growth regulators, for some broadleaves also. Yet faster, more versatile dormancy-breaking treatments are needed for nursery production and laboratory testing. Difficult-to-standardize subjective tests (such as tetrazolium staining) are still used for tree seeds, but they often underestimate/overestimate seed quality. Laboratory tests that correlate with nursery production on a local level have been developed, but more work is needed to make these applicable regionally. Vigour testing, adapted from agriculture/horticulture, is not widely successful in tree seeds mainly because of the inherent heterogeneity in crops from natural stands, and even those from seed orchards Some indicators, such as respiratory activity of embryonic axes in beech, or of entire subalpine fir seeds, as well as protein levels in fir, have been suggested as possible vigour indices, but much more work is required. A brief review of the organization of the Research Group is appended, and several suggestions for the future are made. Contributors to the SKR are acknowledged.

Planting Dipterocarp Species For Forest Plantations: Is It Viable?

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Keywords: seed collection, storage, forest plantation, phenology, recalcitrant

The Dipterocarpaceae has long been accepted as the main family producing valuable timber of medium to hard density. Such timbers were once considered to be Malaysia's main export. However, the current concern for sustainability in wood production and genetic conservation has increased the need to protect more of the natural forest, and to harvest only on a sustainable basis from the productive forest. The timber supply deficits thus created will have to be supplemented through plantation forests.

Because of poor seed availability caused by the gregarious mass fruiting habit that produce crops only once every 3-7 years, dipterocarp species tend to be of low priority for selection for forestry plantation programs. Adding to these difficulties, most species produce seeds that are recalcitrant, and which suffer desiccation damage if dried below a relatively high moisture content. Such seeds cannot be stored for long periods, therefore.

This paper highlights the results of monthly phenological observations in selected forest areas, as well as dipterocarp seed storage studies, conducted over the last 10 years by the Seed Technology Section at FRIM. To maintain a continuous seed supply, collection efforts should be concentrated in seed production areas during mass fruiting years, but should occur also in all phenological observation areas during the off season periods when some trees tend to flower and fruit sporadically. Current research advances in prolonging seed viability after collection, and during transportation, will be discussed.

Wide differences between species in levels of critical moisture content at which viability is lost, were observed. This could be due to the stage of maturity, seed size and structure. Most seeds could be stored for less than two weeks. Several methods for obtaining continuous supplies of planting material are discussed.

Tetrazolium Test: A Tool for Predicting the Viability of Some Tropical Tree Seeds

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Keywords: TTZ, root mean squares, *Acacia nilotica*, *Albizia procera*, *DendroCalamus strictus*, *Sesbania sesban*

The tetrazolium (TTZ) test has been an important and useful tool for determining the viability of a range of seeds since its introduction by Lakon in 1942. The method gained popularity for its simplicity, ease and rapidity of application, and because it can evaluate viability whether or not the seeds are dormant. This study highlights the standardization of evaluation criteria for using the test on seeds of four important tropical tree species. *Acacia nilotica* seeds require a long time to germinate because of their hard seedcoats. Apparently-sound and healthy *Albizzia procera* seeds often harbour insects (as shown by x-ray radiography) and are incapable of germination. Low viablity of Dendro*Calamus* strictus, seeds compounded by gregarious flowering, makes testing the seed lot before sowing imperative. Germination in Sesbania sesban varies because of seed coat and seed size differences.

Seeds were collected from four to nine Indian provenances. Four working samples were drawn for each lot, then subdivided into two subsamples, one for TTZ staining and one for germination testing. Fresh solutions of 2,3,5-tetrazolium chloride dissolved in double-distilled water of neutral pH were prepared. A fragment of the testa of the seeds of *A. nilotica* and *A. procera* was filed off to facilitate imbibition; all seeds were soaked in distilled water for 24h (10h for *S. sesban*) then cut with a sharp blade, or decoated. Seeds were placed in 1% TTZ solution (0.5% for *D. strictus* and *S. sesban*) and incubated in darkness at 30-10C for 24 h. Staining patterns for individual seeds were documented in 6 categories for *A. nilotica*, and 7 categories for the other species, as follows: 1-embryo and cotyledons fully stained. 2-embryo fully stained with less than 3/4 of the cotyledons unstained. 3-embryo fully stained and more than « of the cotyledons unstained. 4-embryo partially stained and very small unstained patches on cotyledons. 5-only embryo stained. 6-embryo unstained and cotyledons stained in patches. 7-unstained seeds.

Division 2

Germination tests were conducted on top of paper (BP for *A. nilotica*) at 30+/-10C for 28 days. Root mean squares were calculated to determine significant differences between staining categories and the appropriate germination test. Staining categories 1 and 7 were recognized as viable and non viable seeds, respectively. The remaining categories each had two possibilities and yielded a different number of combinations of evaluation criteria. Categories, or combinations of categories, giving the least RMS were interpreted as "best", i.e. as viable seeds.

Thus, for *A. nilotica*, combined categories 1, 2 and 3 were best (category 5 was absent); for *A. procera*, combined categories 1 and 2 were best; for *D. strictus*, combined categories 1, 2 and 4 were best; and for *S. sesban* combined categories 1, 2, 3 and 4 were best. Whenever any other category was included in the above combinations, RMS values increased. Staining patterns were documented as line diagrams.

Division 3
Forest Operations and Techniques

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3.02.00 Effects of nursery and silvicultural operations on the environment and society

Effects of Different Mediums on the Growth of Oriental Spruce (*Picea orientalis* (L.) Link.) Seedlings Produced in Enso-Pot Tubes

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Keywords: Growing medium; Oriental spruce; Seedling product; Enso-pot

Oriental spruce (*Picea orientalis* (L.) Link.) is the main species in the Eastern Black Sea Region of Turkey. Using high quality, container-grown seedlings in the plantation areas is very important, to mitigate against very dense green-cover in the region. The Turkish-Finnish Forestry Project was established in 1992, for producing economical container-grown seedlings in the of Forest Nursery. in this project, production techniques for growing Oriental spruce seedlings under the regional conditions were investigated. Thus, common growing media in the region, sowing times and growing periods in the greenhouse had to be investigated. in this research, forty growing media, two sowing times and two growing periods in greenhouse were studied. Commonly-used local Barma peat was the main component of the media. Thirty-nine growing media were prepared with various supplemental materials (river sand, perlite, composted tea remnant, composted barnyard manure, wood shavings and bran) mixed at different ratios by volume to the Barma peat. Vapo peat (Finnish) was used as a control. For all treatments, height growth, root collar diameter, survival percentage, dry weights and stem weight / root weight ratios of the 2+0 seedlings were measured. The results were:

1. The best height growth under the of Forest Nursery conditions were in the following media respectively:

60% Barma peat + 20% comp. Tea remnant + 20% river sand; 50% Barma peat + 20% comp. Tea remnant + 30% river sand; 50% Barma peat + 20% comp. Tea remnant + 30% perlite; 60% Barma peat + 20% comp. Tea remnant + 20% perlite; 60% Barma peat + 20% comp. barnyard manure + 20% perlite

2. Traditionally, 2+3, 3+2, 4+0 and 5+0 Oriental spruce seedlings have been planted in this region. This study showed that 2+0 seedlings were large enough for planting with the growing media mentioned above, using the Enso-Pot tube system.

Effect of Selection of Soil Type on the Establishment of Ectomycorrhizas and Growth of *Pinus patula* Seedlings in the Nursery

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Keywords: Ectomycorrhizas; *Pinus patula*; "shola" soil; *Thelephora terrestris; Laccaria laccata; Rhizopogon luteolus*

A *mycorrhizal* association is essential for forest trees. Ectomycorrhizas are found mostly in conifers. in the present investigation, an experiment was conducted to study the effect of soil type on the establishment of ectomycorrhizas and growth of *Pinus patula* seedlings in the nursery. Three different soil types, viz., "shola" soil (forest soil), grassland soil and riverbed sand were used. Initially, both surface-sterilised and non-surface-sterilised *Pinus patula* seeds were sown in "shola" and grassland soils and later, after 3 months, the seedlings were transplanted again to "shola" soil, grassland soil or riverbed sand. The results showed that the local "shola" soil was the best soil type, based on the different growth parameters such as root and shoot lengths root collar diameter, shoot and root dry weight, number of *mycorrhizal* tips and establishment of different *mycorrhizal* types. The *ectomycorrhizal* types found in seedlings grown in the three different soils differed. The *mycorrhizal* types formed *by Thelephora terrestris*, *Laccaria laccata* and *Rhizopogon luteolus* were found only in the seedlings grown in the "shola" soil, whereas the *mycorrhizal* types formed by fungi-like species of Hebeloma and Inocybe were found only in the seedlings grown in the grassland soil. Another *mycorrhizal* type, Cenococcum graniforme was found only in the roots of the seedlings grown in riverbed sand. The significance of the findings is discussed.

Nursery and Plantation Activities for Revival of Tribal Habitat and Lifestyle - A Case Study from Kerala, Southern India

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Keywords: Rehabilitation; India; Nursery; Afforestation

The outcome of attempts on rehabilitation of two highly degraded tribal settlements in different regions of Kerala State, southern India, are discussed in this paper.

A Participatory Rural Appraisal (PRA) exercise was undertaken to acquire information on the views and expectations of the local population and also to create an awareness about the potential benefits on the quality of life by restoration of their habitat with scientific inputs. A programme was subsequently implemented which was centered mainly around nurseries, planting activities and field training. Species selection, nursery management, silvicultural techniques for plantation establishment in degraded zones and soil/water conservation measures adopted in the study are discussed. The importance of effective human resource development and proper species selection was revealed in the first three years of the project. The paper also discusses the potential for increasing employment opportunities through the afforestation activities and development of self-reliance amongst the local tribal population.

Comparative Studies On Survival and Growth of Seedlings and in *Vitro* Raised Plants of Teak

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Keywords: Teak; Propagation; Seedling; in vitro culture

Teak (*Tectona grandis*) is one of the important timber trees in South and Southeast Asia. The plant is generally propagated by seeds but the fruit and seed set is very low in this plant. A protocol has been developed for propagation of teak through in vitro culture of shoot tips and nodal explants of seedling plants. Explants were washed thoroughly under running tap water. Surface sterilization was done with 0.2% $HgCl_2$ for 5 minutes followed by washing with sterile distilled water giving 3-5 changes. Explants were cultured in 0.7% agar-gelled Murashige & Skoog's (MS) medium with 3% sucrose and different concentrations and combinations of auxins and cytokinins were used for shoot proliferation. For rooting the regenerated shoots were excised and subcultured on half strength MS medium with a range of concentrations and combinations of auxins. Though rooting was achieved in 90% regenerated shoots, their survival rate in the open field was only 45-50%.

Germination of seeds collected from mature trees was 50-55% but the survival rate of seedlings was 75%. Growth parameters of surviving plantlets were measured at six-month intervals up to 24 months. At the 6th month, the height and base diameter of seedlings were 25 cm and 0.5 cm respectively. in in vitro raised plantlets the height and base diameter values were 20 cm and 0.35 cm respectively. At the 24th month the height, base diameter and diameter at breast height of seedlings raised plants were 198 cm, 3.9 cm and 1.4 cm, respectively. in in vitro raised plants these values were 216 cm, 4.1 cm and 1.5 cm, respectively. Potential growth performance of the two categories of plants is discussed.

Private Individual Tree Nursery Management and their Role on Environmental and Community Forestry in Tanzania: an Overview

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Keywords: Tree nursery, Management, Environmental, Economic, Quality stock

Before 1990, community and individual forestry programmes for environmental and economic purposes in Tanzania depended mainly on the nursery plants raised and managed by trained government nursery managers. The ecological and economic reasons for afforestation have increased significantly in recent times. Because of a general policy of reducing public expenditure by Government, the Forest Department has reduced its production of nursery plants for use by the community and individuals. A few government nursery centres still raise and sell seedlings to individuals, but the costs are generally high. More externally- and internally-financed NGOs are now engaged in planting trees than ever before. They all need tree seedlings, which must be raised and managed in nurseries for about a year before they are ready for outplanting.

To meet this increased demand for nursery stock, many people have organised themselves as individuals or groups to raise tree seedlings and sel1 them at lower prices than those from government or some Non-Governmental Organisation (NGO) nurseries. This has attracted many tree practitioners to buy seedlings from such centres, and hence the number of such centres has increased, as shown by a recent survey in some parts of the country. Such centres have increased much-needed self-employment. Therefore, they have a big role to play in this country. However, some scientific questions arise as to the quality of the nursery stock and the resultant quality of the established trees.

This paper reviews the nursery management practices of private individual small nurseries as compared to the more-organised government nurseries, including seed collection, sowing, nursery cultural operations and management. The effects of plant quality, which may not be noticed until after early field establishment, are discussed.

General Views on Silviculture of Protection Forestry and the Agroforestry Potential in Egypt

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Keywords: Silviculture; Egypt; Agroforestry; Arid land

This paper briefly describes the silviculture of forest trees on the arid lands of Egypt, the roles they can play and the products they provide. The management of protection plantations (sand-dune fixation, windbreaks, shelterbelts, etc) with particular reference to sand-dune fixation is described. The main objective of management is sustainable protection. Production or other roles should be considered as by-products of sustainable protection, but the income they give should contribute to maintenance. The second part of the paper deals with the agroforestry potential in the arid region of Egypt and begins with a definition of agroforestry. The benefits obtained from agroforestry in arid lands are discussed and a review of the different traditional agroforestry systems is made. Finally, the paper discusses what should be done to improve and to extend agroforestry in Egypt.

3.04.00 Operational planning and control; work study

Investigations on using of geographical information systems on the forest road networks in Turkey

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Because of the deep interference all over the world the forest regions are drawing back to mountainous regions day by day. Forest road network supply easy transportation to forest areas to maintain the usage and protection of forest resources and improvement substructure establishments for forest works.

In forming the forest road networks these are planning-projecting, building and maintenance expenses and such problems, that are hard to solve or expensive. Also cause ecological damages hard to improve and cause loss of forests. in this study we discuss the utilization of geographical information system technique in stages of planning forest road network and the point that we have arrived about this topic in our country.

The planning studies of forest roads in our country with using geographical information system has still at the academic level. We exposed the results of usage geographical information system technique about determination of terrain evaluation for forest road routes, determination of forest road routes, determination of forest roads loads and forest road buildings in studies of planning forest roads, that we have done in last three years.

General Directoried of Forestry started the studies of systematic forest road network planning in 1964 and completed them in 1974. in this studies, only the productive forest area took into account and total road length planned as 144425 km. in recenst years, the improvement of forestry techniques, the wants of rational forestry and the results guided after the application of the plans. According to the new plans total road length is planned as 201810 km. At the end of the year 1998 the 65.75 % of this, 132693 km is constructed.

Research area is between the boundaries of Trabzon Regional Forestry Headquarters, Macka Forest Enterprise. The research area; Ormanüstü planning unit is Education, Research and Application forest of Karadeniz Technical University, Forestry Faculty.

The stand type symbols are appointed to polygons for building database on the stand type digital map. The layer that involves stand typesi combines with the layers involve compartment boundaries and rivers so that the digital stand map is formed for Ormanüstü planning unit. in studies for preparing the forest road network plan first evaluating of terrain were done for forest road routes. For this, the terrain data were collected from different layers of geographical information system database and suitable and non-suitable areas were determined by spatial queries. After this, forest road networks plan alternatives were formed. in these plans, the road loads and requirements of water constructions were determined. As a result, the optimal road network plan is formed according to the evaluation that is made between two alternative.

The built two forest road network plan is evaluated by using Geographical Information System database and analysis, this was impossible by the other classic methods. This showed advantages of using system in alternative forest road network planing operations.

A study on the productivity and work loads of natural forest harvesting in Central Kalimantan

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Keywords: Harvesting; Productivity; Work loads; WBGT; Indonesia

It is necessary that productive, ergonomically sound and environmentally friendly harvesting systems should be introduced to Indonesian forestry. The objective of this research is to study and improve the productivity, work loads, noise and vibration in natural forest harvesting for the sake of forestry workers and company profit. in addition, environmental aspects of natural forest harvesting were also investigated, as few natural forests are left in Indonesia nowadays and such forests are regarded as important for the ecosystem and global environment. For these purposes, we conducted the following research in Central Kalimantan in August 1998.

We measured the productivity, work loads and work conditions during felling and cutting trees in the natural forest on the first day. We also measured the same during natural forest harvesting on the next day. This work was done by two workers, such as a skidder operator and his assistant. First, the operator drove the skidder and it moved from the landing to the harvesting site.

The skidder operator assistant was also on it. The skidder sometimes moved constructing skidding roads. At the harvesting site, the assistant pulled out a winch rope and attached it to a log, while the operator was driving the winch drum. Then, the skidder operator pulled in the winch rope and the log was carried to the skidder while the assistant was walking or running to the skidder. After that, the skidder moved to the landing carrying the log. When it reached the landing, the assistant got off the skidder and removed the log form the winch rope. Then, the same cycle was repeated again for another log. To investigate work loads, we used watch-type heart rate memories which measured heart rates of workers at five-second intervals. Furthermore, WBGT, an index of thermal conditions of the work environment, was measured to clarify work conditions.

On the first day, 17 trees, whose total volume is 165.1 m^3, were felled and cut by two workers, such as the chainsaw operator and his assistant. Total time to fell and cut these trees was 5:48:55 excluding lunch time and the productivity was found to be 28.4 m^3/hour. On the next day, 13 logs, whose total volume was 86.0 m^3, were harvested from the natural forest. Total time to harvest these logs was 6:19:35 excluding lunch time and the productivity was found to be 13.6 m^3/hour. The work loads of the chainsaw operator and his assistant were found very high. On the other hand, the work loads of the skidder operator were lower than those of the other workers. The observed WBGT was very high on the forest road while it was moderate in the forest. Noise caused by the chainsaw and skidder was very hard for the operator. Therefore, operators should use ear muffs to avoid damage to his ears although most of operators are not accustomed to using them. Vibration of the chainsaw and skidder was also very hard for the operator. We suggest that chainsaw and skidder operators should not be exposed to vibration continuously for long time and that they should wear gloves of good quality.

Finally, we would like to suggest some points to reduce environmental impacts caused by logging in natural forests. Main roads should be narrower and landings should be smaller. Trees far from main roads or other trees harvested should not be cut and should remain, which would reduce skidding roads and even harvesting costs. Log length should be adjusted or should be shorter in order to reduce environmental impacts caused by logging and to enhance productivity. Winch systems should be improved so that logs can be collected from longer distance, which could reduce skidding roads and even environmental impacts. More buffer zones should be necessary along riparian and protection areas, as such areas are known as environmentally sensitive.

Allocation of Equipment of Forest Extraction by Use of the Geographical System of Information (GIS)

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The objectives of that work went use the Geographical System of Information (GIS) as tool in the aid to the location of the productive units of a structure approximately regulated and the allocation of the "Forwarder" and "Guincho Arrastador" in the operation of forest extraction. The work was accomplished using a map in the scale of 1:10.000 of a project of reforestation of *Eucalyptus* of a forest company of Brazil. The project with total area of 441,81 it is characterized by wavy medium relief, presenting polygons of different sizes and ages. Using the program IDRISI (EASTMAN, 1997), version 2.0 for Windows, the entrance of the data was proceeded by means of a rasterization using a mesh of cells of 3 mm x 3 mm, in way to produce digital maps of use of the soil, streams, roads and level curves. Soon after the control method was used by area for definition of the compartments of annual harvest. It was established the slope limit of up to 15§ for the allocation of the "Forwarder" and above 15§ for the "Guincho arrastador". Initially a map of interpolated relief was produced, calculated its slope and reclassification in two slope class as described previously. The map of use of the soil went reclass to obtaining of the *Eucalyptus* areas that will be harvest annually, and soon after, it was made the overlap of these maps with the maps of the areas adapted for each equipment, in way to obtain a general map with all the areas adapted for the allocate of the equipments in the polygons that will be harvest annually and of the areas of forest reservation and of permanent preservation. As a result of this work, it was obtained a digital map of the project contends the delimit of all the areas of forest preservation, permanent preservation, streams, roads and *Eucalyptus* polygons. It was obtained the annual area and the wood volume to be annually extracted for the equipments. However, it was verified that the "Forwarder" will be used in 65.6% of the harvest areas, extracting a total volume of 51498 m^3 of wood for five years, while the "guincho arrastador", in the same period, will be used in 34.4% of the areas, extracting 25730 m^3 of wood. Therefore, the obtaining of those information together the information of revenue of the equipments propitiate to the planner to determine with larger precision the need of equipments for harvest areas, seeking a better alocation of the resources.

Design of an Integrated Forest Management System for Madhya Pradesh: Towards Sustainable Forestry

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The Madhya Pradesh Forest Department (MPFD) is responsible for the management of the forest resources of the State of Madhya Pradesh, a serious obligation given the extent of these forests and their importance to all the people of the State. Besides providing revenues to state coffers, these forests are essential to the welfare of millions of rural and tribal communities and the integrity of natural ecosystems. Responsible, sustainable forest management is the goal of MPFD. Forest sustainability involves the maintenance or improvement of environmental, economic and social values. It is recognized that these forest values have not been adequately maintained in Madhya Pradesh. Some of the major factors that have contributed the deteriorating situation include:

- a rapidly increasing population growth and resulting biotic pressures;
- an over-emphasis on timber production in the management goals;
- inadequate knowledge of forest processes and their valued outputs;
- a lack of strategic, tactical and operational management tools that are needed to plan, implement, monitor and control forestry activities in a complex decision-making environment.

The objectives of forest management in the State have evolved to reflect a more holistic understanding of the value of forests to society. The challenge for MPFD is to translate broad objectives into strategies, tactics and practices that can be implemented and controlled in the context of the resources and time available. This can only be accomplished through a process involving effective planning, organization, monitoring and evaluation of all of the important activities of the Department. The MP Forest Department has initiated a project aimed at producing the information required for such a management process.

The Forest Management Information System (FMIS) initiative involves the design and development of information and decision support systems to support the management functions of all Wings and levels of the Department. This paper, however, focuses on technology that will be used to enhance the sustainable forest management capabilities of the organization: an integrated forest management system (IFMS).

An IFMS is a suite of models and information systems designed to support the major long, medium and short-term decision-making needs of forest managers. IFMSs are intended to ensure that short-term (operational), medium-term (tactical) and long-term (strategic) decision processes are linked in such a way that there is continuity of management decisions across all forest units and over all time horizons. These linkages are accomplished by means of the integrated design and development of databases, models, information and decision support systems and related technologies such as geographic information systems (GIS).

Analyses of the management decision-making needs at MPFD have been undertaken by consultants from India and Canada. A design is presented that is based upon these analyses and experience from previous IFMS research and implementation projects. Although based upon existing IFMS and GIS technologies, the actual system for MPFD will incorporate improved features and capabilities, including closer integration between the IFMS and GIS and linkages to other sub-systems of the FMIS.

The implementation of integrated systems to optimize the use of machinery in forest operations

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Spain

During the past ten years forest managers and forest organizations worldwide have been looking at sustainable forest management as a concept to introduce in their forestry practices and principles. Sustainability refers to not only forest structure itself but also resources, people and other type of land that closely stand by the forest habitat. These other components of the forestry management environment have to be considered while planning forest management. in fact, scientific/technical forest management should be undertaken for a better reporting on sustainable concepts, which means that forest information, forest planning projection and forest operation budgeting should be supported by concrete reports.

An appropriate management plan in advanced must be a fact for the global addressing of all the activities to be carried out within a forest scenario. This management plan will ensure that all the activities considered in it will be environmentally appropriate, socially beneficial and economically viable. As well, it will consider the long, medium and short-term status for the managers to plan in advance and coordinate these planning phases.

This paper deals with the development of an integrated system for the decision-making support in the use of machinery in forest operations that are included within a management plan. Specially it deals with how the GIS used (CARIS¸ of Universal Systems, Ltd) helps in the evaluation of management unit features and characteristics related to machinery selection information. The parameters defined were: slope, ground strength, ground roughness, forest road density and machinery available on the market. After the GIS has analyzed the management unit parameter, a connection with an integrated forestry management system (IFMS¸ of FORCE/Robak Associates Ltd) is necessary to obtain a unique interface that specifies the spatial data onto a mapping basis.

3.05.00 Forest operations in the tropics

Long-Term Effects of Logging in Wet and Dry Forests in Ghana

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Exploitation of timber resources in Ghana is based on the removal of single trees of economic species scattered over a given area of the forest. Felling operations results in the removal of up to 3 trees ha^{-1} in wet and dry forests which affects up to 13% of the total area. Assessment of the impact of logging have in the past focussed on only the short-term effects. The long-term impacts of logging, especially on the regeneration of economic tree species, are unknown. Such data is neccessary to formulate appropriate harvesting control measures. Data on long term ecological impacts of logging was collected using permanent sample plots (PSPs). A total of 12 one ha. PSPs in wet and dry forests were selected on the basis of availability of adequate records of past logging history. PSPs were also selected such that their last year of logging falls into one of three ranges namely: short term (5-10 years old); medium term (15-20 years old); and long term (greater than 20 years old). The results indicate that whereas logging disturbance and tree damage levels are acceptable in the short term, regeneration of economic tree species is low in the long-term. The composition of the regeneration after logging, even in the long-term, does not necessarily mirror the current composition of the mature trees. This drift in forest composition may not be a problem if efforts are successful in generating a market for a wider range of timber species, including lesser used species. The highly variable and patchy nature of species regeneration even in the long term draws attention to the importance of seed trees and timing of logging in relation to seed fall. It is suggested that more attention to the forest cycle is needed to enhance regeneration of desirable species. The paper concludes with recommendations on fine tuning the felling cycle, yield allocation procedures and harvesting controls in Ghana.

Growth, yield and mortality after improved Selective Logging in Tropical Rain Forest of Sabah, Malaysia.

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In all commercial usage of the Tropical Rain Forests, the harvesting intensity and the technical quality of the harvesting procedure are crucial for sustainable timber production. This study focuses on the response of the residual stand to operational planning and pre-logging treatments. The field study is a comparative experiment using a complete randomised block design where the long term effects of four modes of selective harvesting are evaluated;
unsupervised logging
unsupervised logging with pre-felling climber-cutting
pre-marked skid trails and directional felling
pre-marked skid trails, directional felling and pre-felling climber-cutting
and no logging, i.e. virgin forest as control.

There are four replicates of each treatment which result in a total of 20 permanent plots. Each gross plot is 5.8 ha, with a net plot of one ha in the central part, climber cutting, where allotted, was carried out one year ahead of logging, and the net plots were enumerated before logging. Logging has been done at full intensity. The entire commercial and accessible volume was logged i.e. all trees of commercial tree species with a diameter above 60 cm were harvested, according to the forest law of Sabah. The experiment was established 1992. The plots were logged and enumerated for a second time in 1993, and since then they have been enumerated every second year. For trees above 10 cm dbh enumeration is done on the total area of the net plot. For saplings, seedlings and germlings, the area invented is reduced. Some preliminary results will be available for presentation at the IUFRO-world congress 2000.

The feasibility of directional felling and pre-felling climber cutting was investigated in a preparatory field study. Professional fellers and local fellers were compared. Impact on accuracy in felling, no. of damaged trees in residual stand and gap size was investigated.

Reduced Impact Logging Using Long Haulage Cable Systems in Hill Production Forest in Peninsular Malaysia

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Currently logging activities in Peninsular Malaysia are confined to hilly areas characterized by difficult terrain and sensitive environments. Poor logging practices, e. g., using heavy machinery (crawler-tractor methods), are very damaging to the forest and often lead to massive environmental damage such as soil erosion and high sedimentation in river systems that reduce water quality. Additionally, the residual crop gets heavily damaged and the overall biodiversity is reduced. Therefore, the current logging practices in Peninsular Malaysia need to be modified to comply to ITTO's Criteria and Indicators for sustainable forest management before the year 2000. in achieving this objective, attempts have been made to review ground skidding techniques currently employed in logging operations in hill forests. A pilot study has been undertaken by FRIM to test an alternative logging method suitable for hilly areas. The new method proved to be cheaper and less damaging to the forest and environment, with only a few modifications to the existing machinery used. The report highlights the methodology of the new logging method and the reduction in damage to the soil and residual stand.

An Assessment of Hollow Logs and Other Logging Residues from Deramakot Forest Reserve, Sabah, Malaysia

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Sabah is in the process of implementing sustainable forest management practices in all its natural forest reserves. The management system model was developed by the Malaysian-German Sustainable Forest Management Project at the Forestry Department and tested in the Deramakot Forest Reserve. During logging operations it was observed that the number of hollow logs was very high.

Although marked for harvesting, these hollow logs are usually not felled. The fellers test the trees by pushing the blade of the chain saw vertically into the stem. in some cases, a hollow stem is assumed, if a crown shows large defects like broken branches and a highly reduced number of leaves. The fellers and sawyers at the log landing cut off large parts of the top and lower portions of hollow logs. According to forest management plan for Deramakot, the annual allowable cut (AAC) is 20,000 m^3. After a compartment is harvested, the compartment is closed for many years. If the amount of timber extracted from one compartment decreases considerably due to a high number of hollow trees, other compartment have to be opened earlier than planned.

Thus, if a forest is to be managed sustainably, we must optimize the use of available resources and reduce the logging waste. A study on the utilization of hollow logs and other logging residues was initiated. First, it was evaluated how much timber can be extracted from trees regarded as hollow by the fellers. Secondly, the amount of timber which is considered as timber of low quality (hollow stem parts, upper stem parts, top portions, big branches) was determined. At the same time it was tested whether the methods used for the detection of hollow stems are reliable.

Some results of the study are:
- A high percentage of logs presently considered as hollow and left in the forest still contains large amounts of usable timber.
- The methods for determination of hollow logs or the extent of the hollow are not reliable and have to be improved.
- in view of the improved processing techniques (*e.g.* finger jointing) the quality standards for logs suitable for log sales have to be changed.
- The concept of logging residue utilisation has to be promoted. Education of forestry workers, field staff of the Forestry Department and of the license holders has to be started in order to change their attitude with regard to log quality. A different salary system for tree fellers has to be developed and implemented. They should be encouraged to extract as much timber as possible within the cutting limits and not discouraged as it is currently the case.
- Recovery studies should be started to determine the amount of sawn timber produced from hollow log parts unsuitable for log sale and from other logging residues.
- Feasibility studies (technical, economic), which cover the same area, should be started.

Harvesting Impacts of Tractor and Cable logging Systems in Dipterocarp Forests, Peninsular Malaysia

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With the objective of attaining the sustainable forest management for tropical natural forests, it is imperative to reduce the impacts of harvesting on the forest environment. in the selective cutting operation, the residual trees and forest floor are easily damaged by felling and hauling operations. This is especially so in conventional crawler-tractor logging, where the hauling damage can be prominent, while using cable systems can reduce disturbance. We compared conventional crawler tractor logging to cable logging for harvesting impacts. The observations showed more than 50 percent of the conventional harvested area was disturbed by logging operations. Soil disturbances were characterized as "mineral soil exposed with heavy compaction", "mineral soil exposed with light compaction", "mineral soil partially exposed", or "mineral soil not exposed". According to the study, the areas classified as "mineral soil exposed with heavy compaction", and "mineral soil exposed with light compaction" when associated with steep gradient, were likely to remain uncovered with vegetation for an extended time. The components that contribute to such disturbances were construction of landings, steep gradient roads, or heavy traffic on skid trails. Using a cable logging system can contribute to reducing the area of disturbance. Cable logging differs from conventional logging in that it doesn't use tractors which need constructed skid trails We have established a 30 ha research plot for a cable logging using a mobile system in Compartment 51, Jengai Forest Reserve, Terengganu, Malaysia. Tail spar trees are chosen to avoid having machines work on steep slopes, and to minimize road construction. The results obtained from the investigation of the cable logging system will be discussed in this paper.

Forest Operation and Forest-road Networks Design in Multi-Storied Forest Management in Peninsular Malaysia

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"The Multi-storied Forest Management Project" is practiced in Perak State, Peninsula Malaysia, as a part of the Japan International Cooperation Association project. The purpose of this study was to promote the development of the multi-storied forests by establishing techniques for felling and hauling the upper-story tree, *Acacia mangium*. Seventy months have passed since the planting of *A. mangium* upper-story trees, which have grown 233 m^3/ha in volume. *S. leprosula* thirty-five months after planting lower-story trees have reached 5.54 m in height. However, as the ratio of height to basal diameter exceeds 100: 1, trees are strongly tapered. To reduce damage to lower-story trees, a backhoe and an agricultural tractor were added to the logging system.

From the results of logging, the damage ratio estimation of the lower-story trees was simulated by using the Monte Carlo method. The damage ratio differed considerably, depending on planting patterns, height of upper-story trees and felling skills. The results of this survey proved that the felling and hauling of upper-story trees would be technically feasible in the future, except when one row upper-story trees and one row lower-story trees method were employed. The labor productivity was 2.36 m^3/person-day in multi-storied plot, 2.85 m^3/person-day in a four-row plot, and 3.86 m^3/person-day in an eight-row plot. The decrease in labor productivity for multi-storied forest management was caused by the difference in cutting row number. The presence of the lower-story tree did not affect productivity much. Felling, delimbing and bucking costs were estimated at 12 US\$/m^3, skidding costs at 7 US\$/m^3 and transportation costs at 28 US\$/m^3 on a whole. The results of the trial upper-story tree felling and hauling in the survey clearly proved that logging of the upper-story tree would be technically possible. The optimum forest road density in the multi-story forest area was estimated at 26.5 m/ha. This density is likely to change considerably depending on estimated maintenance and administrative costs. Therefore, costs in the tropical area is a critical factor which will determine the level of any permanent forest road networks for sustainable forest management.

3.06.00 Forest operations under mountainous conditions

Roaded Stream Crossings Decrease Productivity in Forest Transport

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The transport of forest products can be delayed when trucks must travel over difficult terrain. Many forest roads are intersected by permanent streams, where the water usually is diverted through pipes, but sometimes also across the roads. in many cases, culverts may fail because maintenance is lacking. This situation produces a severe loss of soil from the road and further downstream, and the accumulation of excess moisture may also decrease the support capacity of these roads.

Our goal was to quantify the effects that roaded stream crossings have on soil loss and, subsequently, on transport productivity. The study area was located in a forested zone called "Vista Hermosa", which belongs to Forest Licancel Industry S.A. The site included 1187 ha of 24-year-old *Pinus radiata* D. Don, with an average stand volume of 350 m^3 per ha, and a road density of 18 m/ha.
Four road situations were considered: 1) Stream that is crossed by a road with truck traffic; 2) Control: a road with traffic but which is not crossed by any stream; 3) Stream crossed by a road, but which has no truck traffic; and 4) Control: a road which is not crossed by a stream and which also has no truck traffic. Each situation was replicated five times. Data from each situation were collected in sample plots located around cut-and-fill areas and road embankments. in addition, we estimated the loss in transport productivity, based on average truck speed and the amount of time that different truck types would be detained in each of these situations. The situation of a stream crossed by truck traffic produced the largest amount of soil loss (55.66 m^3 per plot).

The least amount of soil was lost from the control (no stream, but with traffic; 14 m^3 per plot). We attribute these results to the effect of water coursing over the road. Transport productivity was 5 to 6% less in the stream-with-traffic situation. When these values are applied to a fleet of 10 single trucks and 10 trucks with trailers, the average number of lost turns per month could be 33.6 and 28.8, respectively, which is equivalent to 1140 m^3 of wood. Our study demonstrates that it is possible to estimate the real effect that water on the road can have on truck speed, and on productivity.

Keywords: environmental factors; forest road; soil loss; truck transport.

Quantitative Analysis of Fragmented Forest Landscape Patterns Resulting from Timber Harvesting Practices: Identifying Key Processes of Harvesting Alternatives for Maintaining Landscape Stability

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Most forest landscapes have been influenced by land-management activities. The outcome is a mosaic of natural and managed forest patches that vary in size, shape, and arrangement. Landscape fragmentation is the process of creating an increasingly complex mosaic of patches that result from disturbances such as human activity. Scientists have studied the effects of fragmented forest landscapes on wildlife and other terrestrial and/or aquatic ecosystem characteristics, and have suggested alternative management approaches. However, these management alternatives have not been quantitatively evaluated because of the inherent difficulties in conducting landscape-level experiments. This is because landscapes are spatially heterogeneous, and their structure, function and changes are scale-dependent. While fragmentation will continue in most forest landscapes (as the result of timber-harvesting practices), its effects must be alleviated through new insights into management strategies, as well as by modifying management alternatives based on landscape perspectives.

This article reviews the use of spatial statistics to quantify forest-landscape fragmentation caused by timber harvesting practices over 60 years (1921-1981) in the Kyoto University Forests. The objectives of the research were:

- to identify significant relationships between pattern and process of heterogeneous mosaics in forest patches over time;
- to develop indices of spatial pattern derived from information theory, fractal geometry, and GIS techniques for measuring fragmentation; and
- to describe aspects of forest fragmentation that result from timber harvesting and subsequent coniferous plantation practices.

A 22-year (1974-1996) trend analysis of forest patterns was made by using orthophotography to transfer forest cover types, interpreted from aerial photographs, into image positions, and also for creating a digital elevation model (DEM). Using a Geographic Information System (GIS), we digitized the base maps and prepared separate transparent overlays for the two photo sets. Each patch was then classified according to cover during each period. The location, size, and shape of each patch were further recorded as polygons for subsequent spatial analysis with the GIS.

We used four groups of statistics to quantify landscape heterogeneity and pattern of the patches as they appeared in 1974 and in 1996. These groups were: 1) size, 2) abundance, 3) shape, and 4) spacing. Patch size was expressed in terms of the average patch area and perimeter. Shape was measured in three ways: 1) edge density, 2) fractal dimension, and 3) diversity index. Edge density was simply the ratio of patch perimeter to patch area. The fractal dimension was estimated by regressing the logarithm of patch area on its corresponding log-transformed perimeter. The diversity index was also calculated by using a perimeter-area relationship. Patch abundance included a measure of density and the percent of land in patches. Patch spacing was characterized by measures of the mean nearest-neighbor distance and a measure of dispersion.

Patch abundance and spacing measures provided considerable information on major patterns of forest landscape dynamics over time. Size and shape indices contributed information on specific characteristics of the individual patches. These parameters may be useful for applications designed to study specific interior and edge habitats, or in determining prescriptions for forest cutting patterns and/or cutting-unit size.

Keywords: forest patch; GIS; landscape fragmentation; spatial pattern; timber harvesting.

3.07.00 Ergonomics 1+2

An Overview of Logging Safety Programs in the USA

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A strong interest has developed throughout the USA to reduce logging accidents and assist loggers with safety programs. Driven by accident costs, liability issues, a desire to improve public image and the threat of additional environmental regulations, the forest products industry has developed a pro-active role in assisting loggers with the education they need to reduce accidents while improving the quality of their work. While the goals of logging safety are the same throughout the country, the methodology to achieve those goals varies. Attitudes vary from voluntary programs sponsored entirely by industry to stricter regulation by government.

Most of the states with a significant amount of forest industry have some sort of logging safety program. Many states (particularly in the southeast) have programs operated by non-profit organizations to educate loggers. Some states make greater use of government regulation and government agencies to do the job, an idea that is generally untenable in the minds of loggers and many other people, especially in rural areas. Although there is a lack of uniformity in the methodology for tackling the logger safety issues, this is generally seen as good. The situation and social culture in each state is a little different, so each state has seized the opportunity to solve the problem in their own way. Loggers and related forestry associations in all of the states are hoping that their initiatives will be recognized by lawmakers and prevent unnecessary new laws and regulations.

In this paper, some typical logging safety programs are described.

An Analysis of the Aerobic Capacity and Physical Working Load in Chain Saw Operators at a Brazilian Forest Company

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This study was based on data from a paper and cellulose company in the State of Sao Paulo, Brazil. Its main objective was to evaluate the operator's physical capacity as well as his working load. The universe of this research consisted of chain saw operators in forest cutting who were developing the following activities: felling, delimbing, logging, stack and stump lowering. in general 85 chain saw operators were randomly sampled, and 51 from those attaining 60% of the total to compose the study on aerobic capacity. According to the obtained results it was concluded that: the highest average aerobic capacity in the population of chain saw operators was equal to 2.93 1 O_2/min, or or 43.59 ml O_2/kg.min or or 14.80 kcal/min. The maximum working load for chain saw operators was equal to 14.80 kcal/min while the useful aerobic capacity was 4.90 kcal/min. Stacking was that activity performed by the chain saw operator showing the highest average energy consumption (8.58 kcal/min) and it was classified as an excessively hard work. Felling, delimbing and logging with an average consumption of 6.58; 7.30 and 7.02 kcal/min respectively were classified as a heavy work. The study indicated that along the working time the operator can perform a highest working load of 4.90 kcal/min (2,352.0 kcal/day) without physical overloading.

The Human Factor in Forest Operations Research

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Keywords: ergonomics; human subjects; variation; research; forest operations

Describes the sources and magnitude of variability attributed to human subjects in forest operations research. The research environment of forest operations is characterized as different from other scientific study fields. Reviews human differences contributing to variability in research studies, e.g., sex, anthropometric differences, age, etc. Task differences are noted and the need for a task analysis emphasized. Attitudes, behaviors, and cultural

differences are discussed. Special emphasis is given to research involving learning effects, learning curves, and experimental trials. Some experimental designs are critiqued and the sample sizes for hypothesis testing are examined. Concludes with some practical considerations, improvements from ergonomic research and suggestions for better research for scientists.

Until robots are commonly used for forest operations, humans performing important tasks present substantial challenges to researchers studying these operations. Not all researchers appreciate these difficulties and frequently make conclusions unwarranted by the limitations of the research. Without large scale research efforts involving substantial numbers of operators (perhaps in excess of 35-40 for a study), most reports of findings involving humans would need to be considered case studies, limited to the operating conditions of study area, operations and specific operators.

Sources of variation come from the research environment for forest operations, from the machine-human interface, from the tasks themselves, from the learning effects or experience of workers, from attitudes and motivation resulting in behaviors, from the culture, and what can be collectively described as human differences. Examples of these human differences include:
Gender/sex
Race
Population/anthropometric differences
Intelligence/education
Literacy
Age
Cardiovascular fitness
Other sources of variation can be identified as well.

The magnitude of variation for human performance is shown in sports competition and selected studies to be on the order of 6-300%. A Task Analysis is seen as helpful in making research comparable. Five strategies are discussed to aid researchers with this issue of human variation.
Control the variation
Measure the variation
Use randomization strategies
Explain the sources of variation
Ignore the variation

There is a tendency to continue with the status quo in all forms of human activities. Little pressure actually exists not to simply ignore sources of human variation in forest operations research. However, researchers do so in peril because wrong scientific conclusions are the basis for important decisions: environmental, economic, safety, health, and personal decisions. As a small community of forest operations researchers, the belief in the need to improve is only likely to be supported by internal and peer commitment. Researchers cannot ignore the variation due to humans in forest operations research.

New Ergonomic Principles when Assessing Forest Machines

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A new ergonomic guideline handbook to the design and assessment of forest machines has been completed in the Nordic countries. Its purpose is to assist manufacturers when developing new equipment and help improve the machine operators' awareness of good design. The guidelines are mostly functional regarding the operator workplace, controlling the machine and its tools, and maintenance work. The guide's striven is to improve the earning capacity of mechanised forestry operations by meeting the demands of the operators on health, safety and well-being. About 100 organisations in the Nordic countries were involved in the developing of the guidelines. As a foundation, a comprehensive scientific review was done regarding work in heavy-duty terrain vehicles. The new classification system is based on the work task and the conditions in which the machinery is to be used. The principle is that work in a forest machine should give about the same impact on the operator's health and well-being, regardless how the machine is rated. This requires the machine to be used according it's designed purpose, and that consideration is taken to work rate, time worked and the difficulty of the work. If e.g. a machine is uneasy to use, the operator's time at the controls should be reduced.

Keywords: Good design, manufacturing, purchasing aid, health and safety.

A research into the changes of ergonomic characteristics of some chain saws during their usually expected service life

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The paper presents results of the research carried out into the operating time influence on noise and vibration levels of motor chain saws.. The research was carried out on the sample of 32 (16 Stihl 038 and 16 Husqvarna 266SG) chain saws in order to find out the possible changes that may occur during the four years operation period of the saws. For that reason the tested sample included chain saws that had been in normal operation for one, two, three and four years. All tested saws were used in the same operating conditions during which they had been maintained in the same way. Measurements were carried out on normal production saws randomly chosen. Previous to testing all saws were examined and adjusted in accordance with the producer's recommendations.

The vibrations transmitted to the hands of the chain saw operator were measured in accordance with ISO 7505 measuring procedures. Prior to measurements, the saws have been run and warmed. in accordance with the experiment plan the vibration measurements on front and rear handle were carried out. All three axes were measured simultaneously. During measurement unweighted accelerometer signals from each of the three orthogonal directions were recorded on the tape recorder. The analysis of the recorded signals was made in laboratory conditions using a computer aided frequency analyzer. Vibrations at the front and rear handle were measured at the following working conditions:

a) idling rotational frequency

b) at full load - at the speed at maximum power

c) at racing - at an engine speed which is 133 % of the speed at maximum engine power

For each handle and for each rotational frequency five independent measurement values were taken. After the 1/3 octave band frequency analysis the weighted accelerations as well as the WAS values for each rotational frequency were calculated. The measurements results are presented in tables and diagrams.

The noise level emitted by the chain saws at the same working conditions was measured too. The measurement procedure was in accordance with the ISO 7182. As at vibrations measurement, for each rotational frequency five independent measurement values were taken. Again, the measurement results are presented in tables and diagrams.

The research has shown that there are almost no indications of significant changes of the investigated ergonomic chain saws characteristics during the four-year normal operating period. This conclusion suggests the necessity of monitoring the main ergonomic characteristics of the motor chain saws during operation.

Partially Autonomous Groups in Forest Work in Germany - A Challenge to Meet New Demands for Work Organisation in Forestry

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Significant changes are taking place in German forestry. These changes have considerable impact on the organisation of forest work.

- Forest companies and state forest services are reorganising their structure, forest districts and management areas are getting larger.

- The number of forest workers employed by forest owners - the traditional model in German forestry - is constantly being reduced. in some forest districts there are no employed forest workers left at all.

- Contract labour becomes more and more important in Germany. Information on the implications of outsourcing, migrant labour and precarious working conditions is scarce.

Most of the German forest workers are well trained. They are predominantly professional forest workers, having passed a three-year-apprenticeship. It can be assumed that their skills and knowledge in many cases are far beyond the requirements of their recent tasks.

A diminishing workforce and rising professional demands, particularly resulting from changes in the objectives of silvicultural concepts, might lead to conflicts and problems, which may possibly not be solved by conventional changes in work organisation strategies, such as outsourcing and mechanisation.

One way to counteract is to develop groups of forest workers into partially autonomous teams. It can be anticipated, that the implementation of teamwork in partially autonomous groups will lead to job enrichment and an increase of competence. Another

expected result of partially autonomous groups is that the employees develop a closer identification with the enterprise. This usually results in higher job satisfaction, which in turn promotes the achievement of the enterpriseïs objectives. Furthermore, a contribution to the improvement of the working conditions is to be expected.
Pilot projects have been initiated in order to implement partially autonomous groups in German forestry in a standardised way with external moderation, following a concept developed in Swedish forestry. Progress and outcome of these projects are subjects of an extensive research program. A group with five machine operators and supervising foresters has been evaluated. Their task is to perform mechanized harvesting with one harvester and one forwarder.

In this case it could be observed that the group members have experienced both job enlargement and job rotation. The supervisors suggest that yet further tasks could be delegated to the team, *e.g.* work place inspection and handing over the harvested timber to customers. By that, the supervisors can make better use of their own working capacity for planning and controlling. The group members have become fully aware of their big influence on and responsibility for their own working conditions. Among others this has increased the job satisfaction.

Exhaust gases in the forest are going to be a problem in technological transition

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Keywords: exhaust gas, CO measurement, chain saw, Slovenia, technological transition

In the past, no attention was dedicated to exhaust gases as a damaging health factor at forest work. Measurements of air concentration of toxic matters gave values under MAC (maximal allowed concentration). Nowadays the CO (carbon monoxide) measurements in the short time intervals prove that the concentrations in some conditions are above MAC during a large part of working time. Too high air concentrations of CO are present at tree felling, at delimbing conifers with large branches and at cutting in dense young forests.

In this paper some results of CO measurement at chain saw cutting on 11 working places in Slovenia are given. 8778 measured data or 24,3 hours were analysed. The widely used types of chain saws of the middle power class (mostly Husqvarna 254 and Jonsered 670) were investigated. The fuel mix of normal benzine and conventional (4-5%) or special (2%) two-cycle motor oil was used. Working operations: felling, limbing, crosscutting simultaneously with measuring lengths were made by chain saw.

The CO concentration near respiratory tract of forest worker with chain saw lies most of the time during chain saw operations under MAC of 30 ppm (0 - 15 ppm). But in short time intervals it can reach the peaks (10 second means) over 250 ppm. This occurs mostly during felling, when the workers posture is bend and his nose is near the chain saw. The duration of these peaks is short, the largest peak over 30 ppm lasted 6 minutes and 40 seconds. CO concentration lies over the MAC values up to 10 % of investigated time. It occurs more often in mature forest at big trees, where felling cut lasts longer. The calculated arithmetical means over the duration of the whole working operation with chain saw were between 5 and 53 ppm. in the whole working time on all working places the mean load was below 30 ppm, because the time share of chain saw operations was always relatively small (52 %). The measured time intervals above 30 ppm of CO occur at limbing (up to 90 ppm) and felling (over 120 ppm) only. Worker's daily CO loads (4 - 26 ppm) are lower than in other similar studies (Stampfer et a. 1997). They were at the vast majority of working places above 7,3 ppm (1/4 of MAC), and therefore measures must be taken to reduce it Investigations of other authors in Western Europe found similar results on peaks and working operations, but their peaks occurred more often, lasted in some cases over 50 % of working time and the calculated working time means were under 30 ppm MAC value too, but higher than in Slovenia. in the same time the measurements of CO blood satiation in Germany gave too high values.

The new studies found that HC (hydrocarbons: benzol, benzopyren et c.) cause different health damages, cancer included. This means that the old MAC for HC are not suitable anymore. The health damages from exhaust gases are important, where the chain saw is primarily used at cutting work. The forestry, the forest employers and above all the forest employees in the countries in transition are not yet ready to pay improvements that producers of chain saws and fuels can make to reduce exhaust gases health damage. Therefore, this is not a technical problem, but rather an economical one.

Comparison of vibrations transmitted to the operator by a saddle type suspension seat and an original seat in a forwarder

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Ergonomically it is more desirable to drive a vehicle off-road in a standing position. Prolonged sitting leads to disruptions in the blood supply causing mineral losses in the bone tissue of the spine, disturbance in the nutrition supply to the intervertebral discs as well as muscle fatigue in the back. Besides a better blood flow, also the load on the discs is 20-40% lower in a standing position than in a sitting. An elevated seat is however required to relieve the strain on the legs. Exposure to whole body vibration may accelerate degeneration of discs and increase the risk for herniated discs. Situated on a normal seat, a machine operator has no choice but to absorb the vibrations transmitted by the seat. Situated on an elevated seat formed like a saddle the machine operator would have the opportunity to rise up while keeping balance with the legs and in such a way avoid exposure to the vibrations transmitted by the seat.

A comparative study was done between a prototype saddle seat and a traditional seat, each mounted on a identical suspension unit and with identical suspension settings. The seats were mounted on a VIMEK 606D forwarder which was driven by two test persons on a test track comprising of a series of even size concrete blocks placed at intervals of 0.8 m for the left wheels and 1.2 m for the right wheels. The forwarder was driven along the track with a speed of 0.35 m/s and 0.51 m/s.

Also the forwarder was driven off the end of a ramp which was 0.3 m high and 3.4 m long at a speed of 0.51 m/s. Acceleration at the floor and seat was measured according to ISO standard 2631. To determine absorbed energy, force and acceleration at the seat as well as beneath the feet were measured with a force plate, build by the department of technical hygiene, national institute of working life, Sweden.

The results of the driving tests along the test track showed that according to ISO 2631 health and comfort evaluation the saddle seat showed significant lower root mean square acceleration levels while the vibration dose values showed no difference. Also a non-significant reduction of absorbed energy was found with the saddle seat. When the forwarder was driven off the ramp both test persons experienced end-stop impacts in all three trials with the traditional seat. With the saddle seat only one end-stop impact occurred for one test subject. End-stop impact occurs when the suspension system of the seat reaches it's maximal comprised level which exposes the driver to very high acceleration levels and is therefore accepted as a health risk.

3.08.00 Small-scale forestry

Twenty years of experience with a cost accountancy network in Farm Forest Enterprises in Baden-Württemberg

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The paper contents two main parts. in the first part a comparison is made between the requirements for establishing and running a cost accountancy network according to the "Guidelines for establishing farm forestry accountancy networks" (draft, European Forest Institute, 2000) and the facts which happen when establishing and running such a network in the practice. The necessities for a correct and scientific appropriate outline of a network are confronted with the constraints and difficulties when going on work with the forest owners.

In the second part the main results of a 20 year running economic survey with an accountancy network in Baden-Württemberg with more than 170 participants are presented. This overview will show the key figures about profitability, costs, expenditures and revenues in graphs and tables for the years 1979-1998. This case study shows the advantages of long-term data for analysing the socio-economic situation of farm forests. Also the possibilities for differentiation by regions and size-classes are mentioned. Some comparisons with economic results in other types of ownership's complete this part.

Advantages by integrating small-scale forestry and local wood manufacturing

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It is found that small-scale forestry has remarkable advantages compared with large-scale company forestry when a large share of the total revenue is produced as timber of high value. Low indirect costs of equipment used by self-active forest owners give the opportunity to perform thinning operations repeatedly in the same stand. The consequence is that the trees may be cut when they have reached an economically matured status, in other words when the wood characteristics of the trees to be cut will give the best profit in monetary terms.

New studies show that also stands under establishment can be treated to produce timber of high value more efficiently by means of equipment and methods used in the small-scale forestry. Dense stands, naturally regenerated and completed by plantation if necessary, should be kept dense up to a height of 6 to 8 metres. After that, the number of stems should be reduced markedly by means of one or more pre-commercial thinnings. The stand will then deliver timber of high value in a number of thinning cuts "from above". Stands planted in relatively dense spaces (1.5 - 2.5 m) without remarkably high numbers of natural regenerated plants can with advantage be pruned followed by a cut programme similar to that of the naturally regenerated and pre-commercially thinned stand above. Stands with larger spacing (>2.5m) are, owing to a high pruning cost per tree and a long period of healing over, not suitable for production of wood of high value. The most efficient cut programme consists in this case of one or two thinnings from above and an early final cut.

The treatment programmes mentioned require a planning system that discovers the opportunities to use the efficient production alternatives. Since the forest status varies frequently, even within the traditional compartments (treatment units) of a forest estate, the possibility of the technical logging system to vary the treatment gives remarkable increase of the profit in terms of capital value of the forest. Many opportunities to cut trees in thinning give possibilities to perform the treatment programmes, which most efficiently harvest the given trees in different stands at an economically matured status.

The capability of small-scale forestry to deliver selected high value timber in a long and short time perspective can be used advantageously by local wood manufacturing industry. The technical development of equipment to saw, dry, plane, finger join and glue wood has given possibilities to produce advanced forest products efficiently in small-scale wood manufacturing. Advanced vertical integration of the production chain from the forest to the customer, including efficient logistics, is a promising way to increase the competitive strength of the small enterprises. Networks of horizontally integrated wood manufacturing industries is another way to increase competitiveness of local forest based industry, increasingly applied in Sweden today.

Summary of Small-Scale Enterprises in the Forestry Sector in Finland

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Keywords: Small-scale enterprise, forestry, strategy of enterprise, competitiveness, innovation.

Small enterprises may have an important role in supporting local development in rural areas and also in improving employment. A literature analysis and some questionnaire studies were made in order to find out the prerequisites for small enterprises to compete in the forestry sector as well as to find means to promote the establishment of new enterprises.

The main strategic groups of small enterprises appear to be:
(1) Entrepreneurs in operations which big forest companies desire to direct to smaller contractors.
(2) Enterprises in areas which big companies want to externalise.
(3) Enterprises providing products or services to limited local markets.
(4) Enterprises working with special products, customer-oriented activities or flexible way of production.
(5) Enterprises opening services outside the traditional forestry, *e.g.* nature tourism and memorable experience production.
(6) Enterprises having products with special quality or narrow special knowledge.
(7) Enterprises established to utilise a new innovation. These are, such as, small forest machine or tool manufacturers, measurement equipment manufacturers and computerised system designers.

The first two categories are a necessity for big companies and these enterprises are established without any external support. For developing countries the fifth category may be very interest, whereas the last one is perhaps the most interesting for post industrialised countries. "Innovation is often a new enterprise." thus, real innovations are important, however, innovative working methods also seem be important means in competing in all the above-mentioned groups.

Our theoretical conclusions were that all eight factors (focusing, differentiation, custom-orientation, quality, knowledge, innovative acting, cost-effectiveness and enterprise networks) are highly important in competition. When small tree nurseries and enterprises of graduated foresters were studied, it was found that innovative working methods were in the highest category in all highly profitable enterprises. Some of these working methods are connected to external relations of an enterprise (networks, patents or invincible expertise), while other are internal (innovative acting, cost-effectiveness, high quality and customer-orientation) and some strategic. The best enterprises are good in all these internal dimensions working innovatively. We also designed a theory on how special knowledge gained from a good experience or a high level education may lead to an innovation, and how applying the innovation in production process can lead to a new level of knowledge within the industrial sector in question.

Enhancing the economic decision-making of non-industrial forest (NIPF) owners

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Keywords: forest management planning, management accounting, ratio analysis, cost accounting, non-industrial private forestry

This paper considers the Finnish experiences in developing special accounting measures for monitoring the socio-economic performance of the non-industrial private forests (NIPFs). These measures improve and combine management accounting and forest management practices based on the relevant forest inventory and book-keeping data, enabling NIPF owners to cope with the economic challenges posed by their holdings. Management accounting, ratio analysis and cost accounting in particular, is utilised in developing and extending accounting practices to cover non-accounting items such as growing stock. The result can also be seen as an improvement and extension of forest management planning.

The theoretical background of several research projects has been synthesised and tailored to yield management accounting systems for non-industrial private (NIP) forestry. Empirical evidence has been widely and systematically employed in developing the management methodology for forestry and in applying statistical methods to testing hypotheses and constructing invariances. The data employed include:

(i) Aggregate regional data: The Finnish Forest Research Institute (FFRI) and the Forestry Development Centre Tapio have collected regional income and cost information on NIP forestry for 30 years.

(ii) The agricultural enterprise and income statistics (AEIS): The agricultural enterprise and income statistics (AEIS) of Statistics Finland is based on enterprise-level forest tax revenue information. The most interesting part of the AIES includes farms which have chosen the new forest taxation based on sales profit in the tax reform of 1.1.1993. The data analysed by the FFRI contains about 5000 observations.

(iii) Farm Accountancy Data Network (FADN): The book-keeping data on nearly 1000 farms from 1976 has been collected in the supervision of the Agricultural Economic Research Institute (MTTL). in addition to agricultural information, this data includes cash-based forestry accounting, which has been improved in accuracy in recent years as a result of scientific cooperation between agricultural and forestry researchers.

(iv) Jointly owned forests (JOFs). The book-keeping, income statements and balance sheets, and forest management plans of 139 JOFs have been analysed as a sample of forestry bookkeeping carried out according to the accounting law. Most of the JOF areas are located in the northern parts of Finland. The profitability of JOFs has already been studied at the FFRI for 10 years.

(v) Case data: "The profitability of NIP forestry" -project collected very detailed test book-keeping data of some 70 woodlots, suited to developing and testing methods of NIPF book-keeping and cost accounting.

(vi) Long term book-keeping woodlots: The FFRI has collected long term NIPF book-keeping records, voluntarily and independently by forest owners, for testing profitability and ratio analysis. At the moment there are records of about 20 case woodlots for periods of minimum 15 and even 45 years records. The data also embraced information concerning the forest management plans and standing timber.

Help for Forest Management Planning: Presentation of a Computerized Model for Private Forest Owners

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This survey is aimed at contributing to thoughts at aiding forest owners to make a decision. It was a matter of specifying which kinds of tools it would be useful to set up to help forest management. The survey covered the strategic aspects of decision that forest owners find themselves faced with. It appears that "classical" economic calculations such as the Current Net Value and the Internal Rate of Profitability, are seldom used to help make an investment decision. Is this because the updating calculations over a period of 30 to 40 years are "not relevant", or does it come from the comparison between different investments ranging further than a generation or, the lack of tools adapted to owner's needs ? The method adopted was to, firstly, define the representative framework of management practices. This was carried out by individual interviews and the main conclusions were shared alternately. Through this survey, management schemes, thoughts about strategic /risk relationships and expectations about decision aid tools have been defined.

The analysis is built around three levels of decisions:

- the strategic level of going from the initial state to the final state in the long term (10 to 30 years).

- the tactical level of being in charge of the management over 3 to 5 years (adapting to changes, markets, new constraints or opportunities)

- annual management follow-up.

Forestry management oscillates between financial and proprietary logic. From self-financing and annual revenue and expenditure balances, the permanent assessment of the stock value and proprietary value, up to a naturalistic logic combined with the search for a revenue/expenditure balance.

Criteria retained in the decision aid tool are quantified and qualified and easily used by forest owners. We have therefore retained three criteria, i.e. money, wood and working time. The indicator retained for each is the flow created.

What is this tool for?

Forecast revenue research, human resource planning, memorising work with a view to succession, justifying the administrator's choices.

Computing, and particularly a data base structure is the solution to process the large amount of data and to structure it according to management targets (regular income, forest value, forest transmission, optimal development of the biological potential), and combined with a cartographic base, the organization of work on the property can be displayed.

Possible outputs can be data files used by forestry co-operatives to programme their wood supplies efficiently. This level optimizes forestry management and wood production by putting them in contact.

3.09.00 Economics and harvesting of thinning

Transition of the residual stand damage after a line thinning operation

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In recent years, the use of large-scale forest machines such as harvesters and forwarders are gradually gaining popularity in Japan. However, most of the plantations were established at a time where the use of such machines was not originally thought of. The introduction of large-scale machines is therefore likely to increase damage to residual stand. in this paper, a report on the transition of the residual stand damage caused by a line thinning operation with a tracked excavator based harvester and a rubber tracked forwarder after five years is presented. The observations revealed that injuries, which were not so severe, did not impair the growth of the trees but light injuries such as those inflicted on outer or inner bark, became more severe like a sapwood injuries. These results showed that injured trees are likely to become weaker to the extent that the injuries could easily become severe even if they are originally very light. The importance of carefully carrying out thinning operations so as to minimize the damage to residual trees were confirmed by this research.

Keywords: Transition, residual stand, damage, tracked harvester, rubber tracked forwarder.

Productivity and costs of group work for harvesting mountainous broadleaf thinning stands

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Group work was researched for felling, processing, skidding and quality inspection activities in mountainous broadleaf thinning stands with approximately the same terrain and stand conditions. The stands were 55 and 70 years old. in the forest communities of the mountainous beech forest with dead nettle (*Lamio orvale - Fagetum sylvaticae*/Ht. 1938) and the forests of the sessile oak and horn beam with beech (*Epimedio* - Car*Pinetum betuli* var. *Fagus sylvatica*/Ht. 1938/Borth.1963) the main tree species are beech and sessile oak with the addition of other broadleaf species.

Productivity was examined on two groups. The first comprised of five workers (A) and the second of four workers (B). The first group was equipped with two tractors and three chain saws while the second used two tractors and two chain saws as well as other necessary equipment. The effective time for the cutters in felling ranged from 36 to 42.9%, in finishing and measurement 21%, while the effective time for the tractors ranged from 42.4 to 59%. The effective time per tree ranged from 3.62 to 3.77 minutes, i.e. per unit it ranged from 8.46 min/m^3 to 12.91 min/m^3. The daily output achieved by the Ecotrac and Torpedo tractors at a distance of 300 meters was for group A 20.77 m^3/day while the optimised output was 67.02 m^3/day. The output achieved by both tractors in group B was 17.25 m^3/day while the optimised was 30.72 m^3/day. The average performance per worker in group A was 4.15. m^3/day while the optimised was 8.38 m^3/day. For group B the average performance per worker was 4.31. m^3/day and the optimised was 7.68 m^3/day. The optimisation of the groups lowered the unit cost of production (300 m distance) for group A from 39.63 DM/m^3 to 17.49 DM/m^3 and for group B from 40.38 DM/m^3 to 22.73.DM/m^3.

Keywords: group work, thinings, time study, productivity, costs

Environmental Damage Control by Information System for Harvesting Vehicles

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Forest stands are easily hurt and disturbed by vehicles through timber harvesting operations in the natural forest management system. Many standing trees are scratched and hit which leads to degrade storage quality and succeeding small trees are lost which leads to make severe to reforestation. Smart control for harvesting vehicles shorten the skidding paths length between landing sites and timber choking points by suppressing branching out of skidding paths. Number of damaged standing trees and the percentage of diminished succeeding small trees are mainly affected by run-about of skidding vehicles. On the gentle slope and steep terrain, many succeeding trees disappeared. The clear deference was found on the diminished percentage of number of small trees less than 6 cm in DBH. Easy to run-about for the skidder would be the reason for the former and easy to slip downward on terrain slope for timber being skidded would be the reason for the latter. An information system to show the skidder operator favorable paths from a landing to loading points was discussed to reduce excessive run-about of vehicle in the stand.

Field trial for the discussion has been conducting for about forty years in university forest in Hokkaido, University of Tokyo, through its stand based natural forest management experiment. A feller-buncher or a felling staff with GPS device collects GIS datum and they are compiled immediately into a database on a PC in the field or on a PC connected by network. Manual data collection simultaneous for the felling, would be useful even if machine operation is not introduced into the process. This real time GIS system informs the skidder on the location and advancing direction. The information would be transmitted to the skidders through field LAN with radio communication.

The site disturbance would be reduced through shortening total length of skidding paths to the half when branching ratio of skidding paths decreased from 3.5, which was on the field operation trial, to 3.0. The branching ratio was based on the stream system ordering by assuming skidding paths from choking points to landings to the ground water stream system from the source to the mouse.

The path length would especially expected to be short at the gentle slope sites through decreasing dozing frequency for rebunching timber in order to set timbers easy for choking.

The operational damages through the information utilizing system, Real Time GIS, would be at least the half of that of the conventional operation system. The importance and need for control of vehicles operating in the forest stands could be confirmed. Validity of the information system was confirmed on the forest harvesting operation for conservation of forest environment. The information system for this operation control also enables timber assortment design at landings, and affords design for natural forest management with higher accuracy accompanied with stand geographical information.

Keywords: Environment, Information, Harvesting, GIS, GPS, LAN, and Skidder

Damage to Residual Stands from Thinning with Short-span Tower Yarders: Re-examination of Wounds after Five Years

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Keywords: Logging, Residual stand damage, Thinning, Transition of wounds, Wounded wood section.

Residual stand damage from thinning is one of the most important problems in the current Japanese forestry. The reason can be explained as the following three points. (1) Thinning rather than clear-cut is preferable cutting method from both environmental concern and forest management. (2) Mechanized thinning, which has been used in the present decade, often causes damage to residual stands of dense man-made forest managed under traditional procedures of Japanese forestry. (3) Japanese timber market requires higher quality for domestic logs in contrast to imported logs.

There are three main subjects on residual stand damage. The first subject is on logging technique by which the residual trees are damaged. The second and the third are on growth and quality of residual trees, respectively. Wounds on damaged trees may reduce their expected growth after the thinning. Wounded sections of damaged trees may develop stain or decay in the wood section and degrade their market value as saw timber. The present study focuses on the last point: transition of wounded sections of damaged trees.

The author investigated wounds of residual trees and compared their current status with the status of five years ago when the stands were thinned. Five plots were established in a typical man-made forest of Japanese cedar (*Sugi*; *Cryptomeria japonica*). A short-span tower yarder logged the plots in 1994 through 1996. This report describes the result of the year 1999 investigation on two of the five plots that were thinned in 1994. The other three plots will be investigated in 2000 and 2001.

The investigated two plots are 0.3 ha in area and had 85 damaged trees. On the damaged trees there were 225 wounds in total. Status of the wounds was defined as four levels of severity that are defined from their appearance. Dimensions and severity levels of the wounds at the time of 1999 were examined and compared with those of 1994. Ten damaged trees were selected for inspection of wounded wood section. The selection was made concerning the distribution of severity levels as well as management plan of the forest. Wounded sections of the sample trees were cut and corresponding disks were obtained for detailed inspection of wound area.

Most of the wounds with lighter severity level have already healed by occlusion or disappeared. Heavily damaged but now healed wounds are smaller in horizontal dimension. Lightly damaged but now badly developed wounds are smaller in vertical dimension. Inspection of wound sections revealed that most wounds developed discolored area in the wood. Only the lighter wounds that had healed earlier have no or smaller discolored areas. Discolored areas of the wounds with still exposed cambium have larger widths than the original wound widths. As a conclusion, horizontal dimension or width, rather than vertical dimension or length, of wounded area significantly affects healing or occlusion of wounds.

3.10.00 Harvesting, wood delivery and utilisation 1+2

Cut-To-Length Logging Systems of Tomorrow

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This article discusses the potential development of a logging system in which logs are made at the stump from a harvester, and carried to the landing by a forwarder. The focus is on Sweden, but the proposal has international out-looks. Trends in logging over the past decade are described, and used to envision the next decade. in the analysis, I consider wood markets, the call for sustainable forest management, safety and health, system produc-tivity and utilization, as well as operational organization, operator education, and technical development. Three mechanized logging methods are compared, as well as three different forest-worker education systems. Possibilities exist for using advanced electrohydraulics, and GPS/GIS. I also include a discussion about the trend toward purpose-built harvesters.

The use of cut-to-length logging will in-crease worldwide, especially in central Europe. Hindrances that are found when introducing cut-to-length systems include operator education, work crew organization, supply of maintenance service, and capital that is bound in other logging systems. Future cost reductions can probably be achieved through more-precisely planned and completed logging operations. This will require motivation by the work force. A crucial element will be to invest in building mutual trust between all parties concerned.

Keywords: ergonomics; forest machine; future; logging method; maintenance; operator education.

A state-of-knowledge report on harvesting, tree processing, and product quality

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This paper identifies key scientific, technical, and social issues relevant to harvesting, tree processing, and product quality. Here, we portray the present state of knowledge relative to each of these issues. Based on a survey of world experts on the various topics, and on the authors' own experiences, the paper highlights what we currently know and what issues are not fully understood from the point of view of scientific research. in some cases, technical solutions may not exist and, therefore, will warrant additional research or development.

The scope of this paper is narrowly defined to address issues that are directly part of the Research Group 3.10.00 mandate. Specifically, we cover technical and operational aspects related to the harvesting and processing of trees, primarily in non-mountainous terrain. Our discussion deals with operational considerations, environmental issues, productivity and cost, machine design, and wood product quality.

Within the above-defined scope, the report sets out to answer the following questions:

- What are the key scientific and technical issues?

- What do we know and what warrants additional research?

On the issue of equipment productivity and the cost of operations, we identified gaps in the modeling of equipment operating under a wide variety of conditions, and in the understanding of the operator's impact on productivity. Our review also uncovered a number of gaps in the technology used in existing equipment; technologies such as traction systems, controls, hydraulics, and vision

require refinement or adaptation to become more useful for the forestry machines of tomorrow. Wood product quality must also be optimized; understanding the interrelationship between wood cost and wood value is a research area that receives and warrants significant attention. 'Social issues in forestry' is another area identified as critical and in need of additional attention.

This broad review of the state of knowledge relating to harvesting, tree processing, and product quality has uncovered a large number of areas that require more science, more technology, and, therefore, more R&D. in general, we conclude that, whereas the basic functions are generally understood, the main gaps usually lie in understanding how one function affects other functions and the overall system. Many research groups now strive toward modeling whole systems and obtaining a clear vision of the overall picture.

Use of Information Technology (IT) to Improve Wood-supply Chains in German Forest and Wood industries

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Forest industries in Central Europe and, especially, in Germany are now at a disadvantage on the international timber market. Very traditional customs and structures, such as motor-manual harvesting systems and tree-length logging, are still most common, but the random-length logs they produce cannot be used without further manipulation. Although the point of sale between forestry and woodworking industries is at the roadside, customer demands necessitate the implementation of a complete wood-supply chain.

In contrast to practices in Sweden and Finland, modern logistic concepts and harvesting technologies currently are not applied here. Mechanized harvesting systems, however, are now used more frequently, particularly to reduce the harvesting costs incurred by early thinnings in younger stands. Because technology recently has been further developed, harvesters can also operate in older stands and on steep terrain. Improvements in production and marketing systems are necessary to capitalize on the benefits gained with this newly-mechanized harvesting.

The main part of this paper is a comprehensive presentation of the necessary improvements being made within the wood-supply chain, as it is conducted under German conditions. Objectives of this on-going investigation are to develop routines for expediting the flow of materials, to apply new techniques for simplifying and reducing transportation, and to improve communication among market partners by providing modern IT tools. A review of the potential for further rationalization of harvesting operations also is provided.

Field trials and studies of raw-material flow in sawmills showed that using the bucking-to-order or bucking-to-value algorithms available from the onboard computers in harvesters provided significant economic benefits. Similar calculations were also made for added values along the wood-supply chain, as derived from the application of newly developed transportation systems. A new communication network has been organized to improve information exchange between market partners; its structure and advantages are discussed here. Applications are envisioned for using Internet websites for marketing purposes.

Study results also are discussed. in addition to drawing some final conclusions, the importance of appropriate education programs is deduced from the personal challenge of modern IT applications.

Keywords: added values; information technology; mechanized harvesting; transportation; wood-supply chain.

Harvesting and the Economics of Thinning: A State-of-Knowledge Report

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The practice of thinning is necessary for timber stand improvements such as concentrating the annual growth increment in fewer trees but of better quality. in addition, thinning may help prevent wind throw, forest fires, insect damage, etc. However, thinning is increasingly difficult to carry out because of high labor costs and the low prices received for small assortments. Large fluctuations in assortment price nearly prohibit long-term planning.

New technologies, e.g., multiple tree handling, computers, and central tire inflation, may possibly reduce the costs of thinning. Even more important than during ordinary harvesting are the links in the forestry wood chain, which operate together to improve quality and reduce costs. These can be accomplished by improving the logistics of all the related operations.

Although research is still focused on finding more rational ways to harvest and transport wood, attention should be increased on combining silvicultural and operational research to make stands more easily harvested. Many of these issues will be addressed at the next meeting of 3.09.00, to be held in Canada in September 2001.

Keywords: forest wood chain; mechanization; motor-manual operation; new-product development; thinning costs

Future Scenarios for Wood Procurement

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Forestry work has changed rapidly during the last decades. Some problems have also arisen; for example, loggers have become unemployed while, at the same time, there has been a lack of professional harvester operators. Whenever a long-term investment is made - whether in industrial plant, machinery, or education - reliable knowledge about the future is always valuable. A decision made today has later consequences. Forecasting over a limited time period is specific to each branch of human activity, and can vary from days to decades. The period used for future studies is

considerably longer than that for conventional forecasting.

The aim of this study was to analyse the changes in wood procurement until 2030, using future-study methods. The scope of the study was forest industry, wood-based energy production, exports and imports of round wood, and international investments. Scenario methods were applied here. These methods were based on the presumption that no single predictable future existed, but a number of futures were possible. Decisions made today impact the future. The objective was to collect, analyse, and present, in written form, the knowledge of experts in forest technology. The results did not conflict with the principles of forest-related scenarios created by other scientists. Such factors as globalization, energy production, nature conservation, and employment will affect forestry and wood procurement in the future.

Delphi is a commonly used method for future studies. The base material for Delphi was collected in a seminar and through thematic interviews. Answers in this study were completely anonymous. People involved in the study were not able to associate an answer with any particular person. The five scenarios were described in written form, and the collected data enabled many more scenarios to be devised. This method traditionally begins with three to six scenarios, which are supposed to cover the possible futures from negative to positive. The five final scenarios used here were 1) Junkyard, 2) Low price, 3) Single-grip harvester and forwarder, 4) Terminals, and 5) Advanced Cut-To-Length.

The most important resource is not a natural resource like forests, but a human resource such as knowledge. Natural resources, e.g., the amount of area covered by forest, are restricted by physical factors. The degree of utilization and the value of products may be increased by using human resources. This improves employment rates and standards of living. in Finland, knowledge is vital concerning forests, forestry practices, and wood procurement and processing. The deepest possible crisis results when forest-related knowledge vanishes.

Keywords: future studies, scenarios, wood procurement.

The Implementation of Bucking-to-Order Harvesting Systems in Germany - Risks and Limits of Advanced Harvesting Techniques

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Because of relatively high timber prices, the German forestry industry has not been forced to rationalize logging operations as much as was necessary in Scandinavia. Motor-manual harvesting systems and the production of tree-length roundwood were and are still most common. Harvester technology was established in Germany following heavy storms in 1990 that blew down entire forests.

However, these harvesters cut only two or three different lengths of sawlogs and a pulpwood assortment, on a schematic basis. Except for a minimum specified diameter, crosscutting is done independent of any particular top diameter. This production of roundwood does not fit the demands of specialized sawmills for well-defined ratios of log length and top diameter.

The onboard computers of modern harvesters can optimize the bucking of stems to achieve maximum value or fulfill a sawmillïs demand list. With support from the State Forest Service, harvesting contractors, and some sawmills, the Institute of Forest Utilisation and Work Science has conducted a two-year investigation of when and how a bucking-to-order harvesting system could be applied under German forestry conditions. During this time, order lists for typical sawmills have been created. in several field trials, we compared the accuracy of measurements by harvesters as well as the success in distributing logs (characterized by their length and top diameter) to fulfill the sawmillïs demand list. We used simulation routines to analyze the monetary benefit of this new system versus that associated with standard bucking.

In most cases, our accuracy of measurement was high under test conditions. However, general guidelines for calibration are necessary at the national level. Mill requirements for raw material can be formulated in price and demand lists. Following these lists in typical stands can change the total volume and revenue that can be realized. Total revenue can vary by about 10% when different bucking instructions are used, which can significantly affect the financial results of forest enterprises. Therefore, the use of simulation tools will become more important in pre-harvest planning.

Although the concept of virtual organization and operation is still far into the future, forest enterprises and the sawing industry can profit from the advanced cut-to-length systems already in place. Improving the general harvesting and processing conditions will be necessary to permit practical implementation of this technique. Maintaining a permanent supply of raw material to the sawmill could cause further problems. To totally optimize this complex system, an on-line data link between the harvesters would be helpful. An integrated optimization program could constantly control the processing status and adjust the entire chain of production. International competition for timber markets also will force the German forest industry to rationalize the wood-supply chain. Our proposed advances in the shortwood system could be one part of the possible solution.

U. S. Forest Engineering and Operations Research and Education in the Future

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Forest engineering and forest operations have provided the ways and means of utilizing a great natural resource for the control and benefit of mankind. The discipline has been critical to the development of our resources, and will continue to play an important, if not pivotal, role in both the consumption and conservation of our forests. Research and education in this discipline provide scientifically-based methods for managing our forest resources wisely and effectively. Trained professionals apply science and new technologies in a changing world to ensure sustainability. This requires that innovative techniques and advance technologies be discovered and applied in road building, operations planning, road-layout design, harvesting, and regeneration. More will be demanded from the forest operations researcher, educator, specialist, and practitioner in forest resource management during the 21st century.

This paper provides a brief history of forest engineering and operations, and describes how this discipline and profession continue to meet challenges in timber production, conservation, and social forestry. We also explore programs for education and application of forest-engineering principles. Funding sources and specific research goals have changed as personnel prepare for the future. The profession of forest engineering and operations will market what it does best, while integrating with other professions to resolve critical challenges, and providing the leadership necessary for sustainable forest management in the 21st century.

Keywords: education; forest engineering; forest operations; harvesting; research.

3.11.00 Forest operations and environmental protection

The Dynamic Analysis of Soil Deformation Caused by a Semi-legged Vehicle

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Keywords: extended distinct element method; soil deformation; reaction force of soil; pantographic leg; semi-legged vehicle

A semi-legged vehicle that has two front stabilizer legs with pads, two rear legs with wheels and a hydraulic boom for working implements and for moving the machine, has been studied for use in forest operations on steep and difficult sites. The hydraulic boom is lowered to the ground and the stabilizers are raised so that the machine rests on only the boom and the rear wheels and moves by applying hydraulic power to the boom. If these wheels are free-rolling and receive no driving power, great forces act on the boom. The machine sometimes has difficulty in moving on soft soils because the boom sinks into the ground. The machine needs to be improved to reduce the holes dug by the boom. Soil deformation caused by the machine was analyzed by EDEM (Extended Distinct Element Method).

FEM (Finite Element Method) has been applied to analyze soil stress and strain. Soil deformation caused by the machine can not be analyzed by FEM because of the shear band and high degree of material movement. in this study, EDEM was introduced. EDEM can analyze uncontinuous materials as it represents soil as independent particles. EDEM can also analyze continuous materials by introducing pore-springs to represent surrounding fill materials. Based on Newton's law, independent equations of motion for each element are established. A Voigt-type dynamic model of the contact point is created and is composed of an

elastic spring and a dashpot. By solving all equations of motion progressively, the motion of elements in the time domain can be followed.

In this method, soil strength was mainly decided by the spring constants and the coefficient of rolling friction. The spring constants were decided by simple shear tests or triaxial compression tests. The coefficients of rolling friction were decided by experiments with soils and a pantographic leg. The forces reacting on the leg were measured while the leg was moved in soils. in this simulation, the coefficient of rolling friction was determined by trial and error. As for the effect of compaction in soft and hard soil, the difference in reaction forces could be expressed. Phenomena such as soil particles not falling into the holes dug by the leg could also be expressed, when the proper criteria were set up in the simulations.

External forces acting on the machine were gravity and the forces reacting on wheels and the boom. in this study, only the forces reacting on the boom were calculated by EDEM. Motion such as lowering the boom to the ground, raising the stabilizers, advancing the machine and soil deformation could be expressed. The effect of the area of the foot was simulated. When the machine with a larger foot area moved on soft soil, the step became longer and energy efficiency became higher. On the other hand, the step scarcely increased and energy efficiency became lower on hard soil because the reaction forces of soil increased.

Mitigating Forest Site Impacts -Role of Woody Biomass and Root Mass Decomposition

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Keywords: site restoration; impact mitigation; carbon sequestration; mulching; soil carbon

Many forest sites are depleted and have limited amounts of soil organic matter, nutrient pools, and carbon capacity. Over many rotations, forest operations contribute to soil impacts by changing soil structure and removing above- and below-ground woody biomass. Limited research has been conducted on understanding the role of biomass in below-ground processes, especially decomposition rates for buried/incorporated woody biomass and root masses. Little is understood about the effects of incorporating carbon on soil carbon availability, carbon retention, and ultimately, nutrient cycles as a way to mitigate forest soil impacts. Little, if any, work has been completed on understanding and optimizing woody biomass form and composition to lengthen carbon sequestration periods, increase soil organic matter, and/or restore and improve site quality.

A potentially effective means of increasing and stabilizing carbon in forest soils is through incorporation of biomass as a forest operational treatment. Mulching and rotor-tilling are methods that have been evaluated for incorporating logging slash and residual vegetation into the soil -- practices with potential for site conversion, fuel load reduction, restoring degraded soils, and enhancing productivity. Direct burial of biomass may offer carbon sequestration potential and long-term site quality enhancement. A synthesis of information on operational aspects of below-ground incorporation of buried/incorporated woody biomass is presented as are research needs pertinent to understanding and managing the potential for woody biomass incorporation to mitigate forest soil impacts.

Tree root development in compacted soils due to logging operations

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Introduction

In the investigations of the environmental stress caused by logging operations we often lack the parameters for alteration detection and judgements. in study the authors have analysed the tree root length structure and small root biomass structure as indicators for stress situations caused by soil compaction.

Material and methods:

Two studies were conducted: pot experiment in nursery and skidder compaction field trial. in pot experiment the four year spruce (*Picea abies* (L.) Karst.) seedlings from nursery were assigned to one of the following treatments: field control, pot control and compacted pot. Roots were washed free of media, scanned and replanted. Field control samples were planted back into the field in nursery. Pot control samples were planted into the homogenised soil from nursery in tin pots and grown in controlled conditions. Compacted pot samples were planted into tin pots like control samples but the soil surface was compacted with 100 kPa and later on treated like pot control samples. After one year the samples were dug out again and the root systems were analysed using manual and computer assisted procedures.

In the second study the unloaded hydrostatic driven skidder Woody 110 (Perkins engine 76.5 kW, mass 5.5 t; 5.3 m x 2.1 m with 500 mm standard tyres) performed 10 passes on the undisturbed brown forest soils at the soil moisture near field capacity. Before and after traffic the cylinder cores at 10 cm depth were taken and soil dynamic deforming module and terrain profile was measured on 6 profiles. Six months after the trial roots in the wheel rut were analysed using the computer assisted root morphology and the root biomass structure analysis.

Results

One year of growth of seedlings in pots resulted in over six fold increase of the total root length in control pots and compacted pots compared to the field control seedlings using computer assisted root morphology measurements. The errors of the computer assisted root length measurements were compensated using T/L ratio (number of tips per meter of total root length). When applied TL ratio statistically significant difference between the control pots compared to the compacted pots was obtained.

The alterations of the soil physical properties in field compaction trial was confirmed with bulk density, percentage of coarse pores and soil dynamic deforming module. Applied traffic caused significant alterations in average values of the total root biomass on both analysed depths as well as alive root biomass and live/dead ratio on the upper 10 cm. We found less alive fine and small

root biomass in the compacted soils. Computer assisted analysis of the fine and small root morphology confirmed the observations during processing of the volumetric samples. The average TL ratio between the compacted and control roots form the 10-20 cm depth significantly differ. The difference in fine root structure goes on the account of the short root decline and the relative increase of the dead thicker small roots.

Discussion

In artificial and natural conditions the significant alterations regarding root morphology were observed. Root morphology of alive fine roots in disturbed mineral soils has showed decrease in the amount of nutrient-uptake-active short roots. Fine and small roots have shown high sensitivity for harvesting impacts but existing measurement methods are too laborious for practical indicator. Further investigations must involve root vitality determination instead of alive/dead classification based on visual criteria. The correlations between root morphology and visual disturbances are needed. Regarding plant rooting the area of direct vehicle-ground contact can be considered as a long-term reversible handicapped area. in sustainable forestry temporary ground corridors have to be evaluated and managed as a distinct disturbance category.

Biodegradable oils in the operation of forest machines

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Forest machines need for their operation relatively considerable amounts of oils both for oil fillings and dissipative lubrication of cutting elements of logging machines. Losses of these oils in the natural environment appear to be the cause of soil and water pollution. A number of countries, particularly European ones, tries to prevent the pollution using laws on the obligatory use of biodegradable oils.

The paper presented deals with selected aspects of these measures:

- Measuring the dispersion of oils and its possible concentration on the soil surface. To evaluate oil dispersion a radio-indicator method has been developed making possible to quantify oil dispersion immediately after cutting.

- Evaluation of the usability of oils at low temperatures. A new method has been developed making possible to evaluate pumping ability of oils and to determine the minimum temperature of usability with the accuracy of 1°C.

- Evaluation of the temperature-oxidation stability - oil polymerization, which can be the reason of the increased failure rate of some operational parts of forest machines.

- Diagnostic signals for determination of the service life of fillings for hydraulic mechanisms and gear boxes. It is possible to say that oil should be replaced at that time when peroxide number reaches its maximum value and its decrease begins.

As for the evaluation of oil usability under low temperatures and their temperature-oxidation resistance it is possible to say that procedures contained in the International Standard Organisation (ISO) Standard proposals do not provide utilisable results.

The aim of the paper is to contribute to achieving the state when ecologically more suitable oils characterized at the same time by excellent technical parameters will be used. Thus, one of the most important negative effects of forest machines on the natural environment would be minimized.

Keywords: forest technology; forest machines; biodegradable oils; oil dispersion; oil evaluation

Harvesting impacts and long-term site productivity: the South African experience

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The widespread use of mechanical harvesting machinery during clear-felling operations in South African forest plantations has led to concern about potential effects on long-term site productivity. This paper describes the results from a series of long-term field trials, carried out by the Institute for Commercial Forestry Research (ICFR) during the last decade, addressing the effects of soil compaction and disturbance on soil physical properties and tree growth.

A wide range of harvesting operations were tested on a number of sites throughout South Africa which were planted to species of *Eucalyptus* spp. (mainly E. *grandis*) and *Pinus* spp. in general, soil compaction/disturbance has resulted in a range of growth responses from a 6% increase to an 21% decrease in growth for *Eucalyptus* spp. and a 47% decrease for *Pinus* spp. depending on site characteristics and age of trees. The effect of soil compaction on tree growth depended on soil texture and depth. The greatest negative effect on tree growth occurred on silt loam soils and a slightly positive effect on very sandy soils. Measurements taken across the trial sites indicated that the effect of soil compaction on available water capacity (AWC) was complex and soil texture dependent. On the older trials, soil compaction levels, as measured by penetrometer soil strength, were still very high 5 and 7 years after the harvesting treatments. Changes in soil physical properties following the impacts helped explain growth differences but it is likely that nutritional effects were also playing an important role.

The lack of major growth decreases of *Eucalyptus* spp. following substantial compaction and disturbance in some cases can be attributed to a number of factors. in most growing regions South African forestry soils have inherently low bulk densities due to high topsoil organic carbon contents. On such soils low to moderate soil compaction may improve water holding capacity of the soils following compaction in generally water-limiting environments. It is likely that the negative effects of compaction on root development may be offset by perforation of compacted soils by root channels from previous rotations and by root systems gradually overcoming compacted zones. The effects of soil disturbance, *e.g.* rutting, loosening and compaction in close proximity caused by logger operations, have had a greater affect on growth than operations causing deep compaction. This suggests that key growth processes, such as fine root development and nutrient cycling in the topsoil, have been affected. Cumulative effects of site damage are unknown and will be difficult to detect without multi-rotational trials being established.

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4.01.04 Using models for forest growth and stand dynamics to evaluate sustainability

The characterisation and incorporation of spatial stochasticity in individual tree growth models

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This paper will outline a methodology for the characterisation and incorporation of spatial stochasticity in individual tree growth models. The methodology was developed in response to a growing realisation that the individual trees of forests are not spatially independent. The spatial processes of competition and environmental heterogeneity operating among individual trees in proximity create an observed spatial dependence in individual tree attributes (Matern 1960). Competition for limited resources creates a negative dependence of a tree's size and growth on that of its neighbours, while environmental heterogeneity creates a positive dependence as neighbours are subject to similar local environmental conditions. Spatial dependence has been observed in tree diameters or basal areas (Reed and Burkhart 1985), tree diameter increments (Biondi et al. 1994), tree heights (Samra et al. 1989), tree height increments (Samra et al. 1989) and the residuals of individual tree growth models (Lui and Burkhart 1994b). The presence of spatial dependence in individual tree attributes invalidates many of the classical statistical procedures (Matern 1994). Thus the only valid statistical interpretation of spatially distributed individual tree attributes is as a field of dependent random variates from an unknown stochastic process (Tomppo 1986). It is the central aim of this research to identify this unknown stochastic process. Further, the spatial stochastic component of individual tree models is rarely studied (Dennis et al. 1985) but is universally prevalent in applications of individual tree models (Burkhart and Gregoire 1994). A methodology for characterising and incorporating spatial stochasticity in individual tree models will be described. Important stages in this methodology include.

- Identifying an optimal individual tree growth model for a particular forest setting.
- Identifying an optimal spatial stochastic structure.
- Interpretation of spatial stochasticity in terms of the causal biological
processes of competition and environmental heterogeneity. Resolving the spatial stochastic component attributable to each biological process.
- Modelling spatial stochasticity through stand development.
- Incorporating spatial stochasticity in individual tree growth projections using stochastic prediction frameworks.

The central objective of this paper will be to determine if the characterisation and incorporation of spatial stochasticity improves the accuracy and precision of individual tree growth models for long and short term projections of forest growth. Independent validation datasets will be used to assess the performance of models whose spatial stochasticity is characterised and incorporated against the purely deterministic alternative. Sensitivity analysis will be used to illustrate the sensitivity of model accuracy and precision to differing magnitudes of spatial stochasticity. This research will determine if the characterisation and incorporation of spatial stochasticity is worthwhile in terms of improved model performance. Spatially explicit individual tree data from both the native and plantation estates of New South Wales, Australia, will be used for developing the methodology as well as for validation.

The ratio of live crown length to sapwood area as a measure of crown sparseness: relation to relative social position, foliage loss, and growth potential

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In many temperate forest species, sapwood cross-sectional area at some height on the stem serves as a very effective surrogate for tree leaf area due to the physiological balance between the conductive capacity of sapwood and the transpirational surface area of foliage. Live crown length also functions as a powerful predictor of tree growth and vigor due to its correlation with the total photosynthetic capacity of the tree. However one possible pitfall of live crown length is variation in leaf area density allowing total leaf area to vary for a given crown length. For example varying defoliation by insects or premature needle loss from fungal diseases may not change the live crown length, but would result in a significantly sparser crown with lower total leaf area. in absence of significant pest problems, similar variation in crown density can be observed across a range in site quality for many conifer species in western North America. Assuming a close dynamic equilibrium between foliage amount and sapwood area, the latter measure may be more reliable under such pest conditions or site variability. Application of sapwood area to indicate total foliage area, however, provides no evidence of biologically significant differences in leaf area density. in this regard, an index that combines both live crown length and sapwood area adds considerable predictive power to either dimension alone. Specifically, the ratio of live crown length to sapwood area can be interpreted as an index of crown sparseness: the greater the length of live crown needed to accumulate a given amount of leaf area (as represented in sapwood area), the sparser the crown must be. To assess its potential performance, CL:SA was computed for Douglas-fir trees over a range in size, stand density, site quality, and condition. This index ranged from 2 to 100 when expressed as cm:m^2 with a mean value of approximately 12. in general, individual trees with a high CL:SA have a lower relative height within the stand; however, even after correcting for stand density and the relative size of a tree within the stand, individual tree basal area growth increases significantly with decreasing CL:SA. Similarly, this index increases with increasing severity of needle loss on sites where Swiss needle cast is causing premature loss of foliage in western North America. Patterns in the variation of CL:SA within a tree, among trees within a stand, and among stands across western Oregon lend some insight into the complexity of this variable, as well as its potential diagnostic power.

Allocation of Leaf Area to Integrate Stand Structural Features into Forest Management Decisions

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Integration of stand structure features into management objectives is a frequent requirement of evolving forest management strategies. These strategies attempt to accommodate multiple resource objectives through design and maintenance of certain types of stand structures. Generally, these objectives are met by stand-level treatments which create stands with a variety of tree ages, species, and canopy strata. A method of integration of structural features through distribution of leaf area has been developed to design structures for management of multiaged stands. Stands are designed by allocating leaf area to stand components such as stand age classes, species, or crown class groups. Increment of stand components can be predicted from component leaf area. Stand volume increment is obtained by summing the predicted increment of individual stand components. Measures of tree vigor, other stocking parameters, and structural development can also be projected over time. The result is a flexible system for designing stand structures using variables that are important to assessing ecosystem function and productivity. This system is appropriate for stands with two or more age classes, or stands typically described as uneven-aged. Applications from several stand types including *Pinus ponderosa*, *Pinus contorta*, and mixed *Picea abies/Pinus sylvestris* are presented.

Accounting for interactions in hypothesis testing of simulated scenarios with a forest growth process model

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Comparison of scenarios through process models is an important aspect in ecological simulation. However, uncertainty (estimation error) is usually not accounted for in simulation studies that compare scenarios. in this work we propose and approach for hypothesis testing through process models accounting for uncertainty in treatment entities (model factors that represent the scenarios or treatments) and external entities (remaining model factors) that interact with treatment entities. External entities may be thought of as a representation of the environment where the simulation experiment is conducted. The method presented here generalizes previous work which assumed no interaction between external and treatment entities. The proposed approach analyzes differences between predictions produced by the treatments, rather than absolute values of predictions from each treatment. Low-order orthogonal polynomials are fitted to identify entity interactions in the process model. The example analyzed to illustrate this method is based on indirectly testing the effect of tree spacing on the growth of a forest stand of a tree species for which spacing is inversely related to wood density. Specifically, we applied a forest growth process model to test the effect of different wood densities (resulting from two initial spacings: 3 and 6 meters) on the growth of basal area in a stand of red pine (*Pinus resinosa* Ait.) from ages 36 to 60 years in the Great Lakes region of North America. in turn, we used results from a field study to characterize the effect of spacing on wood density. Accounting for uncertainty in interacting external entities produced a variance of the mean difference between predicted treatment means that was six times larger than the variance obtained when that source of uncertainty was not accounted for. Basal area resulting from the wider spacing was significantly greater regardless of whether uncertainty in interacting external entities was accounted for. However, the power of the test was considerably affected by the type of uncertainty accounted for.

Individual-based modelling of tropical forest growth and yield: structure and calibration of the SYMFOR 2000 modelling framework

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For several years there has been an identified need for predicting the effects of silvicultural intervention on future forest growth and yield. Forest concession companies in Indonesia collect data from permanent sample plots (PSPs), but these data are not, in general, analysed. Scientific researchers, forest managers, policy makers and certification bodies are all interested in using PSP data to predict forest growth and yield. SYMFOR 2000 is the latest version of SYMFOR (Sustainable Yield Modelling for tropical Forestry), which is designed to meet these needs for such users.

SYMFOR is a computer simulation program using PSP data in a framework designed to house individual-based forest growth and yield models. It makes predictions about the future growth and yield of tropical forests following silvicultural interventions. The individual-based nature of the framework allows an explicit and unique treatment of the processes of damage and silvicultural techniques, such as the creation of logging skidtrails, damage due to felling and enrichment planting, and allows alternative methods to be tested on simulated forest. A combination of deterministic calculations and Monte Carlo representations of real stochastic processes lead to a realistic representation of growth and other forest processes in most areas of lowland dipterocarp forest in Southeast Asia.

The framework currently contains a process-based tree growth sub-model and empirical sub-models of tree growth, natural mortality, ingrowth and damage, as well as several silvicultural management option routines. The process-based tree-growth model incorporates the effects of competition for light, water and nutrients to predict individual tree growth after each model time-step derived from the "Hybrid v3.0 model"(Friend et al. 1997. SYMFOR gives a representation of the environment in which each tree grows, from which the response and interactions of individule tree sub-models can be calculated. Other sub-models necessary for simulating the state of the forest are empirical, having been devised and calibrated directly from real data.

The paper describes the framework, the models within it, the calibration process and the uncertainty of results arising from the models. Comparisons are made between the empirical and process-based tree-growth models, and also between individual-based models and other model types more traditionally used for tropical forestry. The paper concludes that whilst different model types may be appropriate for different applications, the influence of specific silvicultural interventions may best be predicted using individual-based models, and that these have an important role to play in future sustainable forestry management practice.

Modeling effects of metabolism and 3D crown structure on tree growth

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We give an overview on the functional-structural tree models (FMSs) that are outgrowth of developments in process-based models (PBMs) on one hand and morphological tree models on the other. We analyze what kind of phenomena can be best studied using FSMs and outline briefly the structure of FSMs. We identify the distribution of metabolites and growth as one of the main focal points to be investigated in conjunction with FSMs. We discuss different approaches that can be applied in construction of the model component for distribution of growth. We present allometric relationships, the pipe model theory, and more complicated methods that are based on considering the translocation of metabolic products.

Then we present a FSM Lignum that treats a tree as a collection of a large number of simple units that correspond to the organs of the tree. The model describes the three-dimensional structure of the tree crown and derives growth in terms of the metabolism taking place in these units. The time step is one year. The structural units are tree segments, branching points and buds. A branching point separates each pair of tree segments. The buds produce new tree segments, branching points and buds. The tree segments contain wood, bark and foliage. A model tree consisting of simple elements translates conveniently to a list structure: the computer program implementing Lignum treats the tree as a collection of lists.

We have adjusted Lignum to a number of tree species, *e.g.* Scots pine (*Pinus sylvestris* L.) and sugar maple (*Acer saccharum*). The structural units of Lignum have been modified for each modeled tree species. We discuss what kind of modifications different tree species (broadleaf versus conifer) require. We present simulations that depict how the physiological traits and branching patterns affect tree growth in different light climates corresponding to different stand structures. Finally, in the light of the simulations, we discuss the utility of FSMs as a component of stand level growth models.

Uneven-aged forest management, does it combine sustainability and productivity?

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Uneven-aged Forest Management (Plenterwald, Dauerwald) is frequently assumed to better meet the requirements of sustainability than even-aged forest management with clearcuts, and at the same time allow high revenues, thus being most productive in terms of economic values too. The objective of this presentation is to compare productivity in terms of growth and yield and in terms of monetary value using a combination of growth series methodology and an individual tree growth modelling approach.

By definition, in uneven-aged management sustainability of wood production is given on the stand level and not only on the level of the management district. Thus, to compare the two systems, clear cut and uneven-aged management, the unit to be compared with the steady state uneven aged stand must be a series of even-aged stands, their ages ranging from 0 (clear cut) until rotation age (Hundeshagen's "Normalwald") on the same site. This can be achieved by (i) searching for such stands, assessing their increment and estimating the volume removed by thinning, or (ii) using an individual tree growth modelling approach, thus simulating thinning an even-aged stand in a way that results in an uneven-aged structure similar to that of the steady state uneven-aged stand. in a combination of both approaches first two growth series were built by selecting stands representing the following stand development stages in two different regions, thus resulting in a total of 16 plots:

Clear cut system: (1) Clear cut, (2) Pole stage stand, (3) Near mature stand, (4) Mature stand.

Transition system: (1) Mature stand with regeneration < 1.3 m, (2) Mature stand with regeneration > 1.3 m, (3) Two storey stand, (4) Steady state uneven-aged stand

In order to not confuse species mixture effect with that of uneven-aged management, only pure Norway spruce stands were selected, allowing only for less than 10% basal are of other tree species. The individual tree growth models MOSES and PROGNAUS were used to simulate the transition from one stage to the next. By trial and error the type of thinning and individual tree harvesting was searched for, which best produced the structure of the following development stage, measured in terms of volume per hectare, tree number and dbh-distribution. Finally the harvesting in the steady-state uneven-aged stand was simulated for forty years in a way that its dbh-distribution stayed unchanged.

Using assortment tables and models to estimate harvesting and hauling costs allowed to convert productivity in terms of wood into monetary values. in this way three management systems could be compared: 1st the clear cut system with a 125 year rotation, 2nd the "natural regeneration system" where the old stand is removed as soon as regeneration is established, and 3rd the steady state uneven-aged management system. These comparisons were based on the following assumptions: (1) The felling and harvesting system is the same in all three management systems, namely tree felling by chain saw and hauling by assortments. in this harvesting and hauling system the costs per m^3 depend on tree size, branchiness of the trees and other technical parameters; (2) There is always sufficient natural regeneration, not hampered by anything except by competition; (3) There are no differences in wood quality produced in all three management systems, except those resulting from tree diameter and height.

The main results are: (1) The mean annual increment (m.a.i.) in the clear cut system is lowest; (2) Mean diameter of the harvested volume increases distinctly from the clear cut systems to the steady state uneven-aged management system, and thus revenues per year and hectare increase in the same direction.

Keywords: Uneven-aged management, individual tree growth models, Norway spruce, *Picea abies* L.

Dynamics of height differentiation in single tree growth models for young Norway spruce plantations

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Keywords: modeling, simulation, stand dynamics, stand structure, growth, *Picea abies*.

A tree level growth and yield model set has been constructed for simulating the development of young Norway spruce (*Picea abies* (L.) Karst.) plantations under alternative treatment regimes in Finland. A major part of the model set consists of height distribution and individual tree height growth models for spruce and two admixture species.

The height growth model has two components: A potential growth (dominant height) model, and a multiplier model that accounts for the variation between trees within a stand. The chosen model structure is intended to produce an exact match between stand level dominant height development and the average height increment of each dominant tree, and to describe the height differentiation within stands that results from growth variations between individuals.

Surprisingly wide height distributions were observed in the data from 36 even-aged young stands. Most of the height differences had resulted from growth differences during the earliest years, when the variation in microsite properties, weed competition, and biotic and abiotic damages tends to be largest. Having overcome the conditions that induced a slow start, most (but not all) small trees increased their height growth. Competition between trees was not intensive enough yet to control their height growth. Additionally, individual trees showed large growth variations between successive periods. A substantial proportion of the spruces had emerged from natural regeneration, adding younger individuals to the smaller end of the height distribution. All these components resulted in a lively random type exchange in tree social positions that decreased in frequency and amplitude with increasing stand height.

The single tree height growth multiplier model was designed to account for all these elements except for the random growth variations. The use of random parameters in nonlinear models might offer a way to solving the problem. The single tree model is intended for use in concert with the dominant height growth model, expressing the general relationship between height and height growth in the population. The model set results in constant height positions, slightly increasing absolute height differences and decreasing height ratio differences between trees except for the extreme smallest trees that retain their low social positions.

4.01.08 Effects of environmental changes on forest growth

Recent changes in climatic conditions and their potential role in accelerated tree growth on sites in Central Europe

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Keywords: Forest growth; forest site productivity; climate change; time series modeling; geostatistical modeling

On many sites in Europe forest productivity has increased considerably during recent decades. Accelerated tree growth is especially pronounced on sites in Central Europe. Some exceptions seem to lie on the periphery of Europe where the signal is less strong. in a current multidisciplinary pan-European study hypothesized important causes of the observed tree growth acceleration are investigated: (1) changes in physical climatic conditions (2) increased atmospheric deposition (esp. nitrogen) (3) increased carbon dioxide fertilization, and (4) changes in land use.

In this report the potential role of recent changes in climatic conditions (primarily air temperature and precipitation) in accelerated tree growth is addressed. The retrospective growth data used in this study originate from several case studies as well as from forest inventories. Time series of meteorological parameters have been obtained from meteorologic monitoring networks. Both data sets are analyzed in the temporal and spatial domain using uni- as well as multivariate statistical methods. Trend-analysis methods are used in order to detect systematic changes in the behavior of the time series, whereas changes in the realized spatial patterns of the variables of interest are identified and described using geostatistical methods.

Climatic conditions have considerably changed during recent decades. The changes in Central Europe are characterized by a strong seasonal component: winter months have become significantly warmer and wetter, whereas during the summer months the probability of moisture shortage resulting in drought stress for forest trees has increased.

Empirical models describing the relationships between variations in weather and tree radial growth are retrospectively parameterized on a subset of the data. These models demonstrate that moisture availability is control-ling tree growth on many sites in Central Europe. Based on time varying coefficient models it is shown, that trees have responded increasingly sensitive to variations in moisture availability during recent decades. However, these findings are curious, because at the same time growth accelerated. Results of the multivariate statistical analysis indicate that beside meteorological parameters additional factors have to be taken into account in order to describe the observed growth changes. A detailed outlook on how these complex interactions will be approached in the ongoing research project is given.

The likely effects of increasing CO_2 and temperature on forest growth in different regions of the world

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Climate change can affect forest growth through many processes, and the ultimate response in different systems may be affected by the response of any one of those processes, or through their interactions. The work presented here concentrates on two aspects of climate change, increasing CO_2 concentration and temperature.

Increasing CO_2 concentration directly affects photosynthesis and stomatal conductance, and increasing temperature affects photosynthesis, organic matter decomposition rates and vapour pressure deficit of the air and thereby the water loss from tree canopies. Increasing temperature can also reduce frost damage in cold regions, but increase heat damage in regions that are already hot.

In addition to these direct effects, there are many indirect effects. For example, the sensitivity of photosynthesis to CO_2 concentration increases with increasing temperature, and the optimum temperature for photosynthesis increases with increasing CO_2 concentration. There are further feed-back effects between carbon gain, water economy and nutrient availability.

Because of these interacting factors, the response of forest growth to CO_2 concentration and temperature can be different for regions currently experiencing different temperatures, and it can shift with changes in the degree of water and nutrient limitation in different systems.

Some of these differences between regions are fairly obvious: growth in boreal systems is more likely to benefit from increasing temperature than growth in systems already experiencing super-optimal temperatures where further increases in tmpeature are more likely to have negative effects. Similarly, it is now fairly well established that the response of systems to increasing CO_2 concentration is more pronounced under warmer, and under water-limited, conditions than under colder conditions or conditions with adequate water supply. Other interactions are less obvious: how would growth under water-limited conditions in cool conditions respond to increasing temperature relative to the growth response of similarly water-limited forests already growing under warmer conditions?

The effect of these direct and indirect effects and their interactions following climate change are reviewed. A range of responses are investigated in detail with the forest-growth model CenW. It simulates the response of forest growth and the storage of soil organic matter with climatic changes. The interactions between these various factors on ultimate forest growth are described for forests in different regions of the world.

Recent changes in atmospheric deposition, soil chemistry, and stand nutrition as possible causes for an increased forest growth in Europe

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Keywords: Forest growth; Europe; recent changes; stand nutrition; soil chemistry; atmospheric deposition

For many intensively-studied forest stands in Europe, a significant positive shift in growth has occurred during the last 50 years. The systematic growth increases were particularly pronounced in Central Europe and southern Scandinavia. The respective area has been also subject to changes in forest utilization practices and climate conditions, as well as to increased atmospheric deposition of nitrogen and soil-acidifying agents. Atmospheric N and acid inputs often exceeded ecosystem demand and acid consumption by weathering processes, respectively.

Consequently, a significant N soil acidification and eutrophication, which often by far exceeded natural rates, was noticed for many European soils. Soil acidification becomes become evident by a considerable decrease of the soil pH and a distinct depletion of base cation pools in the rooted topsoil within a few decades. N eutrophication of forest soils becomes evident by either a decreased forest floor C/N ratio, or by an increased pool of humus in the humic topsoil, with its C/N ratio remaining unchanged.

Long-term (20 to 40 yr) temporal courses of stand nutrition in Central European forest ecosystems, which often had been depleted seriously in N, P, and base cations by intensive, non-sustainable forest utilization for centuries, indicate a recent recovery of the nutrition status of many European forests. This recovery is particularly distinct for N, which is probably due to high atmospheric N deposition. Besides other factors, this improvement in N nutrition is suggested to be a key factor for the increased growth that has been reported recently for many European forests. However, there is also evidence for a tendency towards imbalanced nutrition on N-eutrophicated, acidified sites. For these sites, in the long run increasing nutrient imbalances may jeopardize forest growth and ecosystem stability.

At present, information about the intensity of the mentioned changes in soil chemistry and stand nutrition as well as of recent growth increases in European forests, and the relationship between these factors is hardly available on a spatial scale, but only for selected study sites.

This contribution summarizes the currently available information regarding the relationships between changes of the growth and the nutritional status of European forests. It links the observed relationships to atmospheric deposition and soil chemistry, and tries to draw some preliminary conclusions concerning the potential causes for the recent growth increases that have been observed for many European forests. Additionally, a comprehensive research approach to obtain more detailed information regarding the spatial pattern of changes in the growth of European forests and the dependence of these changes on changes of important growth factors, is presented. This research approach is currently being realized within the EU-funded research project REGOGNITION, where Relationships Between Recent Changes of Growth and Nutrition of Norway Spruce, Scots Pine and European Beech Forests in Europe are investigated by intensive collaboration of 25 research groups in 14 European countries.

Accelerating forest growth in Europe

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Keywords: Forest growth; forest site productivity; European forests Growth of European forests has changed considerably in recent decades. Forest growth has increased on many sites. The observed changes may have been caused partly by inconsistencies in inventory methods, by changes in forest area, by changes in species as well as in age composition. Excluding these factors various studies showed that site productivity has increased on many forest sites.

An increasing growth trend has been observed in the southern regions of Northern Europe, in most regions of Central Europe and in some parts of Southern Europe. Only in exceptional cases site productivity has decreased. Possible causes for the changes in site productivity are changes in land use, in forest management, in natural disturbances and in climate such as CO_2 increase and nitrogen deposition. The changes in site productivity may have been caused by one factor, a factor combination or by regionally changing factors which finally had similar effects on growth. The significance of each factor possibly varies in space and time. Growth responses to the influencing factors are modified by site and stand conditions. The observed results led to intensive public discussions, because they were connected with forest decline, an emotional topic, especially for the German public.

The long-term increase of growth clearly indicates changes of site conditions. Consumers of wood may appreciate the increased wood resources. Increased carbon storage potential may be an other effect of faster forest growth. However, these changes may also be associated with ecological and economic risks. Increased growth affects nutrient cycling. Changes in nutrient and water supply may also affect species composition and tree health. The density of forests is rising, if removals do not increase at the same time. Dense forests offer less space for light demanding tree species and ground vegetation to live and therefore may affect biodiversity. Higher trees and a high standing volume may increase the risk for water stress and storm damage. Wood quality may be altered as well. Changes in site productivity have an impact on forest management, for example on species selection, amelioration, regeneration techniques, weed control, tending, pruning and cutting strategies (incl. allowable cut). Past growth observations may not reflect actual growth adequately. Therefore, improved anal-ysis and prediction tools are needed to ensure continuous sustainable management.

As long as neither the causes of the observed growth changes are fully understood nor future development of the causing agents can be predicted the risks involved in these changes cannot be assessed in a reliable way. The amount and complexity of the scientific problems evolving from the observed forest growth trends show that solutions can only be developed by the cooperation of scientists covering various disciplines on a European or world wide level. One approach to get a better understanding of the possible causes is the RECOGNITION research project which is coordinated by the European Forest Institute and funded by the European Union. in this project 25 partners work together.

4.01.00 / 4.02.00 / 1.07.00 Using growth models for better forest management in the tropics

A system for yield regulation in natural tropical forests

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Conventionally, yield regulation in natural forests uses either aggregated stand tables and simple assumptions of growth and mortality rates which treat the forest as spatially, floristically and structurally homogeneous, or complex dynamic models that require extensive permanent sample plot information. This paper presents a method of yield regulation based on equal volume coupes that can be derived from static inventory information alone. The method allows for spatial variation in stand structure and composition. Growth parameters for species are estimated from tables of pan-tropical growth rates allied to information on typical size, wood density, and ecological guild. Logging damage and stand density effects on growth are also allowed for based on pan-tropical studies. The method seeks to provide sustained volume production over time from the whole managed area. Constraints can be imposed at the species level reflecting statutory, environmental, or commercial limitations. The system is packaged as a Windows-based computer program. It is designed to be practical for both small-scale management typical for community and for larger industrial-scale logging, and is especially intended for situations where local permanents sample plot data is limited or absent.

Natural forest productivity in several Venezuelan life zones and possibilities of their ecological sustainable management

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The understanding of changes in the productivity of natural forests helps to adopt valid options for forest management planning and the development of systems that assure forest sustainability. in this paper we study interannual variation of tropical forest biomass productivity in several life zones (sensu Holdridge) of Venezuela. This is possible because this country has a network of growth permanent plots that has been measured with a near annual frequency for over 30 years; an exceptional case in the tropics. Twenty four 0.25 ha (50 x 50 m) plots, located in six life zones, were chosen: tropical thorn woodland (T-tw), tropical very dry forest (T-vdf), tropical moist transition dry forest (T-m/df), tropical moist forest (T-mf), tropical lower montane moist forest (T-M-wf) and tropical montane wet forest (T-M-wf). Forest productivity is estimated based on successive measurements, from the time of plot establishment, of tree girth at breast height, subsequently converted to diameter (d). Aerial biomass is calculated with individuals of d 10 cm by life zone and for the total period through regression equations developed for tropical forests. The T-mf (km92) presented the highest mean productivity with 3,83 Mg ha^{-1} yr^{-1}, following in descendent order the T-m/df (2,86), T-mf of Rio Grande (2,64), T-vdf (2,33), T-M-wf (2,09), T-tw (-0,01) and the T-M-wf) (-0,43). These results are interpreted with regard to climatic characteristics, soil texture, carbon and nitrogen soil content, and forest dynamics.

Growth Performance and Yield Potential of *Populus Deltoides* Bartr. in Agroforestry Plantations in Punjab, India

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The economy of the Punjab State, situated in the north-western part of India, is mainly agrarian 83-84% of its total geographical area under cultivation. The recorded forest area in the state is just 5.6% of which only 2.7% has a crown density of 40% and more and are distributed largely in the form of strip plantations along the roads, rainway lines and canals. The rest are just of protective nature in the submontane Shivalik out crops, with no dense forest worth the name. The agriculture in the state is highly capital-intensive and over-exhaustive on water and soil resources. Such a land use scenario transformed the state into a wood-deficit state, where 95-98% of its industrial and construction timber requirements are met with imports from other states. The adoption of *Eucalyptus tereticornis* plantations in agri silnvicultural system by the farmers in early eighties turned the state surplus in eucalypti timber (dhanda, 1989). The farmers had to resort to distress sale of farm grown timber. Now the farmers in the central part of the state are planting populas deltoides in agroforestry and are having sugarcane, wheat, oats, winter fodder potato and turmeric crops along with poplar tree crop. The growth of Poplars in agri-silvicultural system is quit encouraging and farmers are harvesting poplar trees at a short rotation of 6 to 7 years when they attain 90cm GBH or more.

The present study was undertaken to assess the growth performance and productivity of poplars in agroforestry both in riverine belts and tablelands under different cultural and management conditions. Four plantations of each age from one-to-four year were selected in both locations and tree parameters like DBH, total tree height, clear bole, utilisable bole height, basal area, and crown spread of poplars were recorded. The mean DBH in riverbed plantations ranged from 6.8cm (1-yr) to 19.4 (4-yr), while it was from 5.1cm to 17.72cm, respectively in tableland plantations. Generally the DBH for river - bed plantations was more than that table land plantations. Similarly, in observations for total tree height, utilisable timber bole height, clear bole and basal area were recorded and compared. This will be dealt in detail in full-length paper. The timber volume production in riverbed plantations ranged from 9.08 mü/ha (1-yr), to 113.87mü/ha (4-yr) while it was 5.95 mü/ha (1-yr) to 79.90 mü/ha (4-yr) in case of tableland plantations. The timber weight production ranged from 5,21m tonnes/ha (1-yr) to 92.9 m tonnes/ha (4-yr) in riverbed plantations, while it was 2.35 m tonnes /ha (1-yr) to 64.85 m tonnes (4-yr). The production was generally more (42.5-43.3%) in riverbed plantations producing an MAI of 28.48mü/ha/annum at four years age.

The similar aged plantations in these two situations were compared on the basis of silvicultural treatments and soil characteristics. The overall performance of riverbed plantations was better than tableland plantation, verified through students' t-test. The riverbed plantations performed better as this weregiven proper cultural treatments viz., soil working, irrigation and fertiliser application and fare care operations by resident farmers. Also the water table was higher in reverie belt which definnitely contributed towards better growth of poplar during summer. It is, thus, clear that poplar plantations in agroforestry system require proper care and silvicultural treatments while the neglected plantations suffer and not put up sufficient growth.

The second cut for hill dipterocarp forests: What growth and yield models indicate?

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Growth and Yield models are explored for data from logged over Dipterocarp forests data at two scales: predicting the diameter growth, percentage mortality and number of recruits for individual trees per hectare per year and predicting the growth, mortality and recruitment in terms of basal area per hectare. The data for model fitting consists of all trees 10 cm DBH and above in 18-1 hectare growth and yield plots established after logging. Growth and Yield models (individual tree and plot scale) are developed for a permanent sample plot data set established and re-measured over a 15 year period. The models predict that the next harvest will consist primarily of non-Dipterocarp species, due to high mortality of residual *Dipterocarps* and low recruitment. A sensitivity analysis indicates that the mortality rate has the biggest influence on the forecasts, and obtaining more precise estimates of mortality is needed. Because the mortality for *Dipterocarps* was still high (3-4%) up to 10 years after logging, mortality models fitted using these data may be overestimating future mortality, as there is evidence that the mortality drops to 1 or 2 percent by the 15th year. Nevertheless, the observed high levels of mortality during years 1 to 10 are real and result in considerable reduction in the stocking of *Dipterocarps* in the stand. This indicates that the effects of harvesting may last over longer time periods than previously thought and several modifications and refinements are needed in order to improve existing harvesting and management system of Dipterocarp forest in Peninsular Malaysia.

A new approach for AAC calculation in tropical moist forest - An example from Sabah / Malaysia

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Keywords: growth & yield; tropical rainforest; annual allowable cut; management planning

The annual allowable cut (AAC) for a forest management unit in Sabah, Malaysia, is derived by a recently developed method which links a process oriented growth model with a Geographic Information System. The investigations, where the area- and volume-control systems are combined, have been carried out in the 55,000 hectares Deramakot Forest Reserve, consisting of heavily logged over and partly degraded lowland dipterocarp forest.

Underlying principle for this approach of calculating the AAC is to rehabilitate the forest conditions by increasing the present growing stock to its optimum, where maximum increment of commercial species can be obtained. The management concept comprises a modest, gradually increasing timber harvest under strict control of harvesting techniques, natural regeneration, and silvicultural measures.

The commonly applied estimations of annual growth are based on small scale sample plots representing minor portions of today's degraded stand types. Data obtained by such empirical method in selectively logged stands cannot be extrapolated to the wide range of devastated forest structures with the required precision. Instead, this would lead to a bias in the prediction of the potential growth and thus to a non representative calculation of harvestable volumes and regeneration time.

For the here presented growth / increment estimations the process-oriented model FORMIX was applied to determine stand development in five species groups on three site qualities in four stand structure types. The model satisfactorily represents forest dynamics and timber increment in degraded and heavily logged forest stands.

Species grouping is based on light response classes and supported by photosynthesis measurements; site quality assessment uses plant-available water and exchangeable nutrients in soils up to 50 cm depth. Stand structure types are derived from 1:25,000 aerial photos using crown parameters for identification.

The model simulates forest development with and without timber harvesting. Silvicultural standards are considered by defining a cutting diameter threshold, by limiting the number of trees to be harvested per unit area, and by prescribing a minimum number of seed trees to be retained after harvesting (i.e. volume control). The GIS environment enables the connection of the aforementioned stand and site classifications to a spatial database. The thus produced site-specific-stand-type map (SSST) includes three crucial forestry planning parameters: increment, harvested volume, and area.

By selecting areas to be harvested in 10 years intervals (i.e. area control) and defining a preliminary working cycle of 40 years, this approach leads iteratively to a realistic, site-and-stand-specific and area-related calculation of stand improving sustainable harvesting-levels.

The calculations reveal that timber harvesting is presently possible. However, harvesting levels range from 200 m^3 to 10,000 m^3 per year for the next 60 years depending on the silvicultural standards applied. Thereafter an increase to 80,000 m^3 would be possible if harvesting damages are kept at 20%, at least three mother trees per hectare are retained, and the threshold for the minimum number of trees to be harvested per unit area is neglected.

Patterns of vegetation recovery on the 1922 and 1959 lava flows on Mount Cameroon

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To assess the role of volcanic eruptions in the maintenance of species richness on Mount Cameroon, the resulting course of primary succession and the mechanisms controlling this were investigated. in 1995, a census was carried out of the vegetation on the 1922 and 1959 lava flows; the results were compared with those of surveys carried out in 1936/37 and 1951. Numbers of plants and species were significantly different between the two lava flows (P = 0.001), but not between the edges and centre of each flow. The primary succession process was complex with a high turnover of species, a larger number appearing and disappearing from the lava flows between 1936 and 1995 than numbers persisting throughout. The results are compatible with a relay floristics model of succession. However, given the slow rate of vegetation development of the sites it is questionable whether the high rate of species turnover reflects mechanisms of facilitation and then competitive exclusion. It may be more of a reflection of stochastic processes in the populations of the species. Trees > 1 cm DBH tend to colonise from the edges of the flow towards the centre whereas the distribution of seedlings and herbaceous plants seems to reflect a more stochastic colonisation process. It will take 300 to 600 years for the initial forest to be reconstituted on those lava flows as estimated from current trend of species composition, basal area and density. About 8% to 18% of species colonising the lava flows are unique to this type of environment, therefore contributing constantly to the richness of the biodiversity on Mount Cameroon.

Simulation models as a tool for sustainable forest management in Venezuela

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Use of simulation models have become wide spread as a tool for natural resource study and management. Particularly, simulation models are a valuable tool in predicting the responses of forest ecosystems to natural and anthropogenic disturbances, given the complexity and longevity of such systems. Consequently, since the seventies a considerable number of simulation models have been developed with that purpose, mainly for temperate forests. in the tropics, however, these models have been scarcely applied, despite the fact that forest management is the subject of strong criticism. Venezuela is one of the few countries where this approach is developing; since 1993 we have worked steadily on this line of research line, which is specially oriented towards the study of forest dynamics in order to analyze and predict the effect of several management strategies. This has been possible in great extension due to a network of permanent plots established in the sixties. in this paper we present a particular case study of the application of an individual-based model (ZELIG) to a Venezuelan western plain forest, classified as tropical dry transition to humid, after Holdridge. We used a data set with over 35 years of measurement from the University Forest "El Caimital" to parameterize the model. Due to the large number of tree species (64), and the difficulty to run the model for such a number, we selected the top 14 species based on a Value Index (VI = 75%). This index is calculated dividing relative basimetric area by relative stand density. The remaining species were classified in six ecological groups, according to their light requirements and maximum tree height. The values of the parameters to run the model were obtained, and a good adjustment was reached after contrasting the model results with the field data. Based on this parameterization the model was applied to predict selective logging effects on forest dynamics. Four selective logging options were simulated with regard to the minimum felling diameter legally established for Venezuela. in the first option, we harvested the total merchantable stand and considered vegetation damage caused by current logging methods; in the second, the damage was estimated for a planned logging; in the third option we only harvested approximately 50% of the total merchantable stand under the current logging method; and, finally, in the fourth option we cut the same proportion as in the third but vegetation damage was estimated for a planned logging method. For each logging option the following parameters were evaluated: mean stand density, mean basimetric area and total timber biomass. Furthermore, we determined the degree of ecological sustainability depending on the level of remaining forest recovery with respect to the initial values of the non logged forest. We also calculated the benefit/cost relationship. in conclusion, the last option assured a faster forest recovery, but from an economic point of view the first option resulted more profitable in a short term. These results show the necessity of reconciling ecological and economic interests in order to pursue sustainable development. The social aspect should be incorporated as well.

Optimising planting density of banana to improve resource use efficiency and productivity of smallholder rubber lands in Sri Lanka.

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Perennial tree crops, such as rubber, play an important role in income generation for smallholder farmers in the humid and sub-humid tropics. Because rubber provides no income during the early years of establishment, farmers are advised to utilise the wide spaces between immature trees to grow shorter duration crops. The versatility of banana, being both a food and cash crop makes it an important component of these intercrop systems. The Rubber Research Institute of Sri Lanka (RISL) currently recommends a planting density of one row of banana between each row of rubber; this is based largely on the performance of banana when grown as a monoculture and is designed to impose minimum risks of latex yield losses through competitive effects on rubber. Prior to this study, there had been no systematic evaluation of the effects of planting density on productivity of component crops and so it was not clear whether the present recommendations represented an optimal use of land during the unproductive phase of rubber. The overall aim of this study was to determine the extent to which planting density of banana could be manipulated to improve resource use and productivity of immature rubber lands.

A large-scale experiment was established on 5 ha. Treatments comprised, sole crop rubber (R), sole crop banana (B) and three intercropping treatments consisting of an additive series of one (BR), two (BBR) and three (BBBR) rows of banana to one row of rubber. Biomass productivity increased in direct proportion to planting density in the rubber/banana intercrop. Despite an increase in leaf area index and shading with planting density, there was no evidence that growth was limited by light. Instead, growth of both rubber and banana benefited from mutual shading in the high density BBBR crop with a 20 and 41 % increase in biomass per plant of rubber and banana, respectively relative to the single row BR intercrop. As a result, the Land Equivalent Ratio (LER) for biomass increased 76% from the BR to BBBR intercrop. Treatments had little affect on bunch yield per banana plant or harvested percentage, with mean values of 6.2kg and 65% respectively. As yield per plant was similar across treatments, yield per hectare increased three-fold from the current recommended BR to BBBR intercrop resulting in an estimated 350% increase in profits from the banana crop during the establishment phase.

Increased productivity in the high density intercrop was driven by an increase in resource capture per unit land area and on average, radiation and water use in the BBBR intercrop increased by 73% and 140%, respectively, over the currently recommended BR intercrop. Increased shading in the BBR and BBBR intercrops had no major impact on photosynthesis and respiration per unit leaf area.

Consequently, the increase in light-use efficiency and whole plant photosynthesis (due to the larger canopy under shade) were identified as major factors responsible for the improved biomass productivity per plant in the high density intercrops. Intercropping also had beneficial effects on growth of rubber, resulting in an increase in both girth and plant height. The increase in of intercropped rubber has been sustained through to the sixth year of growth with the result that tapping will start earlier in the intercrop than in the sole crop rubber. We conclude that amongst intercrops, the highest density BBBR treatment always performed best in terms of both stand parameters and performance of individual component crops. The implication of these findings for improved income generation on smallholder rubber lands is discussed.

4.02.01 Forestry products collection and sustainable forest management

Urban Tree Database Information System (Infoplant): Dissemination of Research Findings

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Urban forestry and tree planting activities are now receiving due recognition. to make Malaysia a "Garden. To this effect, dissemination of urban tree information is very crucial and would give a great impact to the landscaping activities. Realising this, and towards making Forest Research Institute Malaysia (FRIM) a center for the Malaysian Urban Forestry research, FRIM is making the first move to bring the wealth of information on urban trees into superhighway by developing a web base computer application known as Plant Information System - INFOPLANT. It is a dynamic database system containing useful information on trees for urban landscape purposes. The system will serve as an effective tool for the dissemination of information on urban trees to the public. As it contain up-dated information gathered from experts. The InfoPlant will intensify and facilitate research work in the related fields.

Infoplant was initiated and created based on systems that were already established in other country like in the USA. Infoplant, the first of its kind in Malaysia is an interactive and dynamic program. It was designed to match specific tree species to particular uses and sites based on compatibility characteristics. The database system includes descriptions and pictorial information of tree species. It provides ready information for fast and effectual retrieval. At present there are informations for 164 urban tree species with 32 parameters/criteria and a total of 365 pictures. This number will increase so as to achieve a target to cover all trees that grow in urban areas and that are proven suitable for urban landscaping. Major advantages of the system includes on-line access via internet, easy-to-work and user friendly, practical and time saving. The development of the database system was divided into two stages. in the first stage, existing records and data in dbase file were converted into Microsoft Access file. A search request was then developed based on the existing and additional parameters or field using Visual Basic Application Software that resulted in the stand-alone version of Infoplant. Stage two concentrated on further enhancement and improvisation of Infoplant Database System into the Internet version using Internet Database Converter. To subsequently strengthen and support the system, apart from accessing Infoplant Database for plant search, users may also access other additional and related information pages which are created and displayed in this web site. This includes plant check list, plant price guidelines, nursery information and pictorial guidelines to tree planting. The release of Infoplant is definitely in line with government's aspiration towards both the greening program and IT development. It aims to provide an interesting platform for FRIM in packaging, disseminating and commercialising information on urban trees and landscaping as well as to enable the general public to retrieve it comfortably. As a technological solution for information dissemination, Infoplant will ultimately evolve to integrate the latest supporting technology available.

Role of Local People in Sustainable Management and Conservation of Bamboo and Rattan Diversities in Bangladesh

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Bangladesh is basically a plain land country lies in the north-eastern part of the South Asian sub-continent. The state owned forest occupies about 14% land of the country which is mostly located in the hills and coastal areas. The country enjoys a tropical monsoon climate. The population of Bangladesh is about 13 million, of which 0.13 million is tribal people. So the 98.7 per cent are plain land people (Bangalees). There are 14 identifiable tribes mainly residing in the hills. Both bamboo and rattan are most priority plants of the country. The natural bamboo and rattan forests are located in the hills while people of vast plain land have been cultivating them in rural areas. Bamboos are being used as a main construction material for about 90% of the rural housing. The economy of the country mostly depends on agriculture. Almost all the agricultural implements are made of bamboo. The use of bamboo as a raw material for the pulp and rayon mills has added its importance to the national economy. Both bamboo and rattan are important raw materials for cottage industries and generate employment for the rural poor. Presently there is a shortfall of bamboo resource by 82 million culms. The increased productivity through sustainable management by application of indigenous and modern knowledge can fill the gaps. There are about seven species of bamboo occurring naturally in the hills. Among them M. baccifera is most common and constitute 80-90 per cent of the total bamboo vegetation. Besides these about 30 species of bamboo have been cultivated in the plains of Bangladesh. Among them *Bambusa balcooa* Roxb. and *B. vulgaris* Schrad. are most common. Rattan being a climbing palm grows naturally in the high forests. Only two genera of rattans *Calamus* and *Daemonorops* occur in the country. *Daemonorops* is represented by a single species *D. jenkinsiana* (Griff.) Mart. and *Calamus* is reported to be represented by 9 species. Among them *C. guruba* and *D. jenkinsiana* are commonly used by the local people for weaving and binding purposes. Due to clear felling forestry operations rattans are disappearing in an alarming rate. The hill tribes usually lead nomadic lives. However, in some settled areas of the forest people have been cultivating some bamboo and rattan species in their homesteads and farm land from generations for day to day uses. Agroforestry practice, and shifting cultivation (Jhumming) are traditional systems for sustainable management and conservation of bamboo resource. During jhumming for up-land rice cultivation, the tree seedlings are also planted. Occasionally rattan seedlings and bamboo propagules are planted as inter crops. Jhumias (shifting cultivators) maintain genetic diversity by borrowing or exchanging propagules. Harvesting of rattan cane starts from 7 or 8 years after planting, when the stem become mature and reaches 6-7m in length. Out of 10 rattan species only *Calamus tenuis* is widely cultivated in the plain land homesteads, specially in marshy low lying areas. Both in hill forests and plain land rural areas local people are managing and conserving diversities of bamboo and rattan resources in sustainable way mainly on three principles-utilisation, cultural value and ritual belief, and environmental stability. An endeavour has been made in this paper to discuss these principle in details.

Recherches sylvo-pastorales prioritaires en Afrique de l'Ouest

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La gestion durable des formations ligneuses sèches d’Afrique de l’Ouest est à un tournant de son histoire. Les changements quantitatifs et qualitatifs déterminants, qui ont marqué au cours des vingt-cinq dernières années ces formations ligneuses fragiles, mettent en évidence les faibles possibilités de reconstitution et posent la question des seuils critiques à ne pas dépasser si l’on vise la pérennisation de ces écosystèmes. Les réflexions menées par ce groupe de chercheurs sur divers terrains portent principalement sur deux zones écoclimatiques, celles correspondant aux climats désertiques et sub-désertiques (dénommée ici zone saharo-sahélienne), et aux climats tropicaux secs et sub-humides (dénommée zone soudanienne au sens large).

L’impact du pastoralisme sur les formations ligneuses, associé ou non à celui des feux de brousse (accidentels ou provoqués), ainsi qu’à celui des autres activités humaines, comme la cueillette et l’exploitation forestière, a fait l’objet de nombreuses études sectorielles, dont on tire déjà d’importants enseignements. Malgré cet apport, divers thèmes d’actualité mériteraient encore un éclairage particulier. Il s’agit par exemple de suivre la baisse de fertilité des sols de ces formations boisées, de la poursuite d’études de régénération de la végétation ligneuse (notamment la multiplication végétative naturelle), du fonctionnement hydrique de certains écosystèmes, des conséquences de l’émondage répété sur la vitalité des arbres fourragers, de la concurrence et / ou de la complémentarité de l’exploitation des productions forestières et pastorales, etc. Au niveau culturel et socio-économique, les processus de prise de décision des pasteurs, leurs choix stratégiques et les pratiques d’exploitation des ressources face à la concurrence exercée par les agro-pasteurs, le savoir faire traditionnel, l’importance des revenus tirés de l’exploitation de produits ligneux et pastoraux sur l’économie des foyers, etc... sont encore insuffisamment connus. Mais, face à la nécessité de développer des actions d’aménagmen» à une échelle plus large que la station, les principales lacunes à combler se situent au niveau des multiples interactions, telles que « arbres-ruminants », « strate-herbacée-strate ligneuse », « pratiques pastorales-gestion des arbres », « couverture végétale-feu-sol », etc.

La production durable et simultanée de bois-énergie, de produits forestiers non ligneux et de produits animaux, nécessite une nouvelle approche, globale et non sectorielle. De plus, celle-ci est à situer dans un contexte de décentralisation et de co-gestion contractuelle des ressources naturelles par les populations. De nouveaux modes d?exploitation des ligneux apparaissent, induits par la croissance de la démographie et par la mise en valeur de terres marginales.

Une recherche-action, basée sur de nouveaux outils, est proposée ici afin d’améliorer les modalités d’exploitation des ressources sylvo-pastorales et de pouvoir proposer rapidement des solutions à la demande des habitants de ces deux régions. Parmi ces outils, l’appui de la modélisation de processus biologiques ou de prélèvement, ou l’analyse sur des représentations spatialisées, trouvent naturellement leur place. Pour évaluer l’impact des nouvelles règles nées de la cohabitation avec des agro-pasteurs sur les pâturages herbacés et ligneux, les systèmes multi-agents devraient être plus fréquemment utilisés afin de modéliser à la fois les pratiques coutumières, le fonctionnement de l’écosystème et la dynamique sociale.

Après une esquisse synthétique des principaux acquis des dernières recherches, les auteurs présentent un choix de thèmes prioritaires de recherche en sylvo-pastoralisme adaptées à des deux régions.

Rural communities as a corner stone of sustainable forest management

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Forest ownership is very variable throughout the world; the percentage of state-owned forests goes from near 100% to less than 50%. But whatever is this percentage, the populations living in the forest neighborhood play a key role in its preservation and its development if people are are intensely and continuousely involved in its management. On the opposite -and this is particularly true in rural areas of developing countries-if the grassroots communities are ignored and not fully involved in what scientists are planning and doing alone in the forest, the population could become the major source of prioblems for the forest, putting in jeopardy its preservation and causing in some areas its degradation and even itsdisappearence. This paper analyses the situation in developing countries, and put emphasis on the necessity to consider people as part and parcel of the forest environment. Their hope, their vision and their basic needs should carefully examined, with them, and included in abnu sound sustainable forest management. Examples of successful, as well examples of failibng forest managements are given and analysed in some countries. Lessons are brought up from these cases, and field-tested recommendations are given for the general preservation and development of our forest environment.

Data collection for sustainable forest development

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Sustainable development of a country particularly in tropics will greatly depend on scientific management of its natural resources. in India, forest is considered an important natural resource. The resource management planning requires availability of adequateand authentic data. The main agencies, that are involved in forestry data collection in India are Forest Survey of India(FSI) and State Forest Departments (SFD). The Indian Council of Forestry Research and Education (ICFRE) also undertake Collection and compilation of forestry data through various State Forest Departments. However, the forestry data collection in India is still inadequate and at times not upto data to facilitate resource management planning. No organised market structure for forest produces particularly for non-timber - Forest - Produces (NTFP) can be developed without reliable data. This has a direct bearing on the economy of tribals and rural poors who greatly depend on forests for their sustainance. Similarly, for large scale afforestation planning, it is not enough just to have basic forestry data but also we must have information on meterological data, soil types, genetic variability, availability of seeds of various species etc. The present paper focuses on the need for authetic data/collection kinds of data required problems associated with data collection and possible improvements in existing system of data collection using latest trends in Information Technology.

Keywords:- Resource, data, forestry, Planning, sustainable development

The characteristics of forest ecosystems with its sustainable utilization around Yalu Tsangpu Grand Canyon of Tibet

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There are three kinds of characteristic with forest ecosystem obviously have been summarized via the six times of the field investigation around Yalu Tsangpu Grand Canyon region over past ten year .

1. Abundance of forest ecosysterm biodiversity reach a peak value on the zone of identical latitude throughout the world. As a result of the strong influence on it's warm ~ humidity current with moisture passage come from Indian ocean through Yalu Tsangpu Grand Canyon, therefore the distribution of tropical monsoon rain forest ecosystem up to 290 30'north latitude. Around Yalu Tsangpu Great Canyon region, the low mountain ever green and semi-ever green monsoon rain forest; the montane everygreen and semi-everygreen broad leaf as well as the subalpine taiga niddle leaf forest have been composed of a richest mountain forest ecosystem in order of vertical zones. Within this region, Only 2,200 square meter is less than1.8% of Tibet total area .So far we know, there are:

3768 species of vascular plants, accounting for 65% of the total species found in Tibet .

512 species of mosses amounting 65% of the total species found in Tibet .

686 species of fungi taking 78% of the total species found in Tibet .

206species of rust amounting 77% of the total species found in Tibet .

63 species of of mammals, taking 50% of the total species found in Tibet. 232 species of birds ,amounting 49% of the total species found in Tibet. 25 species of reptile taking 43% of the total species found in Tibet. 19 species of amphibious animal amounting 47% of the total species found in Tibet.

1500 species of insect ,taking 60% of the total species found in Tibet.

2. The Yalu Tsangpu Grand Canyon with it's length, depth, and water flow hit an all ~ around world supreme. The biological species on richest and original forest on densest, covering in high snow mountain and deep valley, composed of a most magnificent landscape in the world.. There is a most attractive canyon nature reserve for ecotourism as well.

3. Owing to advantageous water heat regimes, the biomass and growth rate of Taiga needle leaf forest around this region meet top level in the world .

According to the characteristic has been described above, the masterplan on forest ecosysterm protection with its sustainable utilization should be carried out in scientific way as following:

- in the southern the part of Yalu Tsangpu Grand Canyon reign is the area of the biodiversity on richest will be built a protected area at national level as a gene bank of mountain bio-resource for biodiversity conservation and sustainable utilization.
- in the northern part of Yalu Tsangpu Great Canyon reign, the national forest Park will be established. Via the ecotourism as an appropriate means of helping to achieve poverty alleviation. and change the traditional practices, such as timber extraction and slash-and-burn cultivation.
- On the periphery of Yalu Tsangpu Great Canyon reign, the sustainable forestry base under scientific management will be built up for the economic timber supply.

Development of Fuel Wood in Chinese Rural Area

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The potential amount of fuel wood in 17 provinces of China can't meet the need. About thirty percents of forest consumed every year is for fuel, so the study on development of fuel wood in Chinese rural area is very significance. The dissertation includes four parts. The first part reviews the present situation about fuel wood consuming in Chinese rural area. The requirement and provident of fuel food in Chinese rural area is compared, and how much of forest consumed as fuel wood every year is analyzed. From these materials and analysis, we can get the idea, The rural community is poorer, and their connection with fuel wood is more closely. Being short of fuel wood has lead much more forest cut down for fire that is one important factor effecting climate changing all over the world. So that developing fuel wood is urgent. The second part forecasts the role of developing fuel wood in Chinese rural area. Firstly it can resolve the most important problem for community in aural area where fuel wood is the main energy resource. Secondly it would prevent a mount of forest being destroyed that is helpful for improving on environment quality, so it can reduce the loss bring about by natural disaster. Thirdly it would bring direct income for those poor community, for example, Providing for forage, fruit, and etc. and if fuel wood can be planted in a large area, it can be made used for papermaking and other industries. From the forecast, we can see that once fuel wood is planted in large area, it would benefit the aural people in many perspectives. The third part looks into the elements that have prevented fuel wood developing in rural area. Poverty is the most important element. One hand the rural communities are wishing to get fuel wood, on the other hand they are eager to get direct economy reciprocation and have no much more interests in planting fuel wood. Then having no ownership of fuel wood they planted is another main element that caused fuel wood be destroyed seriously. Other elements are also analyzed. These elements are obstructive to fuel developing. The fourth part looks for ways that lead fuel wood to sustainable management. The first step is the ownership exchanging. For example, the ownership of fuel wood should belong to the local people and not to state. Then management technology should be improved on. For example, the administrating system should accept the free market rule that is who gets benefits should response for. Let people, who need fuel wood mostly, take part in making decision, and the main thing state should do is to stimulate and encourage the local people on policy. Then long-term task, invest and others are also be plunged into for fuel wood sustainable management.

Participative Strategic Planning for Sustainable Community Forestry in Chihuahua, Mexico

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Chihuahua, Mexico has 5.1 million hectares of forested area that occupies 27% of the states total area. During historical development, Chihuahuas forests typically were harvested by private enterprises and, rarely, by ejidos and communities. Folllowing the Mexican Revolution, the government instigated agrarian reform programs, establishing the ejido as a land grant to peasants.

Peasants or ejidatarios have use rights over the land and harvest the ejidos forest resource communally. Over time, ejido communities often included both ejidatarios, with land use rights, and avecindados, those who live in the community but do not exercise land rights and cannot participate in harvesting forest resources as owners but they can just participate as workers. Thus neither ejidos nor their communities have obtained the major benefits from forest resources. However, they now demand to participate actively in the productive process to obtain more benefits. New forestry strategies propose to integrate social and economic development with environmental protection, and to expand participation of different sectors.

This research study focused on strategic planning for sustainable community forestry in Chihuahua, Mexico. The research focused on two forest ejidos in the Sierra Tarahumara: Basihuare and Cusarare. We hypothesized that Basihuare (the intervention community) would have more positive and statistically significant changes in attitudes toward community development than Cusarare (the control community). Our objectives were: 1) assess the current forest resource management in both communities, 2) conduct participative strategic planning methodology (Search Conference) for forest-based community development to achieve a greater awareness of development needs, positive attitude change and to design a strategic action plan for a future community, and 3) assess the attitudinal and perceptual impact of the strategic planning intervention (SPI) of local people toward community development.

A static group comparison was conducted in this study. The study consisted of applying a pre-test (attitude questionnaire) in both communities. The questionnaire consisted of 20 statements, including questions about local peoples participation and the design of strategic action plans for community development, among others. After that, a SPI was conducted in Basihuare. Later, a post-test (same as the pre-test) was applied in both communities.

In addition, qualitative research including ethnographic interviews, participant observation, direct observation, and follow-up encounter provided further insights into evaluating the forest resource management, and the impact of the intervention. Comparisons were carried out between two ejidos before and after conducting the SPI to measure the changes in attitudes The results showed that: 1) ethnographic interviews were a valuable complement to and cross-check on the participatory approaches to obtaining views from the community members about their community forest resource management, and 2) the SPI achieved a greater awareness of development needs and created more positive attitudes and perceptions about community development (Basihuare). As a result, it is possible to note that SPI significant changed the respondents attitudes and perceptions in intervention community. Statistically, there were significant differences in attitude changes in people that participated in the SPI (Basihuare) compared to people who did not (Cusarare). Additionally, the planning conference helped the Basihuare community to design its own strategic action plan for future development. The community not only developed its own strategic action plan, but also, because of the participative and democratic process they used, they developed community plans. in the research, even though, Basihuare lacked financial resources for investment, profits from its sawmill, and resource planning, local people did not display negative attitudes toward for community development in the future. If resources are available, they are motivated and interested in implementing the action plans for their community. The results confirm the initial hypothesis and suggest that the study can serve as a model for the application of the Open Systems approach to the development of sustainable community forestry for the Sierra Tarahumara and elsewhere.

Forest Research and Sustainable Forest Management in Estonia

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Forests (2.01 million hectars) cover about 48% of the territory of Estonia. Since 1940, forest area has increased by 1.07 million hectars. The gross annual increment is 9.5 million cubic metres. Timber and timber products account for up to 18% of Estonian export. Forest and timber related production forms 1/3 of the GDP.

The objective of forest related research is to provide scientific background information in support of practical decision-making in forest management, conservation and multiple use of forests.

To complement investigations on forest ecology, increased emphasis will be laid on analysing the entire chain of forest-based production. Other priority areas of research include the development of environmental monitoring systems, research on biodiversity management and environmentally friendly forest management. Forest research will also support the formulation and evaluation of forest related policies by conducting scientific analyses on key issues.

Basic research is integrated with teaching activities in the Faculty of Forestry of Tartu Agricultural University. Institutional environment will be developed in view to enable research and development activities to be carried out in collaboration with forest enterprises.

To rationalize resource utilization, full benefit will be taken of the research carried out within the international research community. Long-term empirical research programmes will be concentrated in areas where the peculiarity of Estonian conditions warrants the effort. in order to ensure balanced development of forest research and efficient use of resources, the identification and implementation of research programmes will be carried out in coordination with other forest related research institutions.

Today, Estonian science of forestry receives only 2% of the finances allocated to the scientific research sector from the national budget.

In 1998, the total volume of cuts was 6 million cubic metres. The total annual maximum volume of wood harvesting in all Estonian forests not exceeding the sustainable level, is 7.8 million cubic metres. Forest, as a renewable resource, should be used within the limits of its regeneration. in our forests we have stopped excessive felling already in 1961. The area of protected and protective forests will be maintained at the current level (15% of the total forest area). The leading role in environmental and forest policy and legislation belongs to the National Forestry Board (NFB) which operates within the administrative area of the Ministry of the Environment. The NFB is responsible for the implementation of forest policy, monitoring of forest resources taking into consideration the environmental, social and economic factors, biodiversity both on the stand and landscape level.

Sustainable forest management in Estonia is based on:
- scientific research;
- Act on Sustainable Development (1995);
- Forest Act (1993, 1998);
- Law on Protected Areas (1994);
- National Environmental Strategy (1997);
- National Forest Policy (1997);
- Development Plan for the Estonian Forest Sector (1997);
- European Union Habitats Directive, including NATURA 2000.

The Challenge of Meeting Domestic Energy Demand in Sub- Saharan African countries

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Most Sub-Saharan African Countries depend heavily on wood for their domestic fuel. Even though the countries are rich in vegetation, there are localised wood deficits. Moreover, wood resources are often far removed from areas of population concentration. Populations are growing at very high rates, and with that, increasing demand for wood for fuel.

These countries are characterised by strong traditions and cultures, some of which are inconsistent with modern day scientific thinking.

People still cling to traditions and customs some of which are inimical to sustainable forest management and hence sustainable supply of fuel wood. Even though the use of wood for fuel has been a century old practice, woodfuel is not given the requisite attention in national energy balances; forest policies also do not give due prominence to woodfuels.

Attempts at meeting future demand (for woodfuels) have been rather haphazard and unsustained or isolated. Instead of planning to increase the supply base, countries have resorted more to control measures most of which have been difficult to enforce or police. Such measures have included bans, fines and legislation. Some countries have also tried to promote substitutes for woodfuel. Others have tried to introduce fuel-efficient production- and conversion technologies and devices. Due to the generally weak economies of these countries, the interventions have invariably had a donor-assisted component.

This paper looks at efforts made by different countries to meet demand for wood fuel for domestic use. Various supply scenarios are evaluated and realistic proposals made for meeting domestic fuel demand in this sub-region on sustainable basis.

Gestion de la Biodiversité: Relations aux plantes et dynamiques Vegetales chez les Dani de la Vallée de la Baliem en Irian Jaya, Indonesie

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This study was conducted in order to have a better understanding in the interrelationship between the Dani-Baliem and their environment as well as the evolution of their traditional activities in its ecosystem. The consequences of their activities in the evolution of environment are shown by different methods that they modify, utilise, manage its environment and its vegetation diversities.

This research consists: analyses the knowledge and utilization of vegetation and its environment. We also describe the field organization and the local knowledge of botany. We treats the agriculture activities of the Dani-Baliem. The other, this research also analyse the floristic diversity in different environment existence in the Baliem valley. This part consists of analyse floristic of the primary forest of different altitude, secondary forest (fallow system of different ages), transition zone (zone ecotone), home garden, villages and sacred sites. and than, we discuss the relationship between the Dani-Baliem and their environment based on their knowledge of plants, its utilization, its dynamic vegetation and its floristic diversity. Here we discuss environment by confronting the point of view of Dani-Baliem and the ecology, in the way how they exploite them. in conclusion we emphasized how the Dani-Baliem influence the evolution of their environment and the floristic diversity.

Estudio florístico de diversidad de especies en bosques de premontana en la Cordillera de Guaniguanico

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A lo largo de los últimos diez años la conservación de los bosques se ha convertido en un tema de gran prioridad, tanto para los que formulan políticas como para el público en general en todas partes del mundo. En 1992, los bosques templados y tropicales tuvieron un lugar prominente en la agenda de la Cumbre de las Naciones Unidas sobre Medio Ambiente y Desarrollo (CNUMAD), Río de Janeiro. A pesar de estos esfuerzos, la destrucción y deterioro de los bosques ha ido en aumento; provocando serios daños sociales, ecológicos y económico e incluyen pérdidas de biodiversidad y tierras natales para los habitantes de los bosques. Actualmente en Cuba los territorios con vegetación natural son escasos y se encuentran en áreas montañosas, cársicos, pantanosos, serpentiníticos y otros que poseen suelos de escaso valor agrícola. En cambio se caracterizan por un elevado endemismo en ocasiones a nivel local.

Nuestros bosques presentan un elevado grado de alteración y destrucción, sin contar las áreas que han desaparecido completamente producto de la acción antrópica. Es por ello que los estudios de diversidad en zonas montañosas adquieren gran importancia y sirven de base para la protección y conservación de la flora. Los bosques de premontaña contiguos a los mogotes cársicos de la Cordillera de Guaniguanico, al norte de la Provincia de Pinar del Río son de gran riqueza biológica. El estudio de la diversidad florística de un área de 5018 m^2, se realizó a través de la metodología de Brawn Banquet, basados en índices matemáticos, a partir de seis muestras donde se contó el número de individuos y se calculó en cada muestra; evaluándose la biodiversidad de especies bajo diferentes condiciones ecológicas, además del estudio edafológico y climático, determinando a través de la ecuación universal una pérdida de suelo de 90 toneladas por hectáreas y un clima típico de la región insular.

Los resultados florísticos condujeron a calificar la zona como bosque degradado, cuantificándose una inmensa pérdida de recursos madereros, fundamentalmente de Cedrela odorata, madera preciosa de alta demanda en el mercado, lo cual representa el no aprovechamiento de este recurso en la construcción de inmuebles, conociendo que con ese volumen (24.92 m^3 por hectárea) se pueden fabricar 24 juegos de livin y 104 sillones, equivalentes a una pérdida en ingresos de 199200 pesos para esa porción de la Cordillera. Esta investigación realizada en un lote forestal del municipio La Palma perteneciente a la Sierra del Rosario, Cordillera de Guaniguanico permitió recomendar especies para otros sitios degradados específicamente en zonas montañosas; además de recuperar una zona de este tipo desvastada por el hombre y los resultados fueron excelentes. El objetivo del trabajo es proponer un proyecto, incluyendo métodos silvícolas con vistas a recuperar, rescatar y conservar esta formación boscosa compuesta por un gran número de especies autoctónas.

Problematique de l'amenagement des Forêts Naturelles des Zones Tropicales Seches

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Le présent mémoire souligne d'abord la complexité de la tâche de l'aménagiste de forêts naturelles tropicales par rapport à celle des zones tempérées. Ensuite il passe en revue les principales contraintes que peut rencontrer cet aménagiste dans sa mission, contraintes générées par les divers facteurs d'évolution d'ordre physique, humain ou technique. Partant de la necessité de l'adoption d'une approche terroir dans l'aménagement de forêts naturelles (AFN) en zones tropicales sèches (ZTS), impliquant d'une part, une responsabilisation et une participation effective des populations rurales locales dans la conception, la mise en oeuvre et le suivi de l'aménagement préconisé, et d'autre part, une intégration des divers systèmes de production existant (Agriculture-Elevage-Forêt) il analyse les interfaces entre ces derniers et propose le développement des interelations positives et des actions à mener pour réduire voire lever celles négatives.

Mots-clés: Facteurs d'évolution, Approche Terroir, interelations entre systèmes de production.

Population dynamics of tropical trees in the Western Ghats of Tamil Nadu, South India

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The tropical forests at Veerapuli and Kalamalai forest reserve, falling within the Agastyamalai hill range (a proposed Biosphere Reserve), is considered one of the 18 hot spots of biodiversity in the Indian sub-continent. During the past few decades these forests were subjected to unscientific exploitation particularly for agriculture, construction of hydroelectric project raising monoculture plantations and other developmental activities. in addition to that the deciduous forests in these regions also affected by annual fires during summer. Such anthropogenic perturbations have often resulted in gradual fragmentation of these forests and such fragmentations inturn has lead to loss of biodiversity. Successful conservation of theses forests will ultimately depend upon the clear understanding of the forest ecosystem dynamics. Therefore, the present study was undertaken (1993-1996) to evaluate short-term population dynamics of trees in both tropical deciduous and evergreen forests in Veerapuli and Kalamalai Reserve Forest in the Western Ghats of Tamilnadu, South India by permanent plot method i.e. thirty randomly located 10 x 10 m^2 permanent quadrats in each study site; 10 in each sub-site.

Mortality of trees (> 10 cm Girth at breast height - GBH) was lower in both the forests compared to recruitment. As a result, there was net gain in population density of trees. Similarly an increase in basal area per hectare was also recorded. The increase in population density and basal area of tree species could be because of their entry into adult stage from the already existing sapling and seedling bank. Both mortality and recruitment of trees were greater in the evergreen forests when compared to that of deciduous forests. Comparatively low recruitment of trees in deciduous forests could be attributed to annual wild fires caused by human interference. in the deciduous forests no adult trees of *Dalbergia latifolia* were found, but the young ones (seedlings) were appeared during the rainy season. This could be ascribed to persistent soil seed bank or immigration of seeds from the neighboring area and also may possibly through vegetative reproduction. However, the survivorship of these

seedlings were very poor and which could be due to wild annual fire caused by anthropogenic perturbations. Greater recruitment of trees to compensate mortality has resulted in a net gain of population in evergreen forests. This net gain of population may be attributed to favourable microclimatic conditions for better growth and survival of seedlings. Greater mortality of juveniles compared to that of adults occurred during the study period. This could be due to intense competition for limited available resources at the juvenile stage. However, population dynamics of trees at species level varied considerably. The present study suggests that the forest ecosystems here are at building phase and needs long-term demographic studies to understand the regeneration niche.

Indigenous Forest Management System (IFMS) and Forest Products Commercialization: The Upland People's Strategy on Forest Conservation in the Cordillera Region, Philippines

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The Cordillera Region is rich with endemic and exotic species whether shrubs, trees or vines. From generation to generation various tribes in the region have somehow practiced their indigenous knowledge in the management of the forest. Thus, different terms were created by the natives to describe their different forest conservation measures. For instance, saguday is describe as a former portion of the communal domain originally awarded to an individual family devoted to pine plantation, and of which continue to be corporately owned by the second generation of heirs. Other forms of forest management includes Komonal, Tayan and others depending upon the forest type and tribe who practices the system.

A case-study on the commercialization of forest products (wildfood plants, bamboo, rattan, medicinal plants, etc.) had been carried out as a part of larger project which was conducted in some communities of the Cordillera Region. The topic to be presented covers specifically how the natives protect and manage their ancestral land domain claims at the Mt. Pulag National Park while wildfood and medicinal plants and other products are extracted for their domestic and economic needs.

Other features of the study are the advantages and disadvantages of the proclamation of Presidential Decree 75 in 1987 and Republic Act 7586. The problems on land tenure as affected by conflicting Presidential Decrees, Migration of other tribes within the region and dependency of the people in the forest will be presented. The contribution of the local people in educating the tourist as a livelihood option and the role of the research service of the Phil. Government during the experimentation stage will be discussed.

The various forest products whether raw or processed which has played integral part on the daily life of the people and its implication to the conservation and management of the forest were documented. Likewise, data on the role of women and men in these indigenous forest management system (IFMS) whether in the protection and utilization were gathered and analyzed.

The objectives of the study are (1) to document the different indigenous forest management practices in the Cordillera Region, (2) to assess the bio-physical component of the Mt. Pulag National Park, (3) to determine the attitudes and perceptions of the indigenous peoples regarding Presidential Proclamation, (4) to determine the role of men and women in the establishment, preservation management and utilization of the various indigenous forests.

4.02.03 / 4.02.06 Update calibration and enhancement of forest inventories through the inclusion of remotely sensed data

Vertical and horizontal integrated inventory of forest resources

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With the ever increasing use of the forest for purposes other than wood production, such as recreation, watershed management, wildlife refuges, protection of nature, etc., the scope of forest inventories has been expanded.

A complete forest inventory for timber evaluation should also provide so-called non-timber information on:
* Recreational, touristic interest
* Soil and land use capabilities
* Watershed values
- Biodiversity
* Protection of nature, impact of deforestation

It is not sensible, nor even possible, to compile all forest-related or relevant information into one forest inventory. On the other hand, an inventory corrected with this in mind, is not only cost-effective and time-saving, but also provides the opportunity of documenting environmentally-relevant information, which can be analyzed in view of ecological landscape management.

In order to make sound political, administrative and management decisions at the different levels, it is necessary to have reliable and current data relevant to forest resources and the changes therein. Forest inventories can usually be categorized into four levels, according to the scale or size of the inventory area studied and their significance and relation to economical and ecological forest management policy, regional planning, planning at the forest enterprise and stand level.
* National (or international forest inventories)
* Regional forest inventories
* Forest enterprise inventories
* Forest stand inventories

In most cases, and in the majority of countries, the inventories are carried out independently at the different levels so that an information flow between the varying levels is not possible. in the age or time of informatics, a "vertical" integration would be very valuable for decision making at all levels. An effective forest inventory concept should integrate the information flow of all four levels, as described above, taking the necessity of the information required at the varying levels into account. This means that the national, regional, enterprise and stand level inventories must originate from a joint inventory concept, filtering down from the top level, i.e., from a national inventory down to a stand inventory and/or from the bottom to the top level.

The efficiency of forest inventories can be increased by employing remote sensing methods using aerial photographs, air-borne scanner and satellite images. in the last years, remote sensing methods have undergone a very rapid development because new, high-resolution sensors and perfect data processing methods are being developed, which allow economical digitized data recordings on a large scale. Traditional aerial photographs are still being employed as valuable supplementary inventory aids, especially at the enterprise and stand levels. However, aerial photographic methods can only be effectively applied in combination with terrestrial recordings and mathematical-statistical methods. Taking this into consideration, aerial photographic methods can applied at varying levels of intensity, from the most simple to the most complex analytical evaluation, depending on the subject of interest.

Complementary methods to assess forest landscape structure: Shannon's entropy and fractal dimension of remotely sensed imagery

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Landscape structure, interpreted as indicator of functional processes, has become a main attribute of multiresource forest inventories, enhancing its value with respect to society needs. This approach implies effective use of earth observation techniques and geographic information systems, enabling a global view of the inventoried landscape mosaics. The objective of this paper is to discuss two complementarily targeted approaches to assess forest landscape structure and complexity: a method based on information theory as introduced by Shannon, and one based on the estimation of local fractal dimension. Both methods together provide an objective assessment of landscape structure at the given resolution.

Estimating the Density of Rare Tree Species - A case Study from Ethiopia

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Rarity is one of the problems in biodiversity assessment, because estimates of the density of these species are often imprecise. It is therefore necessary to identify sampling designs, which can yield precise estimates. in this research a relatively new method called adaptive cluster sampling was applied to a forest area in Ethiopia, and compared with simple random sampling. The comparison of adaptive cluster sampling and simple random sampling was based on the relative efficiency of their variances. The results reveal that under certain conditions, adaptive cluster sampling of rare species is more efficient than simple random sampling. The degree of efficiency of this sampling design was found to be influenced by the level of rarity, and the size of the rare species groups.

Automatic estimation of volume factors in real stands by digital image processing

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A practical application of automatic stem number estimation by kernel smoothing on digital aerial photos is presented. This application improves forest inventory results compared to results obtained by established methods, for *e.g.* Norway spruce (*Picea abies* [L.] Karst.), through improved stand level stem number estimates. Rough estimates of tree characteristics such as height and diameter of the mean tree corresponding to basal area retrieved for example by ocular assessment can, in a roundabout way, be used to assess other volume factors. However, the first step to improve stand level volume factor estimates is to obtain sufficiently accurate estimates of stem number. Kernel smoothing of digital aerial photos is demonstrated to yield this stem number estimate in real stands. Further, it is demonstrated how the method in a second run will provide individual tree characteristics such as position in a global co-ordinate system, heights and diameters. A comparison to other "similar methods" as for example ray tracing will be presented.

Climatic Regions Classification of Taiwan

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The ecosystem should be based on multiple factors. Ecosystems are defined by multiple factors. As Sokal (1974) pointed out, "Classifications based on many properties will be general: they are unlikely to be optimal for any single purpose, but might be useful for a great variety of purposes." This is termed a "natural classification". and some scientists use land-use, landscape vegetation pattern, ... et al. But most scientists use the criteria of climatic characteristics, because climate is the limit factor of biology distribution. There are three methods: regionalization, map-overlay, and multivariate clustering method introduced to reclassify the climatic regions in Taiwan. There were 8 climatic regions by regional and Zheng-Xiang Chen (1957) abbreviated regions from 20 climatic sub-regions that used 100 climate stations according to Thornthwaite System. The map-overlay method was used Holdridge life zone classification model to produce 11 climatic regions in Taiwan. There are 948 habitat clusters reclassified into climatic region diagram by average linkage method by multivariate clustering method. These 948 habitat clusters in Taiwan environment factor database were clustered from the 1km*1km grid of Taiwan by 12 habitat factors. The 12 habitat factors include elevation, slope, aspect, mean temperature per year, mean high temperature of July, mean low temperature of January, total precipitation per year, precipitation winter semester, precipitation summer semester, soil class, soil texture, soil effective depth. The relationships among each classification system were discussed in the paper.

The climatic region maps and the intercross tables are showed the relationships among the Chen's climatic regions, Holdridge life zone classification model in Taiwan and climatic cluster regions in different levels. There are 8 Chen's climatic regions in Taiwan, which were (1) North-East (NE), (2) North (N), (3) South-West (SW), (4) South (S), (5) East Coast (E), (6) Central Mountain (CM), (7) West Coast (W), (8) Peng-Hu (PENG), according to factors: (1) monsoon (2) precipitation (3) potential evapotranspiration and moisture balance (4) average annual thermal efficiency. The factors used in Holdridge life zone classification model were (1) mean annual bio-temperature (2) average total annual precipitation (3) potential evapotranspiration ratio to map-overlay. There are 11 life zones developed with Holdridge model. Those zones are (1) sub-alpine rain forest (2) mountain rain forest (3) mountain wet forest (4) lower mountain rain forest (5) lower mountain wet forest (6) lower mountain moist forest (7) subtropical moist forest (8) subtropical dry forest (9) tropical wet forest (10) tropical moist forest (11) tropical dry forest. The climatic regions diagram shows there are stable climatic clusters where Euclidean distance between 0.8 ~ 1.4. There are plain, slope-land, mountain, northeastward wet forest, southwestward wet forest, slope-land where summer monsoon and winter dry, like Tai-Wu, Ma-Jia region, southern wet forest, Da-Wu-Mountane region as stable climatic clusters. The difference among three methods were due to diverse in interest classified factors.

Forest and Woodland Ecosystems in Dinder National Park: A challenge to integrate Conservation

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National Park status is desirable for most conservation areas because this confers greater legal security for the land and usually allows greater power of control and law enforcment. However, with human population increasing rapidly and the short-full in food production increasing annually, many national parks in Africa have become islands of natural resources in good condition surrounded by high human population densities occupying degrading lands. The conservation of the biological diversity they contain affect the livelihoods of the rural populations in the surrounding because of the regulation needed to support conservation. DNP in Sudan is facing the same situation.

Knowledge of the nature and seriousness of any conflict require accurate assessment and true evaluation of the resources available and the needs of the local communities. A vegetation and landscape survey including interpretation of Land Sat MSS images and aerial photographs, was conducted in Dinder National Park, accompanied by social studies via questionnaires and informal interviews during 1996-1999. The landscape ecology vegetation map was produced. Four major landscape units were found:- alluvium, clay plain, depressions, hills and pediments with varied soil types and vegetation subsystems. The distribution of the vegetation in DNP seems to be influenced by several factors; water regime, topography, soil types and human activities in the park. The local communities (Rahad villages and Maggno indigenous population) in their sharp reaction against laws and regulations resort to antagonistic actions, utilizing the resources illegally. They suffered from penalty and under development. Their continuous demand for the resources might lead to severe destruction of the productive ecosystems Riverine forest and Woodland ecosystems have great potentiality of providing wide range of economic, social and environmental benefits. New strategy for management, utilization and conservation should be addressed to suit the new concept of community based integrated resource conservation, in order to safe guard the remaining resources towards sustainable development.

Modeling regeneration establishment for Austrian forests using neural networks

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Artificial neural networks represent a computational methodology widely used to uncover the structure of a large variety of data. in general, one may recommend the application of neural networks in areas characterized by noise, poorly understood intrinsic structure and random impacts. Each of those characteristics is present in predicting regeneration establishment within uneven aged mixed species stands. in this paper we describe the design and estimation procedure to predict regeneration situation in uneven-aged mixed species stands using neural networks. The result of the study is that the number of juvenile trees per unit area and the relative percentage of individuals by tree species can be predicted with neural networks and that the estimation procedure is more accurate versus the conventional statistical approach based on regression analyses.

Keywords: Regeneration, Neural Networks, Uneven-aged mixes stands

Draining and secondary inundation in the Leningrad Region

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During the last two centuries approximately 750-800 thousand hectares of forest stock in Leningrad region were drained. That is no less than 14% of its area or 55% of the water-logged land. At present the area with still working draining systems is reduced to 480 thousand hectares. Region forests growing on water-logged lands (with peat or without it) are divided into four main groups. The first, the second and the forth groups are represented by pine, spruce, birch and partly by other broad-leaved forests, which refer to swampy-grassy soil on the eutrophic peat, grassy-bog mossy(grassy-sphagnous) on the mesotrophic peat and long mossy-blueberry on the peaty(less than 0,2-0,3 m of peat) and mineral gleysol soils, respectively. The third group(named "bog-mossy") is characterized by pine forests on the oligotrophic and oligotrophic-mesotrophic peat.

Draining of the first and the second forest groups produces the greatest forestry effect. The quality of locality increases from IV-V to II-I, and the annual mean increment of timber is 2-5 m^3 per hectare. in the third and the forth groups the annual mean increment doesn't exceed 0,5-3 m^3 per hectare.

Secondary bogging of drained lands happens because the work of draining channels deteriorated due to the lack of care and inadequate extent of draining(density and depth of channels), established in the projects. Losses of annual increment of timber due to the bad condition of channels reach about 30-60%. More than that, up to 50-60% of drained and adjacent to them earlier drained lands are flooded because of beavers' dams, built on the channels.

Up to 200-300 hectares are flooded by roads; approximately the same territory is flooded by reservoirs. Nowadays, among the factors determining bogging dynamics the leading one comparable to the natural process of bogs-growing is a technogenic factor; that is construction of roads, dams, oil and gas pipe-lines.

Forecast of the balance between over-drained and drained lands for the next twenty years indicates reduction of the area with provided draining norm on 112 thousand hectares; 70 thousand hectares will be transferred into the category of secondary bogging. It is necessary to take prompt measures to carry out repair works in the draining systems.

Technological Inventory for Norway Spruce in Italy

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Knowledge of the quality of timber produced in natural forests allows for rational management. Although in forests growing in the Alpine chain the productive function plays a complementary role, the revenue from timber sales covers the cost of cultural and thinning operations. Since the quality of the timber is strictly related to the quality of standing trees, a large study to relate the properties of trees to the properties of sawn timber was carried out.

A thematic map on wood quality is therefore an important element towards better planning and management of forest assets and of mountain areas in general.

The main objective of the research is to identify significant correlations between the morphological parameters of standing trees and the quality and quantity characteristics of the products obtained from primary processing, such as defining wood quality on a geographic scale and thus creating a specific thematic map.

The research was conducted in the forests in the province of Trento (Italy). The prevailing species in this Alpine area, and also the most interesting from a commercial standpoint, is Norway spruce (60%). Consequently, this species was chosen as the subject of this study.

The study can be divided into three distinct phases.

The first phase foresees:

- the preparation of a set of operating tools (methods, protocols, instrumentation, classifications, etc.) suitable for identifying the main parameters that will be considered for the study on correlations between standing trees and timber characteristics;

- the writing up of a visual classification of standing trees, with allocation of each single plant to quality classes;

- the calculation of the sawn yields according to round wood quality and determination of the Quality Index (QI) of the visual classes adopted (QI indicates the value of the unit volume of round wood expressed as the value of the final boards).

The second phase consists of extensively applying the protocols and methods perfected in the first phase. A map of a small pilot area is prepared, on which wood quality is indicated both in terms of the "intrinsic quality" of the raw material and in terms of the value of the final assortments obtained. Mapping is performed on the basis of a very high number of sampling areas concentrated in a restricted area so as to obtain a dense sampling lattice. The pilot area is selected so as to contain areas with various exposures and gradients and to cover a wide altimetric range. The identification of the laws of distribution of the variability of the parameters researched allows us to modulate the mesh of the sampling lattice necessary for the third phase.

Preparation of the standard map constitutes the third phase of the study. The model obtained can then be applied progressively to the forest areas with production functions in the provincial area.

Monitoring Forest Cover Changes in Malaysia Using Remote Sensing Technique

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Forests are a renewable resource that play a vital role in the development of the national economy. Malaysia is endowed with extensive tropical forest resources. It was reported in 1992 that about 19.06 million ha or 57.9% of total land area is covered by forests. Remote sensing is acknowledged as the most powerful tool to monitor detect any changes of a forested area. This paper reviews the potential of using remote sensing technique in detecting land use and land cover changes in Malaysia. Studies in Sabah (197601983), Rawang (1988-1995), Sungai Buloh Forest Reserve (1988-1995) indicated that that were significant forest cover changes occurring in the study sites. Causes and rate of forest cover change were quantified and discussed. The usefulness of remote sensing technique in detecting forest change in Malaysia has been explored significantly. Although much of the efforts are still at the infant stage, the potential use of the technique at the operational level is very promising.

Monitoring for Survival Rates of Young Plantation Trees in Japanese Mountainous Region Using Landsat TM data

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According to the increase of plantation area, the afforestation has progressed to inaccessible mountainous regions located at high altitude and in cool temperate conditions. The plantations in inaccessible mountainous regions were liable to be under severe conditions because of Kyushu Deer (*Cervus nippon*) grazing impacts freezing and drought damages. Therefore, unsuccessful plantations have been increasing with planted trees' disappearance and competition with naturally invaded broad-leaf trees. It was hard to monitor the state of every plantation by field observations because of lack of time, efforts and costs. Then, the effective method has been needed for monitoring the state of unsuccessful young plantations in inaccessible mountainous regions. The objective of this study was to develop the method to estimate the survival rates of planted trees in young Sugi (*Cryptomeria japonica*) and Hinoki (*Chamaecyparis obtusa*) plantation sub-compartments by analyzing the Landsat TM data. The study sites were young plantations in Kyushu University Forests in Miyazaki that were located in southern Kyushu, Japan and within the cool-temperate deciduous zone. The series of plantation has been developed since 1978 under the clearcutting system in blocks surrounded by shelterbelts. Each cutting block was divided into slope units by slope azimuth because the survival rates have varied with azimuth. The method of this study was composed of three principle parts. 1) Interpreting survival rate of planted trees on a pair of aerial photograph. 2) Field measurements of spectral reflectance on both planted trees and grass to examine the difference in spectral reflectance characters of two vegetation types. 3) The analysis between the TM data and the survival rates of trees under two MODELs. MODEL I using NDVI and MODEL II using the TM band 3 digital number (DN) for detecting the difference in spectral reflectance between planted trees and grass. As the results, 1) there were wide differences in the survival rates among slope units and also among cutting blocks, and a northern exposure slope had a relatively high survival rate comparing to a southern exposure slope. 2) It was difficult to estimate the survival rates of planted trees by NDVI. 3) DNs in the TM band 3 were preferable to estimate the survival rates of planted trees. The relationship between survival rates and average DNs for northern and southern exposure slope groups showed strong negative correlations with the coefficient of determination 0.98 and 0.62. in addition, two correlation lines had the same regression coefficient from the result of 5 % significant level test. From this the difference in intercepts of both lines might indicate the reflectance characteristics of two slope azimuths. This study would supply the effective monitoring method for unsuccessful plantations in inaccessible mountainous regions.

Inventory of Remote Sensing Applications in Forestry: State of the Art

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To consistently and repeatedly monitor forests over large areas, it is desirable to use remote sensing data

and automated image analysis techniques. Several types of remote sensing data, including Aerial photography, Optical Multispectral Scanner, Radar, Lidar (Laser) and Videographic data have been used by forest research and operational agencies to detect, identify, classify, evaluate and measure various forest cover types and their changes. Over the past decades tremendous progress has been made in demonstrating the potentials and limitations of the applications of remote sensing in forestry.

For several types of applications of remote sensing in forestry in specific regions of the world such as tropical areas, users of forest information are demanding new establishment of sensors and platforms. in order to see what kind of information we can extract from the current remote sensing sensors and platforms, an inventory of all remote sensing applications in forestry is needed.
This paper presents a literature review of the use of remote sensing for measuring, estimating or describing forest characteristics and mapping forest cover types. It deals with all forest types around the world, on all latitudes and climates, natural as well as man-made, but not with other land cover types. The paper starts with an introduction to remote sensing, followed by definitions of forest types and characteristics, as will be used in the remainder of the paper. Then an overview of the applications for forestry per type of sensor "type" which defined by the portion of the electromagnetic spectrum that is used and the way of recording (digital or analogue), not by the platform. The paper will then discuss the applications of the sensors in forestry. A section on synergy, where applications using a combination of different sensors are reviewed. The publication ends with conclusions and an outlook.

Remote sensing can detect, identify, classify, evaluate and measure various forest characteristics in two ways: qualitatively and quantitatively. in a qualitative way remote sensing can classify forest cover types to: coniferous and deciduous forest, mangrove forest, swamp forest, forest plantations, etc. While the quantitative analysis can measure or estimate forest parameters (*e.g.* dbh, height, basal area, number of trees per unite area, timber volume and woody biomass), floristic composition, life forms, and structure.

4.02.05 Remote sensing and forest monitoring

Global Observation of Forest Cover: How IUFRO can help achieve an elusive goal

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Keywords: remote sensing; monitoring; global forests; forest cover; forest changes; climate change; biodiversity

Since the launch of Landsat-1 in 1972, earth observation satellites have been promoted as a means of obtaining information about forests and other natural resources on a global scale. Many organizations, including international agencies, the global change research community, and non-governmental organizations have had a long-standing interest in such information. National forest ministries are also interested in the "big picture", and are often willing to participate in efforts to assemble regional and global information. More recently, additional impetus has come from several international conventions. All of these groups have recognized the impossibility of assembling a reliable, global picture of forest conditions (especially forest changes) from the diverse and inconsistent data obtained by hundreds of different agencies using different methods for different purposes. Although satellite data cannot provide all of the information required (e.g., stand age), they are the only source available for objective, timely and consistent worldwide forest observations. The IUFRO working group on Remote Sensing and World Forest Monitoring has completed a landmark document which provides guidelines for combining plot measurements with remote sensing observations to produce a consistent global picture.

However, the potential of satellite observations to monitor forests on a global scale has not yet been realized. Recognizing this, the Committee on Earth Observation Satellites selected Global Observation of Forest Cover (GOFC) as one of six pilot projects which form the core of its Integrated Global Observing Strategy.

The GOFC strategic design calls for implementation of three major components: forest fire monitoring and mapping, forest cover characteristics and

changes, and forest biophysical processes. Forest cover characteristics and changes is the most difficult component to implement, but is also the component of greatest interest to a wide variety of potential users. During GOFC's design phase and early implementation, institutional and technical challenges have been identified which must be addressed before this component can be realized.
Institutional action is needed to:
- develop mechanisms which make information more accessible and easy to use;
- foster a policy environment that promotes the broadest sharing of remote sensing information on forests;
- overcome shortages of technical skills in remote sensing and GIS which exist in many organizations.
Technical challenges include:
- acquiring and processing fine resolution (~25 m) data for a large fraction of the world's total forest area;
- merging data from multiple satellites in an optimum fashion;
- developing appropriate information products which can be produced in a highly automated manner (to minimize costs);
- detecting and quantifying changes which result from partial removal of trees;
- collecting and analyzing substantial amounts of in-situ and airborne data for calibration and validation;
- ensuring the continuity of fine resolution data with global coverage;
- making information available in a rapid, simple, and meaningful way to all interested parties.

GOFC is intended to address global information requirements related to international policy, particularly with respect to the sustainability of forest resources, climate change and biodiversity. There is a crucial need to demonstrate and evaluate products which can provide such policy-critical information, and to develop the infrastructure needed for data and information sharing.

Direct research priorities include developing, testing, and automating the extraction of information from large regional and global data sets, combining satellite, aircraft, and ground observations. It is hoped that these research efforts will spur international capacity building, particularly in developing countries, and lead to increased use and sharing of earth observation data and derived information products.

Forest Information from Remote sensing - Biomass and Wood Volume assessment and mapping

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Keywords: Remote sensing, bio-mass, volume.

In 1997 the CEO (Center for Earth Observation) Project launched two application projects in support to the FIRS (Forest Information from Remote Sensing) Project. One of these projects, the FMERS-II project, was a research and development study to investigate if existing remote sensing data could be used for inferring two of forestry's important variables, namely above ground woody biomass and volume of forest and other wooded land. The study investigated three different spatial resolutions of RS data, namely, medium resolution (100-300m from the IRS-WiFS), high resolution (less than 100m, from Landsat-TM), and very high resolution (less than 10m obtained from aerial photos). Two different approaches were tested. The application of K-nearest neighbour classification and estimation method (kNN), and regression models.

Two test sites were used for the study. One in the Atlantic-Mediterranean region of central Portugal, and one in the Boreal zone in northern Sweden. The latter was extended to western Finland to evaluate the performance of the models when extrapolating them to areas outside the calibration site. A comparative analysis between TM-derived estimates in the Finnish NFI and the WiFS-derived estimates gave results of mean biomass of 59.5 tonnes/ha and 58.3 tonnes/ha respectively.

Whereas the results from the Boreal site were convincingly good, those for the Portuguese site were rather poor. The reason for the poor results from the Atlantic-Mediterranean test site is not completely clear. Possible explanations include the heterogeneity of the stands, the presence of an established understorey (which influences the spectral signal) and the inadequacy of the available ground data for correlative and calibration analyses. More research clearly has to be carried out in order to reach a better understanding of the potential of using RS data for estimating biomass of the complex and heterogeneous forests and shrublands of the Mediterranean.

Following the results from FMERS-II, the monitoring of biomass and volume in the boreal forests could be carried out on an operational basis using remotely sensed data. The medium resolution WiFS data render the possibility to cover Europe (in approximately 40 scenes) with an appropriate temporal frequency and at a relatively low cost. The derived information could be foreseen to support the EU's external commitments, such as the Kyoto Protocol and serve as input to internal policies of the Union, such as the European Forest Strategy.

The role of scale in monitoring tropical forest from space

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Keywords: remote sensing, cartography, forest monitoring

The effects of spatial and temporal scales must be considered in both theoretical and applied forested landscape ecology.The structure, function and changes of forested landscapes ate scale dependent, because of their spatial heterogeneity. Recent theoretical developments in landscape ecology have emphasized the relationship between pattern and process and the effect that changes in spatial scale have on our ability to extrapolate information across spatiotemporal scales. The landscapes have critical thresholds at which ecological processes will show dramatic qualitative changes. Different landscape indices may reflect process operating at different scales. Quantitative methods linking spatial patterns and landscape-ecological processes at broad spatial and temporal scales are needed. One of the methods that can be applied to forested landscape data collection, processing and interpretation at multiple spatiotemporal scales is remote sensing. The article describes the theoretical principles of space, time and scale concepts (effects of scale changes, impact of scale on analysis) in landscape ecological monitoring and analysis of forested landscapes in the tropics, as well as operational spatiotemporal scales for forested landscape analysis with the examples (deforestation, patch dynamics, ecotones, etc.). Hierarchical organization of landscapes (with examples and corresponding soil, vegetation and land units according to the classification of selected authors), recommended mapping scale and remote sensing platforms are given.

Classification of the native vegetation of the Conguillio's National Park in the andes Mountain in Central Chile through Landsat-TM images and Geographical Information Systems

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Keywords: National Park, Forest Ecosystem, Remote sensing

Natural forest ecosystems belonging to Mediterranean-Temperate climate in Central-Southern Chile have been deeply harvested. However some relicts are remained in andes Mountain. A good sample of that is placed in the National Park Conguillio. in this National Park there are several species of great scientific importance such as the millenarian conifer *Araucaria araucana* in cohabitation with some hardwoods belonging to *NothoFagus* genus.

This study has a main purpose to classify the Park cover in different category of ecological importance in a volcano environmental. The above is reached through the visual and spectral analysis of Landsat TM "Volc n Llaima. The false color image TM3,4 and 5 allowed the analysis of landslide in forest areas. From the NDVI 29645,8 ha of vigorous vegetation was detected. At the same time 3157 ha in critical conditions were observed. The same Index registered a positive value (0,13) in beds of basaltic lava colonized by liqueur. Furthermore the band 1,2,3 have allowed the detection of 33 categories recognizing forest, grasslands, beds of lava, shadows, water, soil and snow. The k obtained in this study was of 68%, in the case of the forest cover the reliability was of 77% as an average.

Monitoring of protection forests in Alpine region

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Alpine forests are exposed to immediate and considerable environmental threat. This is due to an aggressive development drive in the past, huge numbers of tourists as well as environmental damage. Particularly protection forests have recently been subjected to particularly damaging natural as well as anthropogenic influences. The catastrophic storms of 1990 and 2000, the resultant, and lasting problem of the bark beetle, and global climatic changes have weakened the resilience of alpine forests. The culminative effect of all these factors often proves disastrous, resulting in irreversible changes in the composition and distribution of alpine forest cover. Far-sighted national and cross-border planning is necessary to ensure that preventive measures can be implemented by Forest Authorities and Nature Conservation. The success of such measures crucially depends on the availability of information about the distribution and condition alpine protection forests and their development dynamics. The Forestry Services in Austria are responsible for these measures. For long term planning most of them have installed a Geographical Information System (GIS) using different raster and vector based data, but they do not have enough data to cover the entire region of interest.

Behind this background a pilot project concerning the assessment and monitoring of forest parameters in alpine regions by means of satellite remote sensing for its use in protection forest planning and control was carried out. The results of this project will be introduced in this paper. Quantitative parameters, such as species composition, natural age and crown coverage, have been assessed using SPOT4 satellite data. It can be stated that with the new mid-infrared band of SPOT4 the main tree species spruce, larch and broadleaf could be separated. The results also demonstrate that in comparison to Landsat TM data the SPOT4 data yield significant improvements in terms of species discrimination, crown coverage estimation and age determination. Using these results the planning personnel of a Country's Forestry Service can improve the planning and controlling tasks with region covering data.

Remote sensing as a source of information for nature protection of landscape and National Parks

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Keywords: remote sensing, nature protection.

Changes in the environment have caused the necessity of large-scale monitoring and cartographic presentation of its condition and the changes it is undergoing. The Institute of Geodesy and Cartography conducts work on the use of a remote sensing and geographic information system for forest monitoring. The Kozienice Landscape Park pilot project aims to create an operational geographic information system for forest monitoring, updating and mapping.

The created forest information system gathers information on the environment from many sources in two related databases: spatial and relational. The spatial database contains not only information obtained from satellite images and also digitised data from topographic and thematic maps. The relational database is created from inventory information from forest management and other information on the environment. This is related to spatial information through reference to actual forest stands, compartments and units of forest administration. The use of data gathered in the geographic information system describing the state of forest stands allows for a more detailed classification of satellite images.

The results of the above study have brought to the conclusions about forest monitoring with the use of a remote sensing. They regard the selection of the best satellite images channels and stands parameters which can be differentiated and cartographically presented as separate classes.

The geographic information system serves for spatial analyses and may be used as a tool for the cartographic presentation of gathered data and results of spatial analysis.

The GIS, containing remote sensed data and other information about the forest, can play a large role in nature protection, correct running and management of the forest. The advantage of these systems is the possibility to combine multi-source and multi-type information about the environment, conduct spatial analysis, update databases, and edit maps and reports.

4.02.07 Scenario approaches, models and assumptions behind the forestry analysis used in regional, national and global policy making

Large-Scale Forest Scenario Analysis in the United States: Comparison of Approaches

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The Timber Assessment Market Model (TAMM) and the Forest and Agriculture Sector Model (FASOM) are examples of two large-scale forestry scenario models that have been employed to analyze the U.S. forest resource situation. The models have been applied to make projections of the U.S. forest sector in regional and national studies, such as the periodic Timber Assessments and Updates by the USDA Forest Service. The purpose of the Timber Assessment is to analyze the timber resource situation over the next 50 years to provide indications of the future cost and availability of timber products in the context of U.S. demands. The analysis also identifies resource situations that may be judged desirable to change and developing opportunities that may stimulate both private and public investments.

The TAMM system has been used for more than 15 years in the quinquennial Timber Assessments and Updates. Using a price-endogenous, spatial equilibrium approach, market solutions are obtained one period at a time using either reactive programming or direct optimization of the nonlinear objective function, depending on the model version. The TAMM system projects prices, consumption and production of softwood and hardwood sawtimber products, and harvest of timber from private lands using an annual time step. Exogenous projections of land allocation are provided by regional area change models, and timber growth and yield projections by the area-based Aggregate TimberLand Analysis System (ATLAS). Exogenous projections of forest management investment are based on single-acre analyses and expert opinion. Projections of fiber products and fuelwood, which were part of the earliest version of TAMM, are now derived from models linked to TAMM through demands for, and prices of, roundwood and residues. On the resource side, the TAMM system uses parameters for most behavioral equations (e.g., private timber harvest) that are estimated from historical data. Private timber supply functions are derived from explicit hypotheses of intertemporal harvest behavior for industrial and nonindustrial owner classes. The relations link harvest to prices, inventory levels, interest rates, and for nonindustrial owners, income from nonforest sources.

The FASOM model is a linked model of the U.S. forest and agriculture sectors developed for use by the U.S. Environmental Protection Agency in studies of global change and energy policy. FASOM is an intertemporal, price endogenous, spatial equilibrium model in which market solutions are obtained each decade in the entire 100-year projection period at one time. Endogenous variables include: (I) land transfers between sectors; (ii) forest management investment activity; (iii) timber harvest and log prices for nine U.S. regions, two species groups, and three classes of products; and (iv) agricultural prices and production in eleven regions for 40 primary and 46 secondary commodities. The FASOM model draws upon demand-side information from the TAMM system, as well as also utilizing ATLAS timber yields.

With respect to analyzing forest scenarios, use of the TAMM and FASOM models can be complementary when analyzing forestry and natural resource policies. For example, the intertemporal optimization framework of FASOM allows ready examination of adjustments or responses to policies that may fall outside the historical range of observations. Examples of large-scale scenarios the models have been employed to examine include: log exports, carbon sequestration through tree planting, reduced public timber harvest, recycling of wastepaper, global climate change, farm programs, production of short-rotation woody crops for pulp fiber, biomass production for energy, agricultural land reallocation programs to promote environmental goals, and sustainability of production in both sectors.

Analysis of Flow-Stock Relationship through Stimualation by Means of a Forest Optimization Model

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Simulation is a very powerful tool in the planning of companies and institutions in the field of forestry, since it allows to carry out different sensitivity tests in different scenarios within a field that has two main features. The first one is that, from the relative comparison of the impacts of the main factors affecting wood supply and demand, it can be seen that, in most cases, the demand for primary forest products takes much shorter to change than the supply of those products. The second special feature is that in forestry systems, the production level of a certain period depends on the production level of previous periods, thus giving rise to a particular interaction between long and short term supply and demand: ceteris paribus, the more wood is used up today, the less we will have tomorrow, and surely at a higher price. The planning methodology this paper will use, based on lineal programming, proves to be an extremely useful tool when it comes to understanding some basic forestry relations such as the one between production flow and stock. The model was applied to planted poplar forests belonging to a paper producing company in the province of Buenos Aires, Argentina. This company obtains their raw material mainly from their own forests, and gets the rest from the market.

The flow-stock relationship can be managed so as to reach specific operative and strategic aims of the company. The managing of flow an stock may allow to handle the response capacity of a forest facing changes in the demand, by increasing several times its regular production in a certain period of time so as to supply the factory when there is a shortage in the market. The model can be used as to a simulation tool to show the evolution of stocks with different extraction flows for all planning horizon. This will allow to fix the new extraction flows to be applied to the forest in order to obtain the necessary stock at the right moment. It is shown the way the model carries out the planning, keeping the stock levels at a minimum, which is important if the consequences of the existence of stock on the accounts of the company are born in mind. On the one hand they generate costs - opportunity, insurance and maintenance costs- which have an effect on the results account; on the other they increase the assets. Both consequences reduce the income yield capacity of the company, thus making it necessary to keep stock levels at a minimum, so that they can allow to bring together the process of primary production and the industrial one. Through a better understanding of the basic developed relationships, it is shown the way companies with their own plantations can not only use them to cushion the effects of the market over the short-term supply, but also handle them so as to avoid shortages in the mid and long term.

This helps solve the problem of many forestry system managers who pose the question of how the forest is to be handled so as to satisfy immediate needs, changing at the same time its structure in order to be ready for future circumstances. On the whole, good handling of the flow-stock relation of forestry systems belonging to industries can allow to put into practice an administration policy in order to avoid risks of depriving the factory of supply.

Timber production possibilities of the Norwegian forest area and measures for a sustainable forestry

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A public discussion on how to bring forest management practices in a more environmentally oriented direction is going on between Norwegian organisations of forest owners, environmentalists, forest industry and governmental offices. Certain requirements or standards as they may be stated in certification documents or as governmental policies are likely to appear in a near future.
In addition to timber the forest is producing a number commodities not traded in any market. If the management of the forest area is designed mainly with respect to timber production, the effects of this management on the provision of the non-market commodities may be negative. On the other hand, an environmentally designed management may reduce timber production. The aim of this paper is to present some long range timber production analyses where the objective has been to map consequences for potential harvest level and net present value, related to varying forest treatments in a environmentally oriented direction as might be defined in the future.

Analyses are done with GAYA-JLP, a model based on simulation of treatment schedules for individual management units and linear programming for solving the management problem at forest level. The analyses cover the productive forest area in Norway. This forest area is divided into 10 regions. Sample plots from the National Forest Inventory are aggregated into 1000 treatment units for each region, i.e. the entire forest area is described by 10000 units. The forest management problems are solved at county level, while the country level results are obtained by summing over the individual regions.

The analyses aim at providing a realistic description of the timber production possibilities of the productive forest area in Norway given consistency in treatments with respect to the real rate of discount. Management strategies with maximization of the net present value (NPV), with and without a non-declining felling path constraint, have been analyzed. The following environmentally oriented

constraints on forest management practices, separately and joint, have been analyzed:
- certain areas of current old growth forest set aside for permanent protection
- minimum target levels for area covered by old growth forest through time
- leaving continuity trees after final felling
- restricted management practices for border zone areas around lakes, rivers, streams, swamps, agricultural land and roads

The results include estimates on possible development for a period of 100 years with respect to potential harvest levels and volume of growing stock. The NPV according to a real rate of discount of 2.5% and with a non-declining felling path constraint, was reduced by 8.7% when 5% of the total area was set aside for protection. The corresponding NPV reductions were 2.4%, 1.0% and 12.7% respectively with a minimum target level of 10% for area covered by old growth forest, by leaving 10 continuity trees ha^{-1} and with restrictions on management practices for a medium border zone width (15 m) around lakes, rivers, streams, swamps, agricultural land and roads.

What will the European forest look like in 2050?

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In Europe, where wood production used to dominate the goals of forest management, nature conservation values are now becoming more important as well. These changes in management may have large implications for the long-term development of the forest. The other potential changes are related to environmental changes, like the climate change.

This article describes an instrument -the European Forest Information SCENario (EFISCEN) model - which provides an insight in the long term implications of these changes. It is a harmonised tool for natural resource analyses of the forests in 30 European countries. A whole new database has been gathered with the help of practically all national forest inventory institutes. EFISCEN uses an area matrix approach to simulate the forest development for a period of 50 to 70 years

Two case studies utilising the model have been described - one in Leningrad region in North-Western Russia, and one comparing the EFISCEN results with national scenarios compiled by UN/ECE-FAO in the European Timber Trend Studies.

Three Approaches for Large Scale Forest Scenario Analysis in Finland

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In Finland, three models have been applied for large-scale forest scenario analysis. The oldest, METLA, is a forestry model designed in the 1970s for the regional and national analysis of timber production based on the sample plot and tree data of the Finnish National Forest Inventory (NFI). SIMA is a gap-type ecosystem model utilised in 1990s for regional predictions on how the changing climate may affect the forest growth and timber yield in Finland. The European Forest Information Scenario Model (EFISCEN) is originally a Swedish area matrix model developed in the early 1980s.

In the SIMA model the growth of trees is based on the diameter growth, which is controlled by light conditions, temperature, soil moisture and nitrogen. The same factors control the success of regeneration, which can be based on natural processes or planting. The thinning rules and the length of rotation can vary according to site type, dominant tree species, and location of stand.

The thinning limits are defined according to dominant height and basal area, and the length of rotation by the mean diameter of trees in the stand.

According to the SIMA simulation based on the permanent sample plots of the NFI the stocking on mineral soils (ca. 80 percent of the total stocking) would increase from the current (1990) 1535 mill. m^3 to 1898 mill. m^3 by the year 2050, if standwise silvicultural recommendations were applied. in this scenario fellings on mineral soils would exceed 80 mill. m^3 in the period of 1990-2000 and drop thereafter close to 24 mill. m^3 - rising up to 50 mill. m^3 during the next few decades. Under the gradual elevation of temperature at the rate of 0.04 $^oC\ yr^{-1}$, the stocking stabilised at the level of 2000 mill. m^3 by the year 2040.

The EFISCEN model requires area, volume and increment data per age class by forest types. The user specifies future development of demand at the national level and possible afforestations. Based on growth dynamics, age class distributions, and theoretical management regimes, the model calculates if and where to harvest, and generates projections of growing stock, increment, timber harvest volumes, age class development over time by country, region, and species. According to EFISCEN scenario based on data provided by the Finnish NFI the average annual felling would remain at 55 the level of mill. m^3 until 2040. The corresponding growing stock would exceed 2500 mill. m^3 in 2040.

The METLA model consists of two parts: an automated stand simulator based on individual trees and the optimisation package based on LP. A finite number of sound and acceptable management schedules - differing from each other, for example, by timing of management activities - are simulated for each sample plot. Hundreds of variables describing the management schedules are produced. The variables available in the LP problem and the report writer describe the state and the development of the forests, as well as forest production and its economy over the calculation period. The optimiser selects simultaneously the production program for the whole forestry unit and the corresponding management schedules for sample plots. The management of forests is endogeneous.

Since 1980's three national level analysis with a standard set of three scenarios based on data from NFI have been carried out. The first scenario resembles the EFISCEN scenario and the second SIMA scenario. The third scenario was allowable cut calculated by maximising the net present value of the future revenues subject to non-decreasing flow of timber, saw logs and net income over a 50-year period. The recent estimate of this maximum regionally sustained felling for the period 1996-2006 was 71 mill. m^3 (of which nearly 90 percent on mineral soils) and rising close to 80 mill. m^3 by 2040. The stocking would remain stable.

4.02.00 / 4.11.00 Design of small and large scale multipurpose forest inventories

Extending forest resource assessments to landscape inventories

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The first swiss national forest inventory (1983-1985) was planned as a multipurpose and multiresource inventory in forested aereas. in the second NFI (1993-1995) the list of attributes to be assessed was extended in order to obtain information on Non-Wood Goods and Services. Among others new attributes describing forest margins and tree resources outside the forested area were introduced.

In the third NFI the information provided will be extended from forested areas to fallow land and extensively managed areas. in addition to the primary objectives of the forest inventories the structural and biological diversity will be emphasized.

The paper discusses the process of transferring an information needs assessment to the final system of nomenclature and measurement rules of attributes, the evaluation of data sources (terrestrial survey, satellite imagery, digital aerial photography) and the comparability problems with previous inventories.

Temporal and spatial error budgets for woody plant biodiversity

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In this paper, a stochastic dynamic monitoring/modeling system for plant and forest biodiversity is presented. The system can project biodiversity both in time and in space. With the system, spatial and temporal error budgets can be generated. The error budgets show the overall uncertainty of regional and localized estimates/predictions of biodiversity. The uncertainty can be partitioned according to different types of error sources within and outside of the system. Some of the errors that are accounted for are sampling errors, measurement errors, mapping errors, calibration errors, prediction errors. The error budget provides a means for the systematic improvement of a system and its inputs. Based on the error budgets, recommendations can be made for reducing the more important sources of controllable errors. Results for one case are presented.

Bayesian synthesis for assessing uncertainty in mechanistic models

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As concerns over global change heighten, some forest modelers have begun to emphasize the use of mechanistic models of forest growth, derived from specific theories regarding tree and/or stand development. Some believe that such models have greater potential predictive accuracy than more traditional empirical models. However, it is often difficult to assess the error associated with predictions from mechanistic models. in this paper I present the Bayesian Synthesis method for constructing posterior distributions of model predictions. I will demonstrate the method with a naive two parameter model, and then present results obtained for PIPESTEM a realistic mechanistic forest growth model.

On bootstraping species diversities indices

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Species diversity indices are central to environmental monitoring and management. Under its current paradigm, it is explicitly assumed that changes in species diversity represent changes in the target ecosystem's compositions, abundance or both. Thus, species diversity indices are used as estimators of ecosystem conditions. However, as estimators, statistical properties of species diversity indices are poorly understood, especially how to obtain standard errors for such estimators for constructing confidence intervals and hypotheses tests. in this paper, we will discuss the use of bootstrapping for obtaining standard errors for commonly used species diversity indices. in particular, the setup of resampling schemes will be thoroughly discussed for applications in ecology.

Tree resources outside the forest: how to assess a scattered heterogeneous resource?

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Presence, relevance and functions of tree resources outside the forest (TROF) are highly diverse and locally different. They occur in natural and cultivated landscapes, and serve then a number of ecological (like conservation of biodiversity, erosion control, carbon sequestration), and economic functions (like provision of timber, firewood, fodder, fruits, shadow for cattle).

Being present in various land use classes, this resource does not form a land use class by its own. in many regions, the decreasing forest cover, the increasing forest fragmentation, and the presence of trees in agroforestry systems make its relative importance grow.

However, compared to other natural resources little is known about tree resources outside the forest on a large area basis. Large area assessments are difficult for several reasons: the resource is highly heterogeneous as to floristic composition, spatial arrangement and dimensions, and has a relatively low density. To come to regional estimates, ways have therefore to be found how to efficiently combine different data sources like field measurements, remotely sensed data, and existing statistics.

This paper outlines an EU funded research project, that aims at developing a method of how to a assess tree resources outside the forest (TROF) and integrate them in a geographical information system, and at capacity building in a number of relevant institutions in the region. The study sites of the project are located in Central America. The general relevance of the resource from a Central American point of view is addressed, as is the definitions and classification issue.

Infrared-triggered camera: a tool for measuring the biological diversity

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Keywords: biological divesity; mammal; infrared-triggered camera; terra-firme forest; boreal forest

We used an automatic camera for recording mammalian inventory and evaluated its validity in the tropical forest (terra-firme forest) of Brazilian Amazon and the Russian boreal forest. The camera system consists of a passive infrared sensor and a 35-mm fully automatic camera with flash. The sensor has a wedge-shaped or a cone-shaped detection field. It records a warm-blooded animal passing through a detection field because it differentiates between animal heat and background field. However, sensor is triggered when sunlight moves across the sensor window. Therefore the sensor was hung or placed on a pole 1.0-1.3 m above the ground so that the sensor detected vertically to minimize the false triggering. The sensor was shielded in a plastic tube. The camera has an automatic film advance devise and built-in flash. It is modified to be triggered by an electrical signal from the sensor and equipped with data back that allows to record the time and date of exposure on each photograph. Camera was attached to the sensor with a cable so that we could choose the appropriate placement of the camera and the sensor flexibly. The camera and controls of sensor were packed in a plastic box and weatherproofed. Bait was placed in the center of detection field.

In Brazil, we conducted investigation for terrestrial mammals in a terra-firme forest located 60 km north of Manaus. We recorded 24 species and 3 genera based on about 8300 pictures taken between February 1996 and March 1998. Varisized mammals were recorded, ranging from mouse (*Neacomys sp*) to puma (*Puma concolor*). This indicated that vertical detection reduced the size-related (therefore, species-related) bias of the sensor pointed out by Wilson et al. (1996). We identified 63.6% of the midium and large mammals (body weight > 500g) in a list by Voss and Emmons (1996), which was compiled from trappings and direct observations for 5 years. The cameras newly recorded 4 species that Voss and Emmons expected the appearance but could not record actually.

In Russia, 2-week investigation was conducted in September 1999 in the boreal forest located 45 km south of Khabarovsk. We focused on Muridae and Sciuridae, relating to the seed dispersal. 8-10 species were expected to occur in the study area. of these mammals, 6 cameras recorded 3 species and 1 genus, while only two species were captured by 20 live-traps during the same period. This showed that infrared-triggered cameras were effective to record the species composition of the mammalian community within a limited period.

The method we adopted here has some disadvantages. For example, classification of related species belonging to the same genus was difficult even on the clear photograph, especially in a group of Muridae. Information on weight, and reproductive condition cannot be also obtained with cameras. On the other hand, infrared-triggered cameras have several advantages over other methods, such as trappings and direct observations. The animals do not have to be captured. Large areas can be surveyed by only a few people, and investigators do not have to attend constantly. These advantages are effective to record rare and cryptic species. in addition, combination of infrared-triggered camera with trapping and marking will provide valuable data on abundance, movement, and activity of mammals inhabiting in the forested environment.

Efficient Modelling of Stem Curves

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The purpose of this research is to investigate the possibility of deriving accurate stem curve models with small numbers of sample trees. The stem curve model investigated is based on relative stem diameters and relative stem heights and can, in principle, be derived by a single sample tree. The main issues investigated are (i) how many sample trees are required in order to achieve a given accuracy and (ii) how should the sample trees best be selected. The accuracy of a given stem curve model is mainly quantified by the accuracy of the predicted total stem volume.

The research material comprises 2326 scots pine (*Pinus silvestris*) sample trees covering the whole of Finland. Each sample tree was measured for diameters at 14 different relative heights. The jack-knife technique is utilized extensively in the analyses which were performed with common spread-sheet software extended by specific stem curve modelling functions. The resulting software can be used for deriving totally new stem curve models. Functionality for utilizing derived stem curve models, for *e.g.* volume calculations, was also included. The investigation showed that since relative tree form is independent of tree size, accurate stem curve models can be derived by as few as five sample trees.

Optimal Forest Inventories based on the anticipated variance

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This work presents optimal sampling schemes for forest inventory. The sampling procedures are optimal in the sense that they minimize the anticipated variance for given expected costs or conversely, the anticipated variance is the average of the design-based variance under a local Poisson model for the spatial distribution of the trees. Exact and best feasible approximations are given for two-phase two-stage cluster sampling schemes. The resulting optimal inclusions probabilities are a combination of probability proportional to prediction and probability proportional to the expected error. Simulations and practical examples illustrate the theory.

Guided transect sampling in theory and practice

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Guided transect sampling is an inventory design developed to incorporate high-resolution prior information in the selection of inventory paths within transect based inventories. It consists of two stages. in the first, strips too wide to be entirely sampled are laid out in the area of interest. in the second, prior information - *e.g.* from satellite imagery - is used to decide the exact route of a transect through each first stage strip in a PPS-sampling manner. Primarily, the method is developed to increase the efficiency of transect based methods when sampling sparse populations. in theoretical studies, results have been promising. The relative efficiency of the method, in relation to a "non-guided" alternative, increases the sparser the elements of interest are. in practise, problems of two basic kinds are encountered. Firstly, the method may lead to increased costs due to complicated fieldwork. For example, the method relies on the use of GPS differential in real time. Secondly, it is not possible to follow the exact paths of the predetermined transects in field. Therefor, the precision of estimates will decrease slightly.

4.02.00 / 4.11.00 Forest resources assessment 2000

The Global Forest resources assessment 2000

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The presentation will reveal the final results of the Global Forest Resources Assessment 2000 (FRA 2000). For each country, available information about extent, composition, protection and utilisation of forests have been compiled and analysed. Special attention has been given to estimate the rate of change of forest resources and to document the underlying factors. This presentation is the first occasion for presenting the global forest change estimates. The FRA 2000 is a transparent process in the sense that all background material and analyses is published. This means that the FRA 2000 constitutes a comprehensive baseline survey of forest resources in all countries.

In addition to the country-by-country survey, the FRA 2000 also includes an objective pan-tropical remote sensing survey of forest cover change; production of global maps of forest cover and ecological zones; and special studies on various aspects of the interaction between people and forests. in total, the results of FRA 2000 will consist of 11 printed volumes, plus a comprehensive presentation on the world wide web.

FRA 2000 is carried out by the Food and Agricultural Organization of the United Nations (FAO) with the assistance of donors, partners and member countries. One important partner is the UN Economic Commission for Europe, that constitutes the focal point for temperate and boreal countries. FAO has been given the mandate to regularly report on the world's forest resources by its member countries, that also take active part in the assessment. It is expected that FRA 2000 will stimulate discussion at all levels, as well as foster decision-making on the management and protection of forests on a global scale.

Accuracy and Reliability of the Temperate and Boreal Forest Resources Assessment (TBFRA) 2000

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Keywords: forest resources assessment, TBFRA, systems of nomenclature, harmonisation, standardisation

Data collection of the TBFRA 2000 is based on a questionnaire approach utilizing forest resources assessments conducted on the national level. Despite the fact that standardized terms and definitions have been formulated for the TBFRA, data submitted are subject to different sources of errors affecting the reliability of the TBFRA results.

In this presentation the reliability and accuracy of the TBFRA 2000 are evaluated in terms of effects of differences in the national and TBFRA systems of nomenclature, non-responses, assessment period and likely ranges of true values.

The UN-ECE/FAO Forest Resource Assessment 2000: an overview

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The UN-ECE/FAO Temperate and Boreal Forest Resources Assessment, as a part of the Global FRA-2000, was launched soon after the high level expert consultation held in Kotka (Finland) in June 1996 had proposed the Global Framework (guidelines, key parameters, terms and definitions) for the Assessment. The main instrument of the data collection for TBFRA-2000 was a detailed enquiry built on the above global platform, and circulated to national correspondents of the 55 temperate and boreal industrialised countries. The majority of countries have satisfactorily replied to the challenging enquiry (25 tables with more then 500 parameters) by August 1998. The range of the information which was received from countries (and analysed) is extremely wide; the quality of country replies was good in general, taking account the complexity of the task of national correspondents to respond to all the questions, and to adjust national data to the TBFRA standards.

Since UNCED (1992) many industrialised countries have reviewed (and revised) their national forest policies, and have prepared strategies on sustainable forest management (SFM). The on-going international forest policy dialogue under the CSD/IPF/IFF umbrella has noted the importance of FRA-2000 process to provide factual, comprehensive and reliable information at the global international level, which would serve the SFM objectives. The results of the assessment are expected to be widely used by researchers in different areas of the forest sector, as well as by many others working closely with forests and forestry (ecologist, environmentalists, forestry specialists, forest engineers and managers, forest products suppliers, wood consumers, forest practitioners, etc).

The interim temperate/boreal FRA-2000 information, covering 36 participating countries, was reported to the pan-European Ministerial Conference on the Protection of Forest in Europe (Lisbon, June 1998). The Main TBFRA-2000 Report on the forest resources presenting more than 2.4 billion hectares of forest and other wooded lands will be published by the Year 2000. The statistical and descriptive country information has been analysed by high level experts in the specific thematic areas. The Assessment will cover the following main issues: Area of Forest and Other Wooded Land (OWL): Situation and Changes, Ownership and Management Status of Forest and OWL, Wood Supply and Carbon Sequestration: Situation and Changes, Biological Diversity and Environmental Protection Forest Condition and Damage to Forest and OWL, Protective and Socio-Economic Functions, etc.

The TBFRA-2000 data set will be the most comprehensive international assessment ever made for the temperate/boreal forests. The information on forest and other wooded land areas, species distribution, naturalness of forests, their availability for wood supply, growing stock, increment, ownership, fellings and removals, biodiversity, non-wood goods and services, forest condition and damages, etc (in digital and textual formats) will be structured into an electronic database and made available on Internet.

4.04.00 Advances in combining productity and sustainability in forest management

A New Planning Approach and Criteria used for Sustainable Forest Management in Turkey

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A new planning approach titled as Functional Planning (FP), and the criteria which should be used for sustainable management planning in the Turkey's forests are pointed out in this paper. After giving a short knowledge about the forest resources, and forest functions expected from the forests in the country, basic principles of the FP approach which was developed for the forest enterprises managed for timber production as well as the other protective functions of the forests such as erosion control, water yield, visual effect, recreational use and, wildlife habitats and bio-diversity are presented. The concepts of "Continuous Forest " and, "Sustainability" are also elaborated in short in the paper. The planning procedure followed in construction of FFM, and in separation of different working circles, combination of various management objectives are clarified. Advantages of the New system as flexible and capable in order to realise the rational utilisation of the forest resources in the case of multiple use forestry, and its current deficiencies which should be promoted for more effective use are explained in the paper basing on experiences gained in the last ten years.

Keywords: Sustainable Forest Management, Functional Planning, Multiple-Use, Turkey

Sustaining Wildlife Populations in Productively Managed Forests

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Keywords: Spatial optimization; Harvest scheduling; Population Persistence; Reaction-diffusion

Wildlife population status is becoming a key consideration in determining whether wood fiber production from managed forests can be sustained. Concerns for wildlife have become a very important part of public land management in many parts of the world, and are being given increased weight on privately owned lands. Jointly maintaining wood fiber production and wildlife populations requires the ability to spatially and temporally design silvicultural activities so as to mitigate negative impacts on wildlife habitat. Consequently, research efforts blending wildlife population persistence with traditional forest management modeling can potentially play a crucial role in maintaining future forest productivity. The purpose of this paper is to synthesize recent and ongoing research combining population reaction-diffusion models with spatial forest management optimization methods for planning the location, timing, and intensity of harvests that will simultaneously sustain wildlife and wood fiber production. Following the introduction, Part I of the paper describes a discrete space and time approach to reaction-diffusion modeling that addresses the effects of various contiguous or fragmented habitat systems on wildlife populations. An ability to model survival of dispersing organisms as a function of the amount of available habitat surrounding breeding sites, with a suitable distance decay, is the primary feature of this method. Part II of the paper discusses stochastic considerations. We explore the differences in results from deterministic versus Monte Carlo simulations of population abundance, distribution, and critical habitat thresholds in discrete reaction-diffusion models. Implications regarding the application of mathematical programming for habitat design are discussed. Although much research on the topic of uncertainty remains to be done, initial indications are that deterministic methods suitable for optimization modeling are reasonably robust with regard to prescribing suitable habitat arrangements. Part III of the paper demonstrates how reaction-diffusion can be combined with other ecological factors that limit populations to form spatial optimization models. These models are suitable for identifying efficient forest management opportunities and for estimating tradeoffs between wood fiber production and wildlife population response. An example combining distinct forage and breeding site requirements with reaction-diffusion processes demonstrates the approach. Possible limitations, alternative approaches, and further research needs are discussed.

Putting Sustainable Forest Management into Practice in Peninsular Malaysia: Minimum Requirements

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The goal of Sustainable Forest Management (SFM) is to manage forests as multifunctional resources. This paper describes the strategic approach to SFM recommended for Peninsular Malaysia. It focuses on three minimum elements required for SFM, which are (1) Forest Zonation, (2) growth-based yield regulation, and (3) the mitigation of the environmental impact of forestry operations, especially road construction and harvesting. The implementation of these elements is also indispensable for successful Forest Management Certification.

Forest Zonation is based on Forest Function Mapping. Its objective is to safeguard the various forest functions within each Forest Management Unit. It ensures that the needs of human society are compatible and balanced with the production and buffering capacity of the natural environment, and derives specific functions (e.g. soil conservation) for each forest area. Based on that, the synoptic process of Forest Zonation results in the differentiation of three Forests Zones: "Protection", "Timber Production" and "Restricted Timber Production". The latter two (minus permanent infrastructure areas) constitute the Net Production Area, which is the basis for the calculation of the Annual Allowable Cut (AAC).

The simple area-based yield regulation currently used in Malaysia is appropriate only for uniform virgin forest. The majority of forests, however, are now logged. Having developed differently depending on the harvesting intensity, site conditions and silvicultural treatments, they are much more heterogeneous. Therefore, area control should be replaced by a volume-based yield regulation, which takes into account the present growing stock (provided by a Forest Management Inventory), growth data from representative (i.e. local) permanent sample plots, computer-based growth simulation, and deductions according to the extent of harvesting impacts on the residual stands.

To mitigate the impact of logging on the natural environment (residual trees, soil, water, and habitats) areas assigned for Timber Production must be logged strictly following Reduced Impact Logging standards (i.e. improved tractor skidding). In Restricted Timber Production areas, furthermore, only Low Impact Logging with aerial yarding technology (e.g.cable crane systems) is admissible.

All prescriptions are included in Forest Management Plans, which cover individual Forest Management Units over a planning period of 10 years.

Timber production possibilities of the Norwegian forest area and measures for a sustainable forestry

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A public discussion on how to bring forest management practices in a more environmentally oriented direction is going on between Norwegian organisations of forest owners, environmentalists, forest industry and governmental offices. Certain requirements or standards as they may be stated in certification documents or as governmental policies are likely to appear in a near future.
In addition to timber the forest is producing a number commodities not traded in any market. If the management of the forest area is designed mainly with respect to timber production, the effects of this management on the provision of the non-market commodities may be negative. On the other hand, an environmentally designed management may reduce timber production. The aim of this paper is to present some long range timber production analyses where the objective has been to map consequences for potential harvest level and net present value, related to varying forest treatments in a environmentally oriented direction as might be defined in the future.

Analyses are done with GAYA-JLP, a model based on simulation of treatment schedules for individual management units and linear programming for solving the management problem at forest level. The analyses cover the productive forest area in Norway. This forest area is divided into 10 regions. Sample plots from the National Forest Inventory are aggregated into 1000 treatment units for each region, i.e. the entire forest area is described by 10000 units. The forest management problems are solved at county level, while the country level results are obtained by summing over the individual regions.

The analyses aim at providing a realistic description of the timber production possibilities of the productive forest area in Norway given consistency in treatments with respect to the real rate of discount. Management strategies with maximization of the net present value (NPV), with and without a non-declining felling path constraint, have been analyzed. The following environmentally oriented constraints on forest management practices, separately and joint, have been analyzed:
- certain areas of current old growth forest set aside for permanent protection
- minimum target levels for area covered by old growth forest through time
- leaving continuity trees after final felling
- restricted management practices for border zone areas around lakes, rivers, streams, swamps, agricultural land and roads

The results include estimates on possible development for a period of 100 years with respect to potential harvest levels and volume of growing stock. The NPV according to a real rate of discount of 2.5% and with a non-declining felling path constraint, was reduced by 8.7% when 5% of the total area was set aside for protection. The corresponding NPV reductions were 2.4%, 1.0% and 12.7% respectively with a minimum target level of 10% for area covered by old growth forest, by leaving 10 continuity trees ha^{-1} and with restrictions on management practices for a medium border zone width (15 m) around lakes, rivers, streams, swamps, agricultural land and roads.

Swedish efforts for a sustainable, multi-resource forestry: the role of research in management planning

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Keywords: Data acquisition; Ecosystem functioning; Spatiality; Planning system

Until the late 80's sustainability to Swedish foresters essentially meant safeguarding the timber production potential of the land base. Today, forest management in Sweden, as in many other places, means the management of multiple resources. These resources include, e.g., biodiversity, recreation, hunting, carbon sequestration and reindeer herding. At the same time, market pressures require that the timber production is made more competitive and environmentally friendly. The increased complexity of forest management has created a surge for improved decision support.

The research community has answered to the demand for improved decision making capability in several different areas. They can be grouped under three headings: general knowledge concerning the forest ecosystem, models for ecosystem functioning including silviculture and the growth process of the trees, and management planning methods.

Much research is directed towards modelling the effects of forest management on ecosystem functioning, such as the consequences of fragmentation on species diversity and acidification of streams and lakes. Active research is also conducted in carbon and nutrient budgeting and estimation of effects of global warming.

Results of research concerning tree growth, silviculture regimes, forest survey methods etc., are contained in computer based systems for forest resource management developed the Faculty of Forestry of SLU. Systems have been developed for forest management planning at a company level and for the analyses of timber yield, growing stock etc., on a regional level. The systems were, however, initially designed in the 70's and almost exclusively directed towards timber management. When the biodiversity issue emerged, methods and instruments to be incorporated in forest management planning were requested. in the beginning of the 90's, case study areas were established by companies and research institutions. A number of conceptual planning models for "ecological landscape planning", such as the ASIO and the Key Habitat – Corridor Model, were elaborated in a more or less formal collaboration between companies and researchers. Typically, however, the latter planning instruments and traditional timber management planning have been used simultaneously but not in an integrated manner.

Another area of research of interest for resource management is improved methods for data acquisition. For example, by combining remote sensing data with ground measurements, estimations of spatial continuous forest parameters can be obtained to describe forest landscapes. That the spatial arrangement can be depicted is essential for the management of many resources. Moreover, methods for gathering data on rare objects also exist, primarily for biodiversity management. Typically, these methods are based on field measurements but methods using the combination of remote sensing and field measurements are under development.

Unless planning for different uses can be made simultaneously, dangers of sub-optimality are obvious. Therefore, research efforts in different areas need to be gathered in a common framework. The Faculty of Forestry has initiated a project for the development of a new system for forest management. It should be designed (i) with a modular structure to allow for the development of different applications, (ii) with the landscape as the basic planning unit, (iii) with the tree as the basic unit of projection of the tree layer, (iv) with models for processes interacting with the management of the tree layer, and (v) with models for risk and uncertainty of data and model projections.

One of many challenges is to be able to give a reasonable description of the landscape, not only in terms of trees but also, for instance, of soil conditions. Another is to try to combine empirical models for tree growth with process models. Although the working name of the project, Heureka, may be associated with a flash of genius, the efforts of coming years will rather be Herculean.

Estimating the thresholds of criteria and indicators in Japan

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Thresholds of criteria and indicators accepted in Montreal Process countries were estimated using a linear programming model. The concept of thresholds contains "feasible region" and "optimum solution", which mean region of indicators satisfying the conditions of sustainable forest management and optimum value of indicators in the feasible region respectively. First, four criteria were selected for the subject of this study, which are

-Biological diversity, -Productive capacity, -Carbon cycles and-Socio-economic benefits, and then tentative indicators, -Area of old growth forest, -Growing stock of commercial forest, -Growing stock of total forest and -Harvesting volume were set for each criteria at the national level.

Next, the thresholds of the indicators were estimated using a linear programming model. The model covers the entire forest in Japan which is divided into four groups, private plantation forest, national plantation forest, private natural forest and national natural forest and has some basic parameters such as planning horizon and number of age class which are set for ten terms (= fifty years) and seventeen classes (= eighty five years). in the model decision variables are cutting area by group, term and age class and objective function is to maximize the total harvesting volume in the planning horizon. Constraints consist of the requirements for sustainable forest management that all of indicators are basically non-decline over planning horizon and some other equations such as cutting regulations, forest transition and so on. The requirements related to sustainable forest management are as follows: 1. Area of old growth forest is non-decline. 2. Normal age class distribution is achieved for ending forest structure. 3. Area of commercial forest is constant. 4. Growing stock of total forest is non-decline. 5. Harvesting volume is non-decline and cannot increase by more than ten percent from the preceding harvest. Last, optimum solution was found and feasible region was sought by a method of parametric linear programming. in the constraints indicators are defined as accounting variables by term, so thresholds have time-series change. To seek the feasible region, the value of optimum solution is given to the indicator by a new equation and the value is changed to find out the region where solution exists. The result was that optimum solution of harvesting volume reflects the trade-off relation toward other three indicators because only harvesting volume corresponds to _gactivity_h and others _gresource_h in the model structure. and each feasible region becomes broader as time passes because the choices of solution become wider in the final stage of planning horizon than the early stage. It was concluded that the concept of threshold is efficient in judging the progress toward sustainable forest management.

A spatial approach to participatory planning in forestry decision-making

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During the last ten years the concept of the sustainability of the forestry has been extended from economic sustainability to include also ecological and social sustainability. To reach ecological sustainability *e.g.* The Finnish Forest and Park Service applies landscape ecological planning for large (10 000-150 000 ha) forest areas. Participatory planning, is one mean to reach the social sustainability. Important question is the ability to produce planning solutions which are acceptable for the decision-maker and the interests participated.

In participatory forest planning public is allowed to tell their opinions about forests and forest management. Public is those people to whom current decision-making affects. in participatory planning they also have right to expect that their opinions are somehow taken care of. The nature of the information concerning public's values and opinions is that it is context dependent. This means that values and opinions are valid only in certain situation. Situation is part of those peoples lifeworld. When managing qualitative information in decision-making, the context should be involved too.

In this paper/poster, an approach is presented to collect and analyse qualitative and geographic information and to process it to quantitative and spatial format. in this study the qualitative research analysis, numerical preference analysis and spatial analysis are utilised.

For example, the Finnish Forest and Park Service receives a great amount of qualitative information about publics' opinions and values as meeting records, letters, and personal contacts during the participatory planning process. Participants have messages concerning hunting, beautiful landscapes, picking wild berries etc. These messages usually refer to certain location, i.e. include geographic data. in this approach messages are analysed by their contents location and context. Qualitative methods, making typologies searching facts and norms, and discourse analysis are used to understand relevant context and situation. Context determines the classification of the messages by their contents. A database for GIS application is created.

Geographical Information System (GIS) applications offer many tools by which information from different sources can be connected and used in the analysis. Cartographic modelling is an area of application for spatial analysis employing concurrent analyses of many sources of information. Using cartographic modelling and modern decision-analysis methods to combine the data collected in the process of participatory planning enables better understanding and visualisation of the different objectives of people. in spatial analysis, an aggregation method is needed to combine individual preferences. in this task, two different approach are being discussed. in the first approach, each individual evaluates the relative magnitude of his/her proposed areas, and the overall preferences are aggregated over individuals. in the second approach areas are classified and the relative importance of classes are determined with respect to large-scale potentials of the planning area.

The advantage of this approach is the ability to carefully organise qualitative information into quantitative format. The most preferred areas are named and their relative magnitude according to the participants preferences are measured. By integrating qualitative and spatial analysis it is also possible to clearly point how and where the participants' opinions have been taken care of. This could be used as a tool to motivate participants behind the decision.

Incorporating Ecological Information into the Forest Management Planning

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Keywords: Ecological modelling; Expert judgements; Forest planning; Multi-functional forestry; Optimization; Uncertainty

Ecological information about the impacts of forestry on the environment, such as the effects on wildlife populations, and assessments of ecological sustainability have rarely been used in calculations of forest management planning. However, some applications exist where models predicting sizes of wildlife populations, habitat suitability, or biodiversity have been used in optimization calculations. The most important reason for not using ecological information in calculations of forest management planning has been the lack of information that can be used in numerical planning packages. These packages, usually based on mathematical optimization, require the ecological knowledge to be presented in the form of relatively simple models. However, all available information should be utilized in decision making. Ignoring other kinds of ecological knowledge than only numerical models based on empirical research would mean waste of valuable information.

There usually exists much more or less qualitative information of the ecological consequences of alternative treatment schedules and production programmes. One such source of information is the expert knowledge held by ecologists. There exist some applications where expert judgment has been utilized in choosing the best management alternatives, with respect to some ecological concerns.

It is also possible to model these expert opinions to a form of mathematical model, which can then be utilized in optimization calculations. On the other hand, models describing population dynamics, for example, are too complicated to be used in usual planning packages. Thus, the information included in such models needs to be reformulated to a simpler form in order to be applicable.
Often, the uncertainty involved in calculations has not been taken into account in forest management planning. The uncertainties inherent in ecological considerations probably are greater than uncertainties of, for example, growth and yield predictions of the growing stock. Information on the uncertainty involved in the decision support is useful in any natural resource and environmental decision making. For example, when evaluating the ecological sustainability of alternative production programmes for a forest area, it is important to know the risk that the sizes of populations of species of interest would fall below presumably critical limits (if the management alternatives chosen in the programmes would be implemented). This is especially the case with rare species. The uncertainty needs to be taken into account in planning to minimize the risk of the population sizes falling below a given threshold value, or to become extinct, due to forestry actions.

In this presentation, possibilities to use different forms of ecological information in optimization calculations of forest management planning are presented. Also the importance of being aware of the uncertainty involved in ecological assessments applied, as well as the possible consequences of ignoring the uncertainty inherent, are discussed. Examples of utilizing ecological knowledge in forest management planning are given. These include modelling suitability of forest habitats for black grouse (*Tetrao tetrix*, *Lyrurus Tetrix* L.) on the basis of pairwise comparisons data, and using an ecological threshold function as a multiplicative part of a utility model in multi-objective optimization calculations.

Application of Criteria and Indicators for Sustainable Forest Management to GIS-based Multiple Criteria Decision Making Approach for Forest Conservation Planning in Kinabalu Region, Sabah, Malaysia

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In 1994, during the Second Meeting of the Intergovernmental Working Group on Forests, forest was recognized as having cross-sectoral linkages that can be dealt with integrated landuse planning. Recently, the importance of the GIS-based multiple criteria decision making (MCDM) approach in planning has been widely recognized. The MCDM approach implies a process of assigning values to alternatives that are evaluated along multiple criteria. However, there have not been criteria in common for landuse planning involving forested land.

Development of the Criteria and Indicators for Sustainable Forest Management (C&I) was initiated in 1992 by International Tropical Timber Organization (ITTO), followed by other efforts such as Montreal and Helsinki processes. The C&I contain the most important forest functions that provide various benefits to the society. However, the forest functions have not been incorporated into the landuse planning process. The C&I have great potentials not only in dealing with the sustainable forest management but also in landuse planning at regional level as far as forest is concerned. in this study, we propose the application of the C&I to the GIS-based MCDM approach for forest conservation planning in Kinabalu region, Sabah, Malaysia.

The study area is located in western part of Sabah, Malaysia. Urbanization has been spreading out from the state capital, Kota Kinabalu. As a result of timber harvesting and agricultural land conversion, forest has rapidly disappeared in this area. Major conservation effort in this region is represented by the initiation of Kinabalu Park (735 km^2) in 1964. Encroachment occurs in western and northern parts of the park boundary by local farmers. in 1986, illegal logging was spotted in northeast side within the park. This shows the conflicting nature of landuse activities in this area.

The criteria adapted are biodiversity conservation and soil and water conservation. Evaluation of forest conservation priority based on these forest functions would satisfy the maintenance of ecological balance and vitality and safety to human lives. in this study, a criterion representing human impacts on forests is also devised as potential threats to forests. in the ITTO's C&I human impacts on forests are emphasized only within the permanent forest estate.

The indicators, adapted from the C&I or devised, are generated from map sources or derived by using known relationship between a spatial factor and the indicator. Forested areas are prioritized to produce a forest conservation zoning map based on a computed conservation coefficient. The results are compared to existing protected areas. It is conceivable that high conservation priority areas are representations of the important forest functions that maintain the ecological vitality and balance, and to ensure safety of the society. in short, forest conservation planning using GIS-based MCDM approach has gained legitimacy from the application of the C&I. As such, community of forest science profession has contributed toward a better construction of criteria and indicators for landuse planning.

The Analytic Hierarchy Process in Natural Resource and Environmental Decisionmaking

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The analytic hierarchy process (AHP, developed by Thomas Saaty in the 1970's) has been applied to a variety of decision-making problems. For example, it has been used for planning, resource allocation, and priority setting in business, energy, health, marketing, forest management, and transportation. Three important components of the AHP that facilitates the analysis of complex problems are: (1) decomposition of a problem into a hierarchy consisting of a goal and subordinate features of the problem, (2) assignment of a numerical weight to each element in the hierarchy (through pairwise comparisons between elements at each level), and (3) aggregation of those weights into an overall preference score for the alternative decision outcomes.

The AHP is relevant to nearly any natural resource/environmental management application that requires multiple opinions, multiple participants, or a complex, decisionmaking process. Considering the complexity of most management issues and compliance regulations, the AHP can extend to a wide array of managerial and planning tasks. in addition to its breadth of application, the

AHP is relatively easy to apply, to understand, and to interpret.

4.04 Recent advances in forest resource management and economics

Does standard discounting incorrectly show an advantage of leveraging forestry investments with debt?

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Typically one uses a risk-adjusted discount rate (RADR) larger than the risk-free rate to calculate the net present value of a project with risky cash flows. In those cases, one can show a present value advantage of borrowing funds at a loan interest rate lower than the RADR. This results because, under the above conditions, the negative present value of loan payments will be less than the positive loan value. Using a zero inflation example for simplicity, at a 5% loan interest rate, annual payments on a $100,000, 10 year loan will be $12,950. Incorporating this loan into a discounted cash flow analysis using a 7% real risk-adjusted discount rate, the negative present value of loan payments is $90,955, or $9,045 less than the loan amount, thereby boosting the project's present value. However, the borrower should view loan payments as risk free cash flows based on a legally binding contract, in which case payments should be discounted with a risk-free rate, say 3%, which is lower than the risk-adjusted rate and lower than the loan interest rate. In that case, the negative present value of loan payments will *exceed* the loan value because the loan interest rate will be above the risk-free discount rate. For the above example, the negative present value of loan payments would be $110,466 at 3% interest, which is $10,466 more than the loan amount. Thus, the previously-calculated present value advantage of borrowing is really a disadvantage. Analyses show how results will vary depending on levels of relevant interest rates, inflation, income tax interactions, loan duration, project life, and the degree to which borrowing increases the overall risk of a project. Forest policy implications are that typical discounted cash flow analyses of leveraged forestry investments could make borrowing appear deceptively attractive. The result could be overpayment for leveraged investments in forested properties or forest management. The analysis raises interesting questions about economic efficiency. Do incorrect analyses of leveraged investments cause a sub-optimal distortion toward higher borrowing levels? Could the result be higher-than-optimal levels of leveraged forestry investment, strictly from a financial efficiency viewpoint? Further research is needed to determine the degree to which such inefficiency is manifested in actual practice in forestry and other investment areas.

Forest Ownership as an Inflation Hedge

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Keywords: forest ownership; private housing; return and risk; inflation; hedging

This paper analyses the extent to which forest ownership, private housing and stocks were a hedge against the expected and unexpected components of inflation in Finland, using the traditional method of dividing inflation into expected and unexpected components. The expected inflation is proxied by the inflation forecasts of the Research Institute of the Finnish Economy (ETLA). Unexpected inflation is the difference between actual inflation and this inflation forecast.

A novel contribution of this study is to construct and use comprehensive, national return series for forest ownership to estimate their relationship to inflation. This estimation of the inflation-hedging characteristics of forest ownership is also the first to use systematically created value-weighted return series that include all economically relevant roundwood assortments. Moreover, this study is the first in Finland to estimate the inflation-hedging of other asset classes than stocks, namely, private housing, in addition to forest ownership.

Results indicate that forest ownership did not provide a hedge against expected inflation over the period 1973-1998 at all, but provided some hedge against expected inflation over the period 1978-1998. One reason for this may be that expected inflation was at very high levels during the 1970s. To summarise, it can be said that the forest ownership has provided a hedge against expected inflation only to some extent and has offered a very effective hedge against unexpected inflation. Forest ownership, or more precisely stumpage prices, have however been a leading indicator of the inflation trend. Private housing provided a hedge against unexpected inflation at a statistically significant level. Forest ownership and housing provided some hedge against expected inflation, but not at a statistically significant level.

Stocks did not provide a hedge against expected inflation at all; in fact, the relation was even negative, but stocks provided some hedge against unexpected inflation, although not at a statistically significant level. It seems that forest ownership and private housing are better assets than stocks for the institutional investor in terms of inflation hedging. Both these asset classes have provided effective hedges against unexpected inflation. It is valuable to have a hedge against unexpected inflation, because an inflation hedge against expected inflation can often be obtained through bond markets.

When the longer five- and ten-year holding periods are considered, the results are almost the same. Forest ownership is a hedge against expected inflation to some extent and a very effective hedge against unexpected inflation. It turned out that the longer the holding period, the more effective a hedge forest ownership has provided against expected inflation as well. These inflation-hedging properties of forests may support regeneration and other investments by forest owners and therewith economically sustainable forestry.

Trees outside forests: why should foresters think about this resource?

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Trees outside the forests are increasingly discussed as an important natural resource. Agroforestry and urban forestry are but two examples of disciplines dedicated to trees outside the forestry context. While the great majority of studies on trees outside forests has a local, small area focus, the present paper attempts to look at it from a large area, landscape perspective, discussing the different functions of trees outside forests. Some preliminary results of studies in Costa Rica are presented that underline the relative relevance of this resource. Comparisons to the forest resource are made, though one should clearly see trees outside forests as a resource on its own, that needs particular attention and a particular management.

4.11.00 / 4.01.03 Planning of long-term observations

Long term observations and research in forestry

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Long term and large area are amongst the principal characteristics of experiments and observations in forest research. When the International Union of Forest Research Organisations (IUFRO) was founded in 1891 one of the most urgent tasks was the exchange of knowledge and experience regarding the planning of long term experiments. While in those days long term experiments were mainly conducted to study timber production, it is nowadays widely accepted that long term experiments are an outstanding tool to describe, quantify and model the effects of changes in environmental conditions.Various aspects are relevant in the context of long term observations: statistical considerations with respect to plot number, plot size, number of replications; aspects of data management; practical aspects of establishing long term experiments.

This paper summarizes an IUFRO 4.11 International Symposium that was held in February 1999 in CATIE, Costa Rica.

Characterization of central tendency and spatial variability of growth and mortality of forests: A comparison of some statistical models

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Forest growth can be expressed as single tree annual diameter increment or as annual basal area increment for an entire stand. Mortality can be expressed as single tree annual probability of mortality or as annual basal area lost to mortality. These measures exhibit differences in variation over time as well as differences in central tendency, depending upon whether they are expressed at the individual tree or whole stand spatial scale of measure. This talk will contrast/compare several models for characterization of central tendency and variation of these measures of growth and morality: generalized least squares, generalized linear models

(Poisson regression for growth, logistic regression for mortality), and quantile regression. Estimates of central tendency are similar for these models, the biggest differences between the models are in the way that they model the variation of growth and mortality rates over time. Differences between the models indicate the degree to which they partition the variability in growth and mortality as spatial variation or random variation. Differences between the models will be illustrated using a 15 year permanent sample plot data set from a Hill Dipterocarp Forest in Peninsular Malaysia.

Long-term experiments: long-term commitments

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Long-term experiments in forestry research lay within a area of conflict: on side research needs good data *e.g.* long data series of optimal quality, on the other side there are costs and long-term commitments which are necessary to get such data. Long-term commitments can be guaranteed best by forest research institutes. But due to shortage of funds these long-term commitments are questioned in such institutes too. Forestry research and research in related fields, *e.g.* in other ecosystem types, is based on long-term experiments because of the relatively slow development in these ecosystems. Therefore changes in such ecosystems can be monitored only using adapted "slow" research methods. Investments, as long as the experiments are not intensive studies usually are overestimated. This can be shown on the basis of long-term recorded time studies. Examples of long-term experiments illustrate the usability of data which exceeds often the questions asked, when the experiments were started.

4.12.00 Integration of GIS and Remote Sensing for Assessment of Forests and Landscapes

Forest Cover Change Assessment at the Pan-Tropical Scale using Earth observation satellite data

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Of major concern is the issue of forest distribution. Assessing the state and the evolution of tropical forest cover is relevant for studying the impact of human activities on the global environment.

New information technologies make possible the development of more advanced systems of data gathering and analysis which can accurately assess the current status of forest cover.

In the framework of the TREES-II project, techniques for the assessment and monitoring of moist tropical forest cover are developed at the pan tropical level. These techniques make use of an extensive satellite data set analysed in an ad-hoc manner. This paper presents a new approach for the assessment of deforestation rates in the moist tropical regions for the period 1992 to 1997 using Earth observation techniques. The approach is based on intensive sampling with fine spatial resolution satellite image pairs, focusing on the most active deforestation areas.

As a first step the humid tropical forest belt was mapped using coarse spatial resolution imagery (NOAA-AVHRR), with fine spatial resolution satellite data (Landsat-TM) used as a reference data source. The 1.1 km resolution of NOAA AVHRR is well adapted to the geographic scale of the monitoring exercise (pan tropical). However, this spatial resolution leads to a loss of detail that makes it difficult to derive a good proxy variable for the measurement of deforestation rates.

At the global level a sampling scheme for forest change assessment has been defined using sampling units independent of any particular satellite sensor. For this purpose an equal probability sampling frame has been chosen.

In the case of spatially correlated data, such as forest cover change, estimates can be improved by performing a preliminary stratification to reduce the variance of the estimated variable. However, at the pan-tropical scale little reliable spatial information is available to stratify on the basis of deforestation rates. Stratification is performed using percentages of forest area (derived from the 1.1 km resolution maps) and areas of known current or recent deforestation activity (elucidated from expert consultation) estimated for each sampling unit.

Sample site selection is performed by using a sample frame based on a tessellation of hexagons on a sphere. This approach allows for sensor independent sample from which unbiased estimators and error variance may be computed.

This sampling scheme is currently in the implementation phase. The total target sample size has been set up to ninety-five as a feasible target linked to availability of resources. Observation units have been selected and image pairs for the nominal period 1992 to 1997 have been acquired. These image pairs are currently being photo-interpreted on-screen by local experts who have ground knowledge of the forests. Digital copies of the interpretations will be collated and analysed and estimates of deforestation rates over the observation period determined. The latest results of estimation of forest cover change in the humid tropics will be presented during the congress.

Monitoring forest fuel maps for helping control and prevention of forest fires

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The aim of this study is to provide a direct, rather simple and friendly methodology for monitoring forest fuel maps. The classification of the vegetation cover of Chile in fuel classes according to its inherent flammable characteristics was the procedure utilized for developing the maps. The forest fuel maps were developed in order to provide basic information for applying fire behavior models. The use of these models facilitates forecasting and control of forest fires. Additionally, application of the models allows an optimal resource assignation for forecasting, prevention and extinction of forest fires. Two methods for monitoring fuel maps were compared, namely the principal component method and the images difference method. These methods haven been used in many forestry applications and are well documented. However, their utilization for monitoring of fuel maps seems to be a novelty. For carrying out the comparative study, satellite imagery data, ground field information and forest fuel map classification in a pilot area were utilized. The satellite material consisted of two SPOT scenes of the same area (the pilot area covered approximately 20 000 hectares and it was located in Malleco Province, IX Administrative Region in the central-south part of Chile) acquired in 1991 and 1994. The Chilean Forest Research Institute (INFOR) provided ground field information as well as the fuel map of such an experimental area. The methods were selected considering that they can be applied in a straightforward manner and they do not specially demand sophisticated software. The results pointed out that both methods are not necessarily mutually excluding, but are rather complementary ones. The application of principal component method demonstrated that this approach is particularly sensible to detect small changes of canopies as well as large and destructive ones like clearcuttings or forest fires.

Although images difference seems simple and highly intuitive compared with principal component method, it became time consuming when a large amount of information is processed. Therefore, in the latter case - that is the usual situation that one can expect when monitoring forest fuel maps - principal component demonstrated to be more efficient. Finally, some recommendations are concluded.

User Requirements for remote sensing-based spatial information for the sustainable management of forests

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Sustainable forest management requires proper decision-support systems. The effectiveness of these, however, is jeopardized by problems related to the timely availability of relevant information, as confirmed, e.g., in Agenda 21, the Intergovernmental Panel on Forests and the Intergovernmental Forum on Forests. The FAME (Forest Assessment and Monitoring Environment) concept addresses this problem, by suggesting an end-to-end forest assessment and monitoring system, ranging from data acquisition, up to the delivery of information to the desk of the user.

As a first step, the Dutch government charged a consortium of Dutch organizations and FAO with a User Requirements Study to assess the needs for spatial information on forests from a user perspective. This study included an interactive questionnaire survey among stakeholders/users, detailed studies in four tropical countries, an assessment of capabilities of current and planned remote sensing-based systems, the development of an international user network and an international workshop. The study revealed a substantial and urgent global need for spatial data and information on forests, referring to both "state" and "change" parameters. This was particularly observed at a local and at sub-national levels. These information needs cannot be fully satisfied by current or near-future remote sensing-based systems. On the other hand, there is a considerable under-utilization of existing data sources. Accessibility to and affordability of existing data and information are the major constraints for all users, with distribution being the weakest part of the chain. The concept of an "end-to-end" information system was re-defined, including the required information infrastructure, comprising data capture, data acquisition and distribution, data processing, data integration and capacity building as essential components. An information strategy at national level should support this system. Furthermore, international protocols are needed for the exchange of data. A further validation of the end-to-end concept is needed.

European forest mapping and monitoring within the frame of the FIRS (Forest Monitoring from Remote Sensing) Project - a review on progress and results.

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The FIRS (Forest Information from Remote Sensing) Project was launched early 1994 as the main European forest activity of the EU Space Applications Institute under the 4th FrameWork Programme. After a two-year foundation action phase, during which studies on regionalization and stratification of pan-European forest eco-systems and on European forest nomenclature for remote sensing applications were carried out, the project launched several major application studies in collaboration with other services of the European Commission.

The four most important studies concerned: 1) The provision of a 1km forest probability map of the pan-European area based on NOAA-AVHRR data; 2) an evaluation of high resolution satellite data for mapping European forest types and other wooded land --followed by a study on using medium resolution (200m) satellite data for regional mapping of forest and OWL; 3) a study on the assessment of above ground biomass and volume in Mediterranean and Boreal forest types using high resolution imagery; 4) a study on the assessment of changes in forest areas using high resolution satellite data combined with a study on the development of methods for assessing the structural diversity, at a landscape level, of forested areas in various European test sites. All studies have been carried out under external contracts on a competitive basis. They have been supported by in-house and external software development.

Based on the results from the first phase of the FIRS Project new forest mapping and monitoring activities have been defined and launched for the 5th FrameWork Programme. These activities are strongly linked to the support of the development of rural areas, both regarding economic aspects, but also regarding environmental issues. They will, among other things, address the development of operational Criteria and Indicators on sustainable development and bio-diversity, the development of automatic or semi-automatic methods for assessing forest growth conditions and forest health, and, new means for assessing the protective function of forests. Methods for integration of statistics and mapped information from Earth Observation data will be developed in support to the EFICS (European Forest Information and Communication System).

Forest Cover Monitoring and Assessment in South and Southeast Asia

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Keywords: Forest Resources, Deforestation, Remote Sensing, GIS

Deforestation is one of the major environmental concerns in South and Southeast Asia. Accurate, timely and accessible information base on the present status of forest resources and their change patterns is lacking in many countries. This is one of the limitations in formulating sound forest resources planning and management strategies at national, regional and global levels. The present study provides a synopsis of forest cover monitoring and assessment project of UNEP Environment Assessment Programme for Asia and the Pacific. Monitoring and assessment was performed using time series coarse spatial resolution satellite data such as NOAA AVHRR. The paper presents the outcome of forest cover change analysis of 12 countries in South and Southeast Asia. Major deforestation fronts (called "hot spots") were identified and investigated in detail using high-resolution satellite data such as SPOT and Landsat supported by field information. GIS and socio-economic databases were prepared and used for further analysis. The major forest cover change patterns and underlying causes of deforestation and forest degradation were underlined. Policy options to arrest the problem of rapid and unprecedented forest cover change were suggested.

Relationship between Forest Parameters (Volume and Basal Area) and Jers-1 Sar Backscatter

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Keywords: JERS-1 SAR, backscatter coefficients, peat swamp forest.

The empirical relationships between Japanese Earth Resources Satellite-1 Synthetic Aperture Radar (JERS-1 SAR) backscatter and two forest parameters (volume and basal area,) are evaluated. These parameters were collected from nine field plots covering a wide range of peat swamp forest classes including Primary, Regenerating and Disturbed forests. The backscatter coefficients were extracted from SAR image acquired in a dry season. A window size of 5x5 pixel was used to suppress the effects of speckle and to correspond to the size of the actual field sample plots. The relationships were evaluated by correlation and linear regression analyses. Results show that basal area and volume (forest parameters that are commonly used in forest inventory) exhibit positive correlations with backscatter coefficients for the dry season SAR image. The highest significant correlation (r= 0.7186) was observed between the dry season JERS-1 SAR backscatter coefficients and forest basal area. This suggest the usefulness of JERS-1 SAR data in determining the density of peat swamp forest stand.

Large Digital Aerial Imagery Mosaics in Land Use and Forestry Planning

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The poster presents the latest developments of an airborne digital camera image acquisition and image mosaic creation. The developed methods are reviewed for their potential for land use and forestry planning particularly in regions where the use of traditional optical remote sensing data is difficult, for instance in the tropics.

Airborne digital camera imagery is a convenient tool for gathering rapid and accurate true or false colour data of the environment with an adjustable resolution of 0.4 - 4 m. The image acquisition can be done from below the clouds and the image quality can be assessed immediately. One of the main problems, however, has been that in order to analyse large areas thousands of images are needed, and a single image only covers a small proportion of the area of interest. A related problem is that the images often have large radiometric and geometric differences.

In order to overcome these problems a system has been developed for collecting the data and creating large image mosaics. The airborne part of the system includes digital camera, GPS, navigation and camera control hardware and software. After the flight the mosaics are created semi-automatically on a standard PC. in order to obtain a result of good radiometric and geometric quality a photogrammetric mosaic is made by correcting for aircraft inclination, camera distortion, terrain elevation differences, sun angle differences and local radiometric differences. Digital terrain models can be created internally or entered from external sources to eliminate the prevailing elevation differences, i.e. to produce an orthomosaic.

The system is in operational use and more than one million hectares on four continents have been imaged and processed for forestry mapping, land use planning and monitoring of natural resources. Further developments are on way for digital infra-red imagery, image processing system based on parallel computers and for automatic single tree detection based on pattern recognition.

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Remote sensing and spatial data for the establishment and visualisation of 3D computer landscape models for impact assessment

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In many cases there is a need to assess and visualise the landscape in order to evaluate measures, which are suspected to have an impact on the landscape. There are many methods to assess a landscape, according to beauty, individuality, diversity or other parameters to estimate the impact of measures on landscapes. Until now the assessment of the impact on the landscape was in general based on qualitative parameters and 2D data based visualisation like maps and photographs. Nevertheless for the acceptance and realisation of planned measures, the inclusion of quantitative parameters and a 3D data based visualisation seem to be good tools.

A research project at the department of remote sensing and landscape information systems deals with the potential of 3D landscape models for the development of for quantitative impact assessment parameters and visualisation. The models were based on photogrammetric measurements from aerial photographs on one hand and auxiliary spatial data from different data pools on the other hand.

The measurements were taken with an analytical plotter (Zeiss P3) which was connected to a CAD-programme (Bentley MicroStation). The measurements included the land-surface as well as surfaces of different forest stands, roads, individual trees and houses. Objects close to the planned impacts (power-lines) were measured, the other objects were modelled based on auxiliary spatial data.

The planned power-lines were also modelled with MicroStation.

In contrast to photographic layout manipulations, this method is based on 3D data. That allows to visualise the impact on the landscape from each position within the model and to calculate quantitative parameters like sensitivity of the landscape, visibility of the impact, a.s.o. on a solid 3D geometric basis. There were two categories of parameters derived from the model, the first was used to assesses the sensitivity of the landscape to possible impacts. The other category is used to quantify the size of the impact. in addition to the usual planners point of view, in which the landscape is studied from above, the individuals point of view, which studies the landscape from within, was used to calculate the visibility of the impacts. Various images and animations of the landscape models were rendered, to visualise the impact, in addition to the above mentioned parameters. Most visualisation products employed the individuals point of view from within the landscape.

In addition to the assessment of the status quo, different situations could be simulated in the model, including variants or future changes, like the growth of vegetation or seasonal aspects.

Identification of landscape types in Croatia using remote sensing methods and spatial analysis

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Landscape analysis is the process of describing and interpreting the landscape ecology of an area. Resource patches and a landscape network of connecting corridors are identified, described and classified. Theusual set of data acquired for a landscape analysis includes :topographic maps, forest cover maps, digital elevation models, satellite images and air photos. A geographic information system is very useful inthis process. In the process of landscape analysis combined methods of remote sensing, spatial analysis and terrestrial works should be used to identify and quantify landscape variables and/or spatial, temporal and functional aspects of landscape.

In Croatia there are a variety of different landscapes, from lowlands inthe north, hilly and mountain region in the middle and the coastal areasin the south. Different agricultural use and urban development in such variety influenced very much the forest landscapes. The investigation of relationships between different agricultural, urban and forest types was performed on the set of 15 x 15 kilometres LandsatTM subscenes. The subscenes were chosen around the most important settlements in all regions in Croatia. On each subscene the several classification methods were used to describe land use of each region.The accuracy of each classification was calculated using topographicmaps, fotointerpretation and terrestrial work. The best classification of each subscene was used for landscape analysis. The results show how many different landscapes can be found in Croatia.

Estimation of Land Cover Change in Peruvian Tropical Rainforests using JERS-1 images

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In Peru, nearly 1,800 acres of tropical and subtropical forests are cut daily, amounting to 670,000 deforested acres each year; this phenomena eliminates critical habitats for wildlife and plants species (Peru ranks number two in the world in bird diversity, number three in mammal diversity and number five in plant diversity, within it's borders exists 83 of the world's 114 natural community types). An accurate and up to date assessment of forest area and rates of depletion is fundamental to the development of improved national forest management strategies. Satellite observations provide an objective and quantitative approach to the measurement of land-cover change; a research is proposed in order to determine the land use change, the conversion from active agriculture to secondary forest (re growth), infer the patterns of land use by type in the long term considering the past and present trends, and propose an ideal map of sustainable land use according to the ecological and socioeconomic characteristics of the site, in a representative area of Peruvian tropical rainforests (Iquitos region, a 75km x75 km area located in the Amazon watershed at 3*43*46" South Latitude, 73*14*18" West Longitude) using JERS-1 images. The Japanese Earth Resources Satellite - 1 has been continuing to observe and collect data since 1992 with a mission data recorder by the high performance Synthetic Aperture Radar (SAR) and Optical Sensor (OPS); TNT mips will be used in order to process the images, a processing system for geo spatial analysis with fully integrated GIS, CAD, TIN, desktop cartography and geo spatial database management.

A forest inventory and information system for forest operations and planning

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The measurement, classification, and interpretation of forest resourcesfor a multitude of forest values is constrained by single purpose databases of often poor quality. Contemporary data bases must allow spatial and temporal manipulation to meet the dynamic planning and operational needs of forestry. The Alberta Research Council in partnership with private industry has developed and tested an integrated hardware andsoftware system that automatically links digital image data with elevation that has many uses in forestry. The initial product of this system is the automated production of ortho-rectified images and photo mosaics. Other software has been developed that analyses these primary data to give tree location, crown diameter, height, and species, which are combined to produce forest inventories. New software to automate the mapping of landforms and combining landform and other forest attributes into a system to automatically map soils is also under development. These data are also being used to automate the polygonization of the stand boundaries, soils, and ecosites with expert systems and user defined attributes. The combined applications he combined applications are an integrated inventory and information system that will have multiple values in developing forest management plans and implementing operations.

Multiple Criteria Analysis and Geographic Information Systems for Assessing Criteria and Indicators in Sustainable Forest Management

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Keywords: Criteria and indicators, multi-criteria analysis, geographic information systems

This paper describes applications of Multiple Criteria Analysis (MCA) in assessing criteria and indicators (C&I) in evaluating sustainable forest management. The MCA methods include: ranking, rating and pairwise comparisons or Analytic Hierarchy Process. These methods were used in a participatory decision making environment under two evaluation approaches; a top-down approach and a bottom-up approach. The former involves a team of interdisciplinary experts from different disciplines such as social forestry, resource economics, ecology, forest management, silviculture, and forest policy and administration. The latter involves a local team representing various stakeholders, interest groups, and other community people affecting, and affected by, the management of the forest. The top-down approach essentially consists of selecting relevant sets of C&I from a generic set such as those proposed by the Forestry Stewardship Council (FSC) and the Center for International Forestry Research (CIFOR). The bottom-up approach involves both the generation of sets of C&I and their final selection at the field level by local forest communities and other stakeholders. Both approaches are structured and organized in a participatory decision making environment.

In addition to describing the procedural details of the two approaches above, the paper also describes the concepts and the underlying theory behind the MCA methodologies. Computational details and other concepts related to consistency of group decisions, priority rankings, and the estimation of relative weights or degrees of importance of each C&I as estimated by the MCA methods are discussed. The steps involved in the application of the MCA methods in assessing C&I on a Forest

Management Unit (FMU) are also described. The evaluation process detailing how the Teams provide their expert opinions on each C&I along with their judgment on the suitability and applicability of each C&I to a FMU is also described. Ultimately, the estimation of a performance index of the FMU based on the ranked or prioritized list of C&I is also described.

A forest concession located in central Kalimantan, Indonesia is used as the FMU for the case study. Results from the study show that the multicriteria methods are effective tools that can be used as structured decision aids to evaluate, prioritize and select sets of C&I for a FMU. Feedbacks received from the two Teams and other participants indicate that the methods are transparent easy to implement, and provide a convenient environment for participatory planning and decision making especially for a complex problem such as the assessment of sustainable forest management.

Finally, the paper also describes an integrated modeling framework for assessing forest sustainability using the biodiversity conservation criterion. The framework essentially involves two general methodologies -- Geographic Information Systems (GIS), and MCA. in assessing overall sustainability using the biodiversity-based C&I elements, the Analytic Hierarchy Process (AHP) is used to determine the relative importance of each C&I. Besides measuring the relative importance of each C&I, their impacts (i.e., degree of negative and positive impacts) are also calculated using a method based on fuzzy set theory. Ultimately, the integrated MCA and GIS-based model allows the estimation of area-specific sustainability index values. Hence, sustainability can be measured particular tracts of land, which can also be geographically identified on the ground (i.e. site-specific). An illustrative example based on an actual forest in Indonesia is described to demonstrate the applicability of the model.

Mapping of 'Green' Cover in Putrajaya New Township Using Landsat Tm

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The need to manage the resource in a more sustainable way and the changing demands of society on its forest are confronting the modern forester. Rapid population growth and development activities has caused high growth of urban environmental quality and traffic disturbances. The objective of this study is to assess the usefulness of Landsat TM data in "green" cover mapping of a new township Putrajaya. A Landsat TM image of 126/58 (path/row) in Computer Compatible Tape (CCT) form, taken on June, 1996, with less than 5% cloud, was acquired for image processing and analysis. Results indicated that band of 4-5-3 False Colour Composite (FCC) was the best combination for the purpose of the study since it can clearly differentiate the "green" cover. A supervised classification of the image result in 12 classes of "green" cover categories. A total of four classes were allocated as potential sites for the development of a forest landscape map. The overall accuracy obtained for this study was 70%. Urban forestry landscaping and planning has great potential in Putrajaya because the area is still mostly surrounded by a "green" cover.

4.04.02 /4.13.00 Sustainable forest management under conditions of growing global pressures

Possible unfair competition from international taxation differences: examples from Scandinavian and other selected countries

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Keywords: Taxation, Forestry, Scandinavia

This paper will deal with taxation of forestry, both in principle and with description of the actual tax scheme in some selected countries. Forestry taxation is of course part of the general tax regime in each country, but in this paper the emphasis is attached to possible special taxation conditions to forestry.

The main purpose of a national taxation scheme is to confiscate capital from the citizens for public use. in addition to this main purpose, there can be many other purposes the politicians also want to stimulate for instance development of forestry.

In forestry it is most common that income assesses directly to the annual result. Both in Sweden and Norway there are different possibilities to distribute the annual result for a couple of year. The mean reasons to insert these rules is to cut the top of the result in years with special high cutting and with that a high income. Some years ago the marginal tax rates were extreme high in the Scandinavian countries and therefor the permission to distribute the result for several years was of big importance.

To day the marginal tax rates are lower so the distribute rules are of less importance than earlier.

Another way to assess the yield of forest is to use sustainable yield, annual increment or area of productive forestland as base for taxation. The taxable amount is for example total annual increment or total productive forestland multiplies with a standard value. in Norway the annual increment was the base for income taxation till 1954 as the productive forestland was it in Finland down to 1993. Finland has now changed over to assess the annual result but with a voluntary changeover period till year 2006. The tax system Finland now leaves has given tax advantage to active forest owners and tax intensification for more passive owners.

Directly taxation of the annual result stimulates to save capital in standing timber and forest regeneration, and can in this way be an obstacle to increase the cutting volume. The increase of capital in the forest will not be taxable before the timber is sold.

In some countries as United Kingdom and the Netherlands, forest incomes from woodlands are taken completely out of the scope of income tax. This tax exemption applies to sales of both felled and growing timber, but other incomes as shooting rights are taxable. On the other hand there are no deduction for operating expenses etc. The reasons for the income tax exemption are both to get more standing timber and the multifunctional use of land.

In a lot of countries they are in the beginning to try to use subsidies and tax structure to support environmental quality and sustainable economic development in the forestry.

In many countries they use a lower VAT rate than the standard rate for sale of timber and other forest products. Some of the EC countries also made use of a special system with flat rate for farmers. The flat rate scheme should be a neutral system, but as a matter of fact in some countries the system uses to subsidise the farmers.

International Interdependencies of the Forest Accounting System and Their Effects on Business Management

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Forest business accounting has long proven its positive contribution to management of forest enterprises. Accounting supports the management in monitoring the success of fulfilling the business strategy be it continuation of the business or shareholder value creation. Due to the high proportion of small-scale holdings only a small part of forest management units utilise accounting to support decision-making and information. The variety of business accounting systems around the world is also reflected in the accounting of forest enterprises. While most rules and regulations of standard business accounting can be applied in forest enterprises, some particularities of forestry have posed problems for both foresters and accountants: The nature of the forest asset as appreciating, self-regenerating asset and the long time horizons involved in forestry can be considered as the two most important specific problems.

The valuation of the forest assets and treatment of growing stock changes through growth, management and removals and the reflection of these values in accounts has not only engaged the minds of leading forest economists since the last century, but is also facing forest enterprises and corporations around the world. While the treatment in internal operating accounts is up to the information requirements of the enterprise and therefore developed individually to the demands of management, the financial reporting legislation determines the reflection of forest assets in external accounts.

Globally a number of methods has been developed to capture forest values and their change in accounting, but a both accurate and feasible method remains elusive.

The different methods contrasted using examples from Europe, North America, Asia and Oceania show the interdependencies of forestry accounting practices with cultural traditions, forestry practices, legislation, economic theory, etc. Differences as paramount as the distinctions between Central European small-scale forestry, Tropical concession forestry or large-scale plantation forestry in Oceania also exist in the different methods of accounting for the growing stock and its changes.

While international accounting harmonisation aims at improved comparability and the emergence of multinational forest industries results in increased attention from the accounting profession, the task of finding more accurate and workable methods will remain a challenge for the next millennium.

The Evolution of Forest Regimes in India and China (A Comparative Analysis)

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Neo-classical framework based on profit maximization leading to a single equilibrium is not sufficient to understand the dynamics of forest regimes. in the world of imperfect markets, transaction costs, and uncertainties, the observable regularities are not a solution to a static problem, but are outcomes that understandable dynamic processes have produced from known and plausibly conditions in the past. These dynamic processes can be understood in the framework of evolutionary economics which has the elements of increasing returns, path dependence, multiple equilibria, institutional hysteresis, and adaptive efficiency. The dynamics of forest regimes in India and China is analyzed in this framework. in India, forest regimes have completed a full cycle from the community regime in the pre-British period through state regimes during the colonial period and the first post-independence phase, and finally back to community-based regimes in the 1990s. in China, forest regimes have also completed a full cycle but starting from private ownership in the hands of landlords and bureaucrats prior to 1950's and reverting back to private regime in the form of household responsibility system in 1980's. in India, during the colonial period, change in forest regimes has been discontinuous but path-dependent in a geographical sense which reflected organizational inertia of colonial structure developed in other countries. in the first phase of post-independence period, many self-reinforcing mechanisms such as increasing returns organizational and institutional inertia, and adaptive expectations contributed to temporal path dependence. in the second phase, forest regimes have moved closer to adaptive efficiency. in China, in late fifties and early sixties, the transition from private regime to commune system was discontinuous, and was a result of organizational energy similar to change in forest regimes in India during colonial period. However, continuation of commune system demonstrated the prevalence of different elements of path dependence.

The latest reforms, in both countries, can be characterized by search for equity-consistent economic efficiency, devolution of the decision making to local communities, and adaptive efficiency. Multiple equilbria are another common feature in both countries. These common elements and their impacts on sustainable forest management elements from two Asian giants with different governance structures can be used for designing forest regimes for sustainable forest management in developing economies.

Operations research, economic planning and decision models: how can international co-operation help administration and decision making in forest enterprises

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As in most of the research fields, international co-operation is essential to improve the grounding in decision making relative to forest enterprises. The general reasons underlying this statement are probably the same in each part of sciences and refer to the similarities between questions raised in different countries, to the complexity of the real world in comparison with available analysis methods and models, to the weakness of means allocated to research beside the hugeness of the task, and to the continuous change of social demand that requires to solve permanently new problems. Obviously, after they are brought back to the administration and management of forest enterprises, these items are worth being commented.

Forest management has been developed at the international level for about three centuries. France, Germany and Austria have played a major role at the beginning. Methods elaborated in these countries have then been exported to the rest of the world where they have been adapted to other situations and supplemented with new tools, exported in their turn and so on. Thus international co-operation is an historical fact. Today, there is still a more favourable context because common international issues have been highlighted, such as habitat conservation programmes, carbon sink issues, criteria and indicators for sustainable forest management, ecocertification and labelling, environmental accounting.

Decision making is a complex subject that uses advanced developments in operations research, economic theory, statistics and even computer science. According to this complexity, any co-operation is essential to progress, not only interdisciplinary one but also international one. This is all the more true that many new methods are nowadays available, that some fundamental economic concepts are not yet quite clear (*e.g.* discount rate value), that risk and uncertainty are involved in the processes under study, that environmental considerations have to be integrated with economic ones, that biological bases become more and more important in economic models.

It must be recognised that ecology, on the one hand, and forest products, on the other hand, concentrate most of attentions on them. Conversely, only a few researchers work on forest economics in each country. in such a context, international co-operation gives the opportunity to gather complementary approaches on the same subject, to create synergies between researchers, to broader the scope under consideration, to generalise existing methods and, in a dynamic perspective, to increase the chance, when a new problem occurs somewhere, to find first features in another country.

Keywords: decision making, quantitative methods, economic planning, international co-operation, forest management.

Sustainable Forest Management Under Conditions of Growing Global Pressure - Challenges for Forest Enterprises from International Agreements to Market Pressures

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This paper briefly describes some of the recent changes designed to promote sustainable forest management globally. These changes can have important implications for the types of products that reach markets, the cost and availability of various wood products and, importantly, on the comparative competitive position of various regions and countries. The discussion examines these implications with particular focus on the comparative advantage and the comparitive position of various countries for forest products trade. The role of forest certification and ecolabeling is also discussed. The paper argues that the regions advantaged and disadvantaged are importantly related to the "rules of the game" as reflected in the various standards applied for sustainability.

Pricing Carbon Retention by means of Reduced Impact Logging: a Case Study from East Malaysia

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Reduced impact logging in tropical countries enhances the local sustainability of forest management. It also significantly reduces the amount of carbon volatilised during and after logging. For this reason, it may attract finance globally as a means of achieving carbon offsets. A model of forest regrowth and of necromass dynamics allows long-term estimation of the impact of different logging systems on both crop regeneration and on carbon fluxes. Overall, reduced impact logging had the expected advantages over conventional logging. However, there were several kinds of additional financial outlays. Moreover, the reduced volume yield from reduced impact logging means that either a large opportunity cost is incurred; or, to achieve a given level of production, a greater area must be exploited. This spillover effect can be incorporated in cost–benefit analyses. These show that, according to the assumptions made about the appropriate level of analysis and the discount rate adopted, the cost of retaining carbon by reduced impact logging may be much greater, or much less than carbon prices which have been derived in other ways.

Keywords: pricing carbon retention, reduced impact logging

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5.01.00 Wood quality

The control of cambium activity and wood formation in forest trees

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The problems to be dealt with concern the biological control of wood production in forest trees and solutions for improving wood quality and productivity by hormonal modifications. As the vascular tissues are complex, being comprised of several types of cells, they are induced by a number of developmental signals which flow in the axial and radial directions. The hormonal signals control the type of differentiating cells, their wall structure and chemical composition. Therefore, understanding the nature and biology of the signals is needed for improving tree quality and productivity by genetic modifications. Studies on transgenic plants with altered levels of hormones confirm this general strategy for improving wood production and quality. The major signals that control cambial activity and xylogenesis are the following four hormones: auxin, cytokinin gibberellin and ethylene. (1) Auxin is the primary controlling signal involved in all aspects of vascular differentiation. The continuity of the vascular tissues along the plant axis is a result of the steady polar flow of auxin from leaves to roots. Low level streams of auxin induce phloem in strands and phloem anastomoses between the strands, while higher auxin levels induce xylem. Auxin which moves preferably through the cambium controls together with gibberellin, the activity of the cambium. Auxin also controls the gradual increase in vessel size from leaves to roots. During evolution, increased sensitivity of the cambium to auxin occurred in limiting environments resulting in the development of the specialized ring-porous wood that maximized the efficiency of water conduction. The wide earlywood vessels in ring-porous trees are induced by low-level streams of auxin at early stages of bud development. (2) Cytokinin from the roots increases cambium sensitivity to shoot signals and promotes vascular differentiation along the tree axis. (3) Gibberellin which promotes tracheid elongation, has become during evolution a specific signal for fiber differentiation. From the original mechanism for tracheid differentiation in conifers, a combination of auxin and gibberellin, the signals for each xylem element in angiosperms became specific: auxin by itself induces vessel elements whereas gibberellin, in the presence of auxin, induces fibers. Auxin and gibberellin are the factors that control the structure of lignin in the cell walls. (4) Ethylene produced in the xylem seems to be a major signal in controlling the initiation, size and spacing of rays. Ethylene also reduces vessel width, promotes tracheid differentiation in the radial direction and is involved in reaction wood formation.

Wood Quality Challenges and Prospects for the New Millenium

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As the world's natural forest continue to decrease in area and production, the role of plantations will inevitably become more important. They will serve to increasingly supply the wood products needs of expanding populations and simultaneously reduce the need for the harvest of natural forests. The wood characteristics of plantation-grown material cannot be assumed to be the similar to the same species from natural forests: factors which can strongly influence physical properties and performance include:

The potential for plantation-grown wood to supplant natural forests is great because there are greater options for

- species selection
- site and climate
- silvicultural regime
- genotype selection

A large body of research results already exists comparing the wood properties of plantation and natural forests. in some species (eg pines) which exhibit strong juvenile wood characteristics, it is common to observe a decrease in average quality when expressed in terms of properties such as wood density, fibre length, spiral grain. This is mainly because artificial forests are encouraged to growth rapidly and are harvested at relatively young ages, resulting in a significantly higher proportion of juvenile wood. To counteract these, often negative, effects, silvicultural management enables some operations such initial spacing, thinning and pruning and manipulation of felling age to improve general log quality and uniformity (size, shape, branching).

Characteristically, the effects of features such as hidden internal defects, (decay, compression wood) are less in managed plantations.

In some parts of the world, plantations have become the dominant form of commercial forestry during the past 50 to 100 years, and many lessons have been learned along the way. The importance of matching species (and provenances) to available sites is now accepted. There are many examples of outright failures with species which have specific requirements. A broad trend is apparent:

1. Species trials and selection of "winners"

2. Development of management schedules to maximise growth rates

3. Commencement of tree improvement programs focused on volume production

4. Selection and propagation of genotypes yielding desirable wood characteristics

Wood products manufacturers and end-users are increasingly seeking uniformity in wood properties and predicability in performance attributes. We are about to enter an era in which the power of molecular breeding technology will be challenged to extend both the range and uniformity of available wood properties from plantations. Clonal forestry offers some exciting possibilities.

Mechanical Properties of *Acacia mangium* planted in Sarawak, Malaysia

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Ten trees of 13-year old *Acacia mangium* were sampled and fifty-four small clear specimens were tested. The British Standard (BS 373.1957) method on testing small clear specimens of timber was adopted to obtain the strength properties of the species. It was found that the mean values of modulus of rupture, modulus of elasticity and compressive strength tested at green condition were 86.4 MPa, 10.9 GPa and 36.8 MPa respectively. The average moisture content was 114 % and their basic density was 0.51 g/cm^3. Based on their compressive strength, the timber was classified under Strength Group C by Burgess's grouping. It was revealed that the strength properties and basic density were higher at outer portion compared to the inner portion of the wood.

Keywords: *Acacia mangium* small clear specimens, strength properties and basic density

Density and Sapwood Variation of Malaysian-Grown Teak

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Five trees each of plantation-grown teak in Malaysia ages 8 and 28 years were studied. Discs of 50mm in thickness were cut at 10%, 30%, 50%, 70% and 90% heights of the clear bole. The sapwood thickness was measured at four different positions of a disc and an average sapwood percentage was calculated. For the density determination, specimens were obtained from the same disc at two radial directions opposite each other with three samples at each radius. The volume of sapwood presence was fond to be quite substantial in both the 8 years and 28 years old teak. The results of the study also indicate that three was a slight decrease in the sapwood percentage with age. On the variation in density, it was found that the Malaysian-grown teak was comparable to teak found elsewhere. Age of the tree has also been found to have a significant effect on the density of the timber.

Physical and Anatomical Features of *Acacia mangium* planted in Sarawak, Malaysia

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The *Acacia mangium* is a major species planted in the reforestation sites throughout the State of Sarawak. To complement reforestation project, the economic utilisation of this species must be found in order to be sustainable. The utilisation potential depends on the properties of the timber. This study investigated and quantified the physical and anatomical features of 13-year old *Acacia mangium* planted in Compartment No. 8401 and 8402 in Sampadi Forest Reserve, Lundu, Kuching, Sarawak. in this study, 12 timber sample discs were collected at DBH and specimens were made from two strips crossing one another through the pith at 90°. The physical features that are important to the utilisation aspect of the timber are the thickness of sapwood, colour and density.

The anatomical features that have the greatest influence on wood properties and secondary processing are the vessels parameters (such as vessel grouping and arrangement, diameter, content,

frequency and vessel element length), and fibre parameters (such as length, diameter and fibre wall thickness).

The average thickness of the sapwood is 11 mm, whitish in colour and the heartwood is slightly pale brownish to purplish brown on prolonged exposure. Average oven-dried density of 469 kg/m^3, substantial variation amongst trees from 419 to 584 kg/m^3, higher variation within a tree of 340 kg/m^3 at the pith and 585 kg/ m^3 at the sapwood, and density increases towards the sapwood. Mostly solitary vessels, multiple vessels common especially multiple of 2; average diameter of 200 µm*, progressively increases towards the sapwood; 4 vessels/mm^2*; evenly distributed. Average vessel element length of 332 µm that also increases towards the sapwood. The average fibre length is 1,073 æm that also increases towards the sapwood. Fibre length variation is higher from the pith up to 80 mm radially and variation decreases to constant length towards the sapwood. Preliminary findings showed that fibre diameter and fibre wall thickness do not showed significant increases from the pith to sapwood. Preliminary results as some measurements and counting are still not completed and this data will be amended in the paper later.

Effect of environmental factors on the fibre properties of Norway spruce (*Picea abies* [L.] Karst.)

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Wood quality is an important basis for forest industry. While the external features of the trees, *e.g.* branchiness, straightness of the stem, have received attention from tree breeders, the physical and chemical properties of wood have been less studied, except for specific gravity. Until now the pulp and paper industry has examined the physical properties of the fibres and the chemical composition of wood mainly after processing, but the biological aspects related to wood formation have not been studied. However, variation *e.g.* in the fibre length and cell wall thickness, or the chemical composition of the wood have influence both on the quality and quantity of the end products. The variation of fibre properties in pulp could be due partly to the processing methods to methods of forest management, seasonal and environmental factors, and to the genetic characteristics of the trees. The main cause for the variation of fibre properties within-tree is the maturation of the cambium (cyclophysis, topophysis).

We have studied the changes in tracheid length, cell form, lumen diameter and cell wall thickness from the pith to the bark and at various heights in the stems of Norway spruce with image analysis using thin sections cut by a cryo-microtome. A fast and convenient method is described to analyse the dimensions of tracheids from a thin section. The analysis is based on 2-dimensional fast Fourier transformations. Data created by the model will be compared with the original data. Cell wall thickness will be analysed accurately with the method.

The effect of fertilization on wood structure of Norway spruce is also investigated. Trees (34-years-old) have been fertilized and irrigated the last 10 years. The structure of the annual rings is compared with samples from control trees without fertilization. in this way we could study how mature wood structure is affected by increasing diameter and height growth. According to the preliminary data, cell length decreases slightly with increasing diameter growth but tracheid diameter remains unaffected. Tracheid diameter is correlated more strongly with distance from the pith than with ring number from the pith.

Pulping, Bleaching and Papermaking Characteristics of Some Native Sumatran Hardwoods

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Thirty-seven native species of Sumatran hardwoods were collected and analyzed for their chemical compositions. Subsquent to kraft pulping, bleaching and handaheet making, their pulping characteristics were elucidated. Lignin content of the woods ranged from 37.6 to 20.2%, averaging 29.6%; holocellulose contents were 76.7 to 55.7%, averaging 68.6%; Alcohol-benzene extractive contents ranged widely, from 1 to 18.1%. Pulp yields ranging from 34.7 to 51.7% of bone-dry wood at an equivalent kappa number of 20. Pulp yields tended to decrease slightly with increasing wood densities. Chemical charges also tended to increase with wood density; but digester efficiency was higher with higher density woods. in terms of pulpability, *Diospyros puntielosa* and *Poyena* sp. were the best, while *Alphonsea javigata* and *Palaquium gutta* were the worst. A standard regime of C-E-D-E-D bleaching sequence could give all the pulps brightness of 80% ISO or better. PC numbers of the bleached pulps were generally acceptable. Average breaking length, tear index, bursting index and compound strength index were 6.94 km, 11.6 mN·m^2 g^{-1}, 4.97 kpa ·m^2 g^{-1}, and 8.83, respepctively. Pulp from Artocarpus eluticus had the best strength index, while

Tetramerista celabra pulp showed the poorest strength index. Bleached pulps showed the same order of strength ranking for these two species.

Impact of precommercial thinning on tree and wood characteristics, Product quality and value in Balsam fir

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Based on a 47-year-old precommercial thinning trial, this study examined the response of various tree and wood characteristics, product quality and value in balsam fir to different thinning intensities. in 1995 (35-year after precommercial thinning), 150 merchantable trees were selected to cover all the merchantable diameter classes in the control, moderate and heavy thinning plots. Based on the sample trees, impact of precommercial thinning on a number of parameters was evaluated at the diameter class level. Parameters studied include tree diameter, tree height, tree volume, tree taper, live crown length and width, length of the log without live crown, branch diameter, bark thickness, wood density, heartwood content, moisture content, log volume recovery lumber volume recovery, lumber grade recovery, lumber dimension recovery, lumber value recovery, lumber strength and stiffness, chip volume and value recovery, chip and paper properties, and total value recovery. Furthermore, this study examined the 25- and 35-year response of selected parameters (e.g., basal area, tree diameter, merchantable volume, product value) at the stand level.

Based on the responses, optimal thinning intensities were recommended for specific objectives and for different industries. Other important questions (e.g., when to thin balsam fir stands, which stands should be thinned) were discussed.

Compared to trees of the same diameter class from control plots, the trees from thinned plots are generally characterized by a shorter tree height, a larger tree taper, a larger live crown width and branch diameter, a shorter length of the log without live crown, a lower tree volume and lumber volume recovery, and a lower total product value recovery per tree. Lumber from trees of the same diameter class in heavily thinned plots has a lower recovery for the best grade, and a lower MOE and MOR value, but moderate thinning has a relatively limited effect on lumber strength and stiffness. On the other hand, tree and wood characteristics, product quality and value vary remarkably with tree diameter.

This study shows that a thinning intensity of 3,500 trees/ha or less is required to achieve a significant gain in tree diameter. Furthermore, precommercial thinning of dense balsam fir stands also increases merchantable wood volume and product value at the stand level. Overall, this study suggests that precommercial thinning of very dense young balsam fir stands appears to be an effective and viable silvicultural treatment. It can reduce rotation age by up to 10 years. A reduced rotation age will also reduce the possible occurrence of rot and decay in balsam fir stands. Furthermore, a larger tree diameter in thinned stands will reduce harvesting and manufacturing costs, and produce larger dimension products. Since the difference in stand value between thinning intensities of 1,000 to 3,500 trees/ha is relatively limited, an appropriate thinning intensity to be taken for balsam fir, to a large extent, depends on what the industry really wants to achieve. For the lumber industry, a thinning intensity of 2,500-3,000 trees/ha is required to maximize the stand (product) value and to produce quality products. For lumber producers whose major objectives are to maximize diameter growth and to minimize rotation age, a heavier thinning intensity of 1,000-2,000 trees/ha could be considered, but in this case product quality may decrease significantly. For both pulp/paper industry and panel industry, a thinning intensity of 2,500-3,000 trees/ha appears to be optimal.

Occurrence of Pith Flecks in Tropical Timbers of Malaysia

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Pith flecks are abnormal parenchymatous tissues embedded in the wood as irregular strands and on longitudinal surface appearing as a streak. Th affected tissues showed large parenchyma cells with random orientation. Pith flecks were formed as a result of traumatic conditions during tree growth, which injure the cambium locally. Such xylem formation may be caused by many factors such as mechanical wounding, harsh environmental conditions (drought, wind or low temperatures), microbial infections or insect attacks. The abnormal xylem may vary in structure according to the cause and tree species involved. Callus may be formed by the proliferation of parenchyma cells adjacent to the cambial injury and eventually restored the orderly divisions of cambial cells.

Normal cells on all sides enclose the callus or pith flecks. The size of the callus pocket presumably corresponds to the extect of the injury. Malaysian timbers showing the presence of pith flecks are those from the family Aceraceae, Alangiaceae, anacadiaceae, Anonaceae, Apocynaceae, Aquifoliaceae, Bombacaceae, Burseaceae, Combretaceae, Casuarinaceae, Celasstraceae, Polygalaceae, Rosaceae, Sapindaceae, Sapotaceae, Sterculiaceae, Theaceae and Thymetlaceae.

5.02.00 Timber engineering

Analysis and classification of acoustic emission waveform

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Keywords: Fracture; Acoustic emission; Signal processing; Cluster analysis; Classification

Detection of AE (acoustic emission) from failure of wood is becoming more important as wooden frame houses grow rapidly in Taiwan. AE is released energy from micro or macro fracture of material. To classify the relationship between wood fracture and AE, AE signals were recorded during the bending test of red oak and their features of AE were extracted and analyzed. The event rate feature might be excellent indicator of loading phase. Features in time and frequency were selected for classification. Cluster analysis showed that AE signals could be successfully classified. Each class might be associated with individual fracture source from fiber breakage, debundling, debonding and matrix cracking.

Predicting the strength of sawn products based on X-ray scanning of logs

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The successful running of a sawmill is dependent on its ability to achieve the highest possible value recovery from the saw logs. Today many sawmills are increasing the amount of customer adapted products. One such trend is that strength graded lumber is becoming more common. When sawing lumber for strength grading in special dimensions it is very important to select the right logs, i.e. the sawmill must be able to predict the strength of the sawn products before the actual sawing operation.

The strength of the sawn products is correlated to density and knottiness. in order to be able to measure internal properties of saw logs an industrial X-ray LogScanner has been developed. Simulations have shown that this scanner can measure variables that would be possible to use for prediction of the strength of the sawn products, *e.g.* knot volume and green density. Hence, the aim of the study was to investigate the possibility of predicting the strength of centerboards from Norway spruce (*Picea abies* (L.) Karst.) saw logs, based on simulated X-ray LogScanner measurements.

The study was based on eight logs. Two fast grown and two slow grown logs from northern Sweden and two fast grown and two slow grown logs from southern Sweden. After CT-scanning, four centerboards were sawn from each log and the modulus of elasticity and the bending strength of the boards were measured. The CT-images were used for simulations of the industrial X-ray LogScanner resulting in simulated measurements of knot volume and the green density of heart and sapwood. Finally multivariate models were calibrated using PLS-regression. These models predict the bending strength and modulus of elasticity based on the variables measured by the X-ray LogScanner. Both bending strength and modulus of elasticity were defined as the mean value of the four boards from each log.

The results were very promising with strong models for prediction of both bending strength (R2=0.73) and modulus of elasticity (R2=0.77). The results also showed that the measured variation of knot volume between different parts of the log explains some of the difference in strength between different centerboards from the same log (R2=0.41).

The study is based on a very small material with a number of special properties. The fact that the logs are of approximately the same dimension and that all logs have relatively large amount of heartwood probably makes the predictions better compared to a larger and less homogenous material On the other hand the large logs have other properties, *e.g.* large pith shakes and four boards from each log, that make it more difficult to predict the strength of the boards.

White Spruce behavior during compression perpendicular to grain

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The intention of this study was to provide an advanced understanding of wood behaviour during transverse compression at ambient and elevated temperatures. in addition the feasibility of a mechanical based model for predicting wood behaviour in transverse compression based on cell geometry and cell wall properties was examined. A new test procedure and apparatus were developed.

This study was carried in two phases: in phase one, specimens of white spruce were subjected to compression tests under microscope at room temperature at three levels of magnifications (low, medium, and high). Wood behaviour at different levels such as: gross behaviour (specimen possessing several annual rings), one annual ring, early-wood, late-wood, cell wall deformation, and mechanism of failure (collapse) was characterized. in addition load-deformation data was collected during compression tests under microscope at low and medium magnification. Geometry of all cells located in one annual ring subjected to compression test was measured. Cell wall properties (modulus of elasticity and yield point) was determined based on transverse compression test results and average cell geometry of same annual rings. The validity of findings of this study was approved during verification tests. The second phase of this study is in process, during this phase the effect of temperature on cell wall properties will be investigated. The results of this study will provide valuable benefits for modelling applications.

Effect of Open-Shed Environment on the Edgewise Bending Properties of Laminated Veneer Lumber

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In recent years, Laminated veneer lumber (LVL) members have been popularly used in the light- and medium-frame of building constructions as headers, joists or flanges in I-beams because of its high strength and uniform stiffness and they can be fabricated in unlimited lengths and/or sizes. At present, most experimental works concerning the structural performance of LVL are conducted under constant relative humidity (RH) and/or temperature. However, LVL is a layered structural wood composite made of veneers which are biological materials and hygrothermal-elastic in nature. Obviously the large fluctuation of RH and temperature in our living environment will have some weakening effect on LVL's structural performance but such information is very limited.

Thus, experiment of long-term exposure of LVL in open-shed environment will provide useful information for wood composite industries to improve LVL's manufacturing design as well as for Timber Engineers to better design structures that are using LVLs as components.

In this study, the effects of open-shed environment on the edgewise bending properties of LVL were investigated. Three types of 13-ply LVL were fabricated with southern pine veneers of B, C, and D grades and liquid phenolic formaldehyde and their layups were: LV L^{-1}: all B grade veneer; LVL-2: two plies of B grade veneer on both faces and all C grade veneer in the core plies; and LVL-3: all D grade veneer. The dimension of specimens was 3.8 cm (thick) x 8.9 cm (deep) x 244 cm (long). Twenty five randomly selected specimens in each LVL type were edgewise bending tested after being exposed under the open-shed environments for one and two years.

Air temperature, as hot as 37.8 C (100 F) and as cold as -9.4 C (15 F), under the open-shed roof was recorded. The highest temperature recorded on the inner surface of open-shed roof was 52.2 C (126 F) while average values of 43.9 C (111 F) and 37.2 C (99 F) were recorded respectively on the top and bottom specimens in the LVL pile when the air temperature was 37.8 C (100 F). During a year, many high RH (90-98%) days were observed while lowest RH recorded was 23%. Testing results from previous studies indicated that structural performance of southern pine LVL was affected by the veneer grade and MOR values: 77.44 MPa, 72.30 MPa and 51.13 MPa and MOEs: 14.64 GPa, 14.25 GPa and 11.56 GPa, for groups of LVL-1, LVL-2 and LVL-3, respectively, evaluated under constant 65% RH and 23.9 (75 F) were used as controls for comparison in this study. After 1-year open-shed exposure, 8.9%, 13.0% and 4.9% reduction in MORs were observed respectively in LVL-1, LVL-2 and LVL-3 and further reductions, 11.4%, 13.7% and 15.3% were recorded in the specimens subjected to 2-year open-shed exposure. The reduction of MOEs for these LVLs after 1-year open-shed exposure was insignificant, and however, 6.6%, 16.8% and 13.1% reductions were observed in the members after subjected to 2-year exposure.

Thus, tests of longer open-shed exposure of LVLs may be needed for the development of models for accurately predicting the degradation rate of MOE and MOR due to the long-term open-shed environmental exposure.

Keywords: Laminated Veneer Lumber, Southern Pine, Bending Strength, Bending Stiffness, Open-Shed Environment.

5.03.00 Protection of Wood from decay and fire

The Effect of Borate Preservatives on Preventing Decay of some Wood Species Used in Egypt

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This investigation was carried out to study the effect of boric acid and borax against wood decay fungi. It also aimed to study the penetration and retention of borate in selected woods. The fungus species, which showed serious affect on poplar wood, were *Schizophyllum commune* Fr. and *Trichoderma viride* (Fr.) Pers. The EC50 values were varied according to preservatives and fungi types. Wide effect of boron compounds against the two species of fungi was detected.

The results indicated that the ability of boron penetration in selected wood species was significantly increased by increasing the wood moisture content. The mean values of penetration in poplar wood were 5.95 mm and 15.32 mm at 12% and 80% MC, respectively. On the other hand, boron retention in seasoned poplar wood was higher than that of the poplar wood of 80% MC in outer layers.

Also, there were significant differences between the retention of boron in *Casuarina glauca* at 12% and 40% MC. This study is considered the first investigation in the wood preservatives field of imported wood species in Egypt.

Keywords: boric acid, borax, penetration, retention, *Casuarina glauca* .

Leaching Characteristics of Water Borne Preservatives According to Tree Species

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In this study, leaching degrees of four different tree species impregnated with Tanalith C-S a waterborne preservative were determined.

Scotch pine, Fir, Beech and Chestnut were impregnated by 3 % Tanalith C-S. Wood samples were prepared in three different dimensions as 50*x*25*x*15, 30*x*20*x*10 and 10*x*10*x*10 mm. Using thirteen different methods leaching degrees of wood samples were determined.

Results showed that, among four tree species the highest leaching was found in Scotch pine. Leaching was found to decrease in the order of Fir, Chestnut and Beech respectively. When comparing the effect of dimension, it was found that there is a linear relation between leaching and sample dimensions. The eluted preservative increased by the increase of sample dimension. Highest leaching occurred in 50*x*25*x*15 mm.

Application of Electron Microscopy in Wood Protection Research

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Keywords Electron microscopy, Wood biodegradation, Wood protection, Preservative penetration, Coating penetration

For decades electron microscopy has played a crucial role in understanding the process of wood formation and has helped unravel those factors and processes affecting the utilization of wood. A notable example of the extensive application of Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) in wood processing is in the field of wood protection research, in particular, wood preservation. Extending the service life of wood requires effective protection of wood from the factors which adversely affect its performance. The methods of protection with wood preservatives and other wood protecting chemicals (including coating materials) vary depending upon the environmental conditions to which wood is exposed. Optimization of the performance of these wood protectants depends on detailed knowledge of the mode of interactions between these chemicals, the wood substrate and their target degrading organisms. Such ultrastructural studies have made significant in-roads in understanding the fundamentals of deterioration in a selection of important tropical and temperate wood species by specialized wood-degrading bacteria and fungi. For example such studies have helped confirm the high preservative or wood extractive tolerance of wood-degrading bacteria and specific rot fungi attacking certain preservative treated and naturally durable timbers, respectively. Indeed a thorough understanding of wood degradation factors, assisted in part by advances in EM, has helped advance the field of wood protection research overall. Examples of the use of electron microscopy in the research work related to these areas will be presented, including studies on wood biodegradation and patterns of penetration and distribution of preservatives, protective coatings and other wood protection and property enhancing substances.

Fire Performance of Hardwood Species

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In this era of performance-based building codes, there is an increased need for models and data pertaining to the fire safety of building materials. in addition to data for the prescriptive regulatory fire tests, material property data are needed to optimize the advantages of the performance-based building codes that are being introduced worldwide. in this review of our research on the fire performance characteristics and fire safety engineering of wood products, we will present results on the fire performance of hardwood species. Two broad areas of fire safety engineering of materials are (1) Fire initiation and growth, and (2) Fire containment.

Fire initiation and growth include ignition, the spread of flames, and fire growth to flashover conditions. The introductions of heat release calorimeters in the 1980's reflect the changes from older prescriptive fire tests to tests that produce data suitable for fire safety engineering analysis. With information on ignition characteristics and heat release rates, it is increasingly possible to model the spread of flame over a material and the fire growth in a room. The best known of the heat release calorimeter is the cone calorimeter. The worldwide use of the cone calorimeter has increased the availability of information on ignition, heat release and smoke development of materials. Research in this area includes a study on the fire performance of hardwood plywoods.

Fire containment is mainly the fire resistance or fire endurance of structural members and assemblies to contain a post-flashover fire. Unlike the tests for fire growth, the test for fire resistance of members and assemblies has remained essentially the same throughout the world. The fire endurance of wood members often depends on the charring rate of the wood. The charring rate of wood has been extensively researched. Recently, the charring rates of composite lumber products of both softwood and hardwood species have been investigated.

Like most wood properties, fire performance properties are affected by density, moisture content, and chemical composition. The high densities of many hardwoods contribute to relatively low flame spread indexes and slow charring rates. However, the low lignin content of the hardwood species reduces the residual char content which results in higher flame spread index and faster charring rates. Fire retardant treatments can be used to increase the residual char content. The limited extractive contents of hardwood species contribute to reduced flame spread and heat release.

Wood protection of six U.S. species by NHA: the wood anatomical perspective of fungal decay

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Progress in understanding the mechanisms of wood decay has not resulted in concomitant improvements in protection of wood from decay. Most wood preservatives fail to target decay-specific processes, but rather are broad-spectrum biocides. in part, this failure comes from a lack of understanding of wood itself, how wood preservatives bind to and interact with wood, and the steps fungi must use to colonize wood in order to destroy it.

Sapwood of six U.S. species with different pit types were selected: spruce (*Picea sp.*), red pine (*Pinus resinosa*), western red cedar (*Thuja plicata*), northern white-cedar (*Thuja occidentalis*), yellow birch (*Betula alleghaniensis*), and poplar (*Populus sp.*). Blocks were cut into 19 mm cubes and then were vacuum treated with a 1% aqueous solution of the calcium precipitating agent N-napthaloylhydroxylamine (NHA). Half the treated samples were leached for two weeks in daily changes of distilled water, untreated control blocks were added, and then all blocks were subjected to a modified ASTM D-2017-81 standard soil-bottle test. Three bottles were prepared for each treatment (leached, unleached, and untreated, per fungus, per wood species) with two blocks per bottle. Four fungi were used: the brown-rotters MAD 698 *Postia placenta*, MAD 6137 *Tyromyces palustris*, MAD 617 *Gloeophyllum trabeum*, and the white-rotter MAD 697 *Trametes versicolor*. One block of each treatment was removed at four weeks and another at eight weeks and was sectioned for light microscopic evaluation of colonization progress. At twelve weeks, the remaining four blocks were ovendried and weight losses were calculated.

Anatomical observations were broken into two categories; comparisons among the softwoods and comparisons among the hardwoods. Four softwoods were chosen to represent variations in specific and general features. Spruce and red pine both have axial and radial resin canals and ray tracheids, but red pine has large fenestriform cross-field pits and spruce has small piceoid cross-field pits. Northen white-cedar and western *red cedar* are softwoods that lack resin canals but have taxodioid cross-field pits. These pits are smaller than those of red pine, but larger than those of spruce. Furthermore, northern white-cedar is known to have a differentiated torus in the circular bordered pits, whereas western *red cedar* lacks a well-differentiated torus.

The hardwoods were chosen because they are diffuse-porous woods with similarly sized vessels and little axial parenchyma. Birch has scalariform perforation plates while poplar has simple plates, but the spaces between bars are ample for hyphae to pass through with ease. The major differences between these woods are in the nature of the pitting; birch has minute intervessel and ray-vessel pits whereas poplar has large intervessel pits and large, simple ray-vessel pits.

With the exception of *Tyromyces palustris*, which caused an average of 25% weight loss in both unleached and leached samples, the fungi caused generally less than 10% weight loss in unleached NHA-treated blocks, and roughly 13% weight-loss in leached blocks. The untreated blocks showed an average of more than 45% weight loss. By light microscopy, differences in the degree of colonization and visible damage to the wood between untreated, leached, and unleached blocks were evident at both four weeks and eight weeks.

The anatomical observations indicated that NHA did not prevent colonization of any of the woods studied. Despite this failure to prevent colonization, NHA did decrease the weight loss caused by these decay fungi.

Current experiments examining the potential cytotoxic properties of NHA are incomplete, but suggest that NHA protects wood in part by inhibiting normal cellular processes in basidiomycete fungi, rather than targeting wood decay mechanisms as expected. Localizing the preservative to the pit membranes is nonetheless an elegant delivery system perhaps fungi, which typically seek the pits to pass from cell to cell, encounter locally high concentrations of a toxic substance and are partially thwarted.

Common Problems of Inadequate Treatment of Mixed Species of Peninsular Malaysian Hardwoods with Copper-Chrome-Arsenic Preservatives for Structural Use

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Industrial timber preservation has had a long history of development in Malaysia, virtually from the time when the nation's sawmill industry developed from about the beginning of the twentieth century. Wood preservation research in Malaysia began in 1918 with research activities focusing treatment of Malaysian hardwoods of quality strength and permeability with oily creosote for use as railway-sleepers and in ground-contact. Performance of such wood products was gauged from numerous wood durability field trials conducted by The Forest Research Institute Malaysia (FRIM) particularly through the 1930's and 1950's. From these trials commercial hardwoods of high strength group and permeability with preservatives were identified apart from the durable woods, and many of these woods are members of the Dipterocarp species. >From the 1960's the water-borne Copper-Chrome-Arsenic (CCA) gradually replaced creosote for both economical and environmental reasons, with the introduction of the Bethell process in the country. Through much of the 1980's and 1990's, shortfall in quantities of commercial logs has led to the wider treatment of lesser used species conveniently grouped as the mixed hardwoods with a mixed of dense and light material and preservative permeability. The wider use of competing materials made of concrete and galvanized irons from the late 1980's have replaced treated wood for ground-contact applications. Currently practically all CCA treated hardwoods in Peninsular Malaysia are used in the building industry for roof and ceiling construction (roof rafters, purlins and battens), and essentially for above-ground contact.

Occurrences of inadequate treatment of such wood products with CCA in the building industry are not recent, being a major factor prompting the preference for alternative construction materials for ground-contact use since the 1980's. Due to changing availability of wood resources, an increased utilization of lesser used mixed hardwoods with a dearth of research on their wood properties and inadequate appreciation of correct industrial wood treatment or pre-treatment conditions, are among the common problems in the production of quality CCA treated wood.

Inadequate treatment of hardwoods with CCA is also attributed to the lack of a regulated wood treatment industry, despite the existence of official national standards on wood preservation in Malaysia. Inadequacies of certain specifications of CCA treated wood in these national standards and building by-laws also need to be redressed.. The inevitable abuses of preservative treatment with CCA, in the midst of a price- (versus quality-) competitive domestic market for CCA treated products has prompted action for improvement in wood treatment. This paper highlights the wide range of mixed species Malaysian hardwoods used in the building industry and their relative permeability to CCA preservatives, wood durability or strength groupings, examples of poor pre-treatment timber conditions, adoption of inadequate Bethell process treatment schedules, and examples of inadequate preservative penetration and retention versus that for for well treated mixed hardwoods. A summary outline of a national quality control system for CCA treated Malaysian hardwoods is proposed to overcome production of CCA treated wood which does not meet the required preservative retention for protection against a termite and decay hazard in the country.

5.04.00 Wood processing into the next millenium (I)

Control of quality of sawn wood in the state of Paraná, Brazil

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Palabra clave: Calidad de madera asserada, Paraná, Brasil.

Las ventajes del control de calidad en el sector maderero son obvias, pero en Brasil el es solamente praticado en las maderas aserradas destinadas para exportación. Asi es que se percibe la necesidad de realizar trabajos de investigación con el objetivo del control de calidad en la industria maderera en general, y principalmente en aserraderos, donde el problema es mayor, con un gran desperdicio de matéria prima y generando mayores costos de producción.

El trabajo desarrollado en el Centro de Estaciones Experimentales de Cangüiri, de la Universidad Federal de Paraná, localizadado en la región metropolitana de Curitiba, Paraná, tuvo como objetivo principal la determinación de calidad de la madera aserrada de 60 rollizos de *Pinus spp*, por el método de clasificación por defectos.

Los rollizos fueron clasificadas en 6 clases segun la longitud y la distribuición diamétrica, con 10 rollizos en cada clase. Estos rollizos fuerón aserrados en sierra sinfin ancha para retirar los costaneros, sierra circular para retirar recortes y sierra circular pendular para despuntes. Fue realizada la clasificación visual cualitatiba de las tablas, antes de secar, con base en las normas TB 397, NB 1381, PB 1560, CB 205 e EB 2169, elaboradas por la ABNT (Asociación Brasileña de Normas Técnicas) para clasificación de madera aserrada de coníferas provenientes de rreforestación para uso general, adecuadas por las investigadoras.

La calidad de las tablas fue evaluada segun 4 clases: en la 1ª clase ausencia de bolsas de resina y médula y el número y gravedad de los defectos deberia ser menor en relación a las clases posteriores. En la 2ª clase podria presentar médula en menos de la mitad del espesor y menos de 1/3 de la longitud de la tabla, diferencia entre una extrenidad y otra de la tabla en espesor deberia estar entre 0,2 cm e 0,5 cm y la diferencia de ancha entre las extrenidades de la tablas entre 0,2 cm y 0,5 cm. La 3ª clase fue dividida en dos sub-clases A y B, siendo que na sub-clase 3A a diferença de espessura y largura entre uma extremidade y otra da tablas deveria ser mayor que 0,5 cm, con corteza ocupando menos de ¼ do longitud de un o ambos lados de la tablas. La sub-clase 3B deberia tener las mismas especificaciones de la sub-clase A, pero con corteza ocupando mas de ¼ de la longitud de un o ambos lados de las tablas.

Después de la clasificación, el nível de calidad fue através de la observación del mayor número de tablas en determinada clase. Do total de 193 tablas analizadas, 38 tablas pertenecierón a la 1º clase (19,69% del total), 26 a la 2º (13,47%), 105 a la 3ºA (54,40%) y 24 a la 3ºB (12,44%).

La evaluación de los resultados mostró claramenta la falta de calidad de la matéria-prima y del proceso de aserrado convencional en aserrraderos de pequeño porte, pues mas de 50% de las tablas fueron clasificadas como de 3ª clase. La inferioridad de calidad puede ser atribuída a los equipamientos y a las técnicas utilizados, además del poco entrenamiento de los operadores.

Se sugiere la utilización de equipamientos y técnicas mas modernas, uso de sierras com dientes menos gruesos y equipamientos com menores desvios de corte, realización de manutención preventiba y adecuada de los equipamientos de las sierras, aserrado de los rollizos con mayores diámetros y longitudes, siendo estos de mejor calidad.

Workplace improvement program for the furniture industry in Malaysia

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The furniture industry in Malaysia has played an important role in the country's economic growth. The growth in furniture export is very impressive from RM 171 million in 1989 to over RM 2.8 billion in 1997. There are over 2000 furniture manufacturers in Malaysia, of which over 200 manufacturers are engaged in the export of furniture and the remaining are small- and medium- sized enterprises. Being small- and medium- sized entrepreneurs, they are very busy looking after problems of finance, production and marketing giving them very little time to spare for improving environment of workplace, operational safety and efficiency, motivation and efficiency of workers and their welfare.

A project entitled "Environmental improvements in the wood processing industry" had been funded by Danish Cooperation for Environment and Development (DANCED) and executed by Forest Research Institute Malaysia (FRIM) since October 1996 and ended on October 1998. Under the project there were three main activities viz. 1) clean technology, 2) waste management, and 3) occupational health and safety. It was under the third activity that a workplace improvement program was adopted and introduced to two groups of furniture companies in assisting them to identity and implement areas of possible improvements. The program is based on the Workplace Improvements in Small Enterprises (WISE) methodology developed by the International Labour Office. It aims to demonstrate to entrepreneurs and workers that better working conditions can result in higher productivity and improvements in quality of work. For example, simple measures such as the regular cleaning of the work area and machines, improved lighting or proper storage of materials, can reduce work hazards while upgrading efficiency. Well designed equipment and organisational improvements can increase the efficiency, motivation and capability of employees, while reducing fatigue, strain, absenteeism, and labour turnover.

Activities in the program are oriented in according with the concept of learning by doing and the participation of participants are greatly encouraged through trained facilitators. These activities are outlined and described in this paper. These include visiting participating companies by the program facilitators, workshops to present technical subjects and ideas, and two intermediate periods for preparing action plans and implementing proposed improvements. All these activities were spanned over a period of one month. Follow-up workshops were carried out in 5 - 6 months' time after the completion of the above activities as a mean to monitor the progress of the participants in relation to the implementation of improvements and to provide any technical assistance as needed.

Achievements of the program were highlighted based on the results from the two groups of companies. These are supported with statistics on the planned improvements and also on the improvements that were fully implemented. Examples of improvements are selected to illustrate the situations before and after implementation. These cover areas on material storage and handling, work station design, lighting, productive machine safety, control of hazardous substances, welfare facilities, work organization, ventilation and premises. A reasonable balance between the productivity and occupational health and safety side of the implemented and the planned improvements can be seen from the results of the WISE program.

CT-scanning during drying

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Wood drying has been studied for several years on a more fundamental level, as well as in more applied projects often in co-operation with the wood working industries. in such projects the objective has often been either to develop fundamental mathematical models for the moisture migration within the wood during drying, or on an applied level, to optimise and construct drying schedules for different wood species and plank dimensions.

A serious drawback in such cases is often the lack of reliable experimental techniques for verifying moisture migration models by in situ measurements of the moisture redistribution. Such techniques should ideally be non-destructive in order not to disturb the drying process. The development of medical CT-scanning technology has made it possible to make high-resolution X-ray images where the X-ray attenuation is converted to a density image by image processing of for instance a cross section of wet wood, or even more interesting, wet wood during drying.

Green wood contains a lot of water; often the weight of the water is more than the weight of the dry wood substance. Most of this water is capillary bound in the sap wood portions of a plank, while approximately 30% of the moisture content is bound in the cell walls by hydrogen bonding. The moisture migration mechanisms are quite different for these phases: The bound water moves mainly with the vapour partial pressure acting as the major driving force, while the capillary water migrates from interior to the surface driven by capillary forces.

If free water is present in the sapwood, the density will be affected in a significant way. This fact makes it possible to use CT-scanning for determining the decrease of density caused by for instance air circulation or micro-wave drying of a piece of wood. The X-ray attenuation values are then transformed into density levels, which in turn can be visualised by adopting image processing which correlates colours to density levels.

Using such CT-scanning technique during drying experiments of green wood, we have been able to show some significant phenomenon that are of major interest for modelling moisture transport in sap wood as well as to reaching a phenomenological understanding of the process. Also, the formation of surface checking and cell collapse can be studied simultaneously.

The conclusions for soft wood of pine and spruce are
- A receding evaporating front develops in green sap wood creating a thin dry shell between the surface and the evaporating front
- The resistance to water flux within green sap wood is little as long as there is capillary contact in the wet portion of the wood
- The heat- and mass transfer flux between the ambient air and the evaporating front controls the drying rate during the capillary regime of drying
- Since heat- and mass transfer controls the drying process in the capillary regime, industrial kiln dryers can be constructed for much higher power input than what is normally the case today. The drying time can thus be dramatically shortened for sap wood planks without causing damage to the wood.

Sawing characteristics and mechanical strength properties of branchwood of *Aningeria robusta* and *Terminalia ivorensis*

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Keywords: Branchwood; Sawing characteristics; Lumber yield; Specific gravity; Strength properties

In Ghana, it is estimated that for every tree felled, nearly 50% of the tree volume are left in the forest in the form of branches and stumps. To ensure that timber harvest can be sustained into the future, there is the need to utilise a greater proportion of the total tree volume. in this regard, sawing characteristics and mechanical strength properties of branchwood of *Aningeria robusta* and *Terminalia ivorensis* were determined to clarify the suitability of branchwood as raw material for downstream processing at the wood industries. Sawing tests were then conducted on branchwood of *Aningeria robusta* and *Terminalia ivorensis*. The log length was 2 m and its diameter ranges from 10 cm to 25 cm. The machine used for the log breakdown is a horizontal mobile bandmill. The saw blade (spring set) had the following dimensions: tooth pitch 22 mm, width 30 mm, kerf 1.6 mm, gullet depth 5 mm. The logs were grouped into four diameter classes and sawn into boards of dimensions 25 mm ? 75 mm using live and cant sawing patterns. The surfaces of the sawn lumber were examined for woolly or fuzzy grain, knot, pinworm holes and washboards. They were then graded into first and second grade boards. It was observed that washboards were induced on some of the boards from *Terminalia ivorensis*. There was absence of woolly or fuzzy grain on all the boards from *Aningeria robusta* and *Terminalia ivorensis*. The mean lumber value yields for first grade boards from *Aningeria robusta* and *Terminalia ivorensis* were 25% and 20% respectively, and the mean lumber volume yield was 40% for *Aningeria robusta* and 32% for *Terminalia ivorensis*. Within each diameter class there were no significant differences in lumber yield between live and cant sawing patterns. However, significant differences in lumber yield exist between some of the diameter classes.

The bending strength, modulus of elasticity, compressive strength, tensile strength and shear strength of small clear test specimens of standard dimensions from branchwood of *Aningeria robusta* and *Terminalia ivorensis* were determined. in addition, the moisture contents and nominal specific gravity were also determined. The results of this study indicate that branchwood of *Aningeria robusta* and *Terminalia ivorensis* were more hygroscopic, that is, their green moisture contents based on the oven dry weight were higher than that of their corresponding stemwood. It was observed that the moisture content has an influence on the strength properties. in particular, as the moisture content increased, the strength properties decreased and above the fibre saturation point the strength properties of branchwood did not further decrease but remained constant. It was also observed that the nominal specific gravity of branchwood was higher than the nominal specific gravity of the corresponding stemwood. The specific gravity of the heartwood from a branchwood was higher than the specific gravity of the sapwood whereas for stemwood the reverse occurred, that is, the specific gravity of the sapwood was higher than the specific gravity of the heartwood. Statistically, there were no significant differences between specific gravity of branchwood and stemwood. This indicates that the branches used for the study are not reaction wood or tension wood. The strength properties of the branchwood were slightly less than the strength properties of the corresponding stemwood. Within species, there were no significant differences between strength properties of branchwood and stemwood. However, there were significant differences in strength properties between species. Branchwood of *Aningeria robusta* exhibited the highest strength properties. Judging from the results obtained for lumber yield and strength properties, it is satisfactory to use branchwood of *Aningeria robusta* and *Terminalia ivorensis* as raw material for downstream processing.

Plasma and corona treatments of wood: modification of surface properties

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The durability of an outdoor wood-coating system is low, especially when the coating is a stain. The most important degradations come from the dimensional variations of wood which strain the coating and lead to its cracking. Thus the service life of a wood coating system can be increased through different routes:

- improvement of the coating flexibility: it can be obtained by decreasing the glass transition temperature (Tg) below the temperature of use. But in this case the coating is more sensitive to water.

-dimensional stabilization of wood: thermal and chemical treatments (acetylation) are efficient but most of them decrease the wettability of the wood surface and therefore the adhesion of the coating is no more guarantee Surface treatments are convenient either to improve wettability and therefore coating adhesion or to decrease wettability in order to provide an extra protection.

That is why plasma and corona treatments have been applied to wood in two ways:

-the first one consists in improving the wettability of wood surface to increase the coating adhesion especially after a thermal treatment. First experiments consisted in selecting treatment parameters (type of gas, treatment duration, power) leading to better surface characteristics of wood, before and after thermal treatments. Plasma and corona treatments are effective to improve the wettabilty of wood but no improvement of the coating adhesion has been observed.

-the second one consists in decreasing the wettability so that the surface becomes waterproof. Some tests have been performed to deposit thin films (based on ethylene or flourine) by plasma or corona treatments. This kind of deposits can be considered either on bare wood or on coated wood with a low Tg stain, that is to say a stain whose sensitivity against water will be solved thanks to this kind of films. This is the aim of an on-going research programme.

New Opportunities in Forestry for the Woodworking Industry in the Russian Federation

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Since financing for forest operations is presently limited and only 25 percent of the allowable cut is harvested, forestry in the Russian Federation should be more oriented to demands from industry. More than half of the timber harvested in Russia is directed to saw mills. Large-scale saw mills profitably produce chips, but the chip production at small saw mills is not always profitable. Possibilities to increase the chip production are not realistic in the near future because of large investments needed for the further stages of the production process. So the main customers for timber from the forests are saw mills and woodworking enterprises. The number of small saw mills (which produce less than 10 thousand cubic meters of lumber per year) is increasing.
For these smaller mills, it is critical that the quality of raw materials should be strictly determined. The present study was conducted to find some opportunities for the Russian forestry and woodworking industry to work more efficiently under current economic conditions.

Information was obtained from interviews with managers of saw mills, woodworking and forestry enterprises. For one woodworking enterprise, an analysis for profit maximization was done with the help of linear programming methods.

Presently, the importance of wood quality by saw mills and woodworking enterprises has not been stressed. Many forest management approaches, which originated under the old centrally planned system, can produce obstacles for development in the new economic environment. If an enterprise does not take into consideration the features of the present economic system, the enterprise can lose considerable money. There are also some logging technology features which are not favorable for wood quality identification. But on the other hand more and more managers of saw mills and woodworking enterprises have begun to realize that wood quality could be a key factor in making a profit. in the centrally planned economy, forestry was oriented to volume of material and not necessarily to wood quality.

Most timber is harvested in natural forest stands, where wood quality characteristics are more varied in comparison to planted stands. The level of wood quality on a volume basis can be determined by three different quality characteristics: knot-free timber, timber with sound knots, and timber with unsound knot. These quality characteristics are not taken into consideration in the present inventory system. New methods are needed to evaluate timber quality to meet the specific needs of the saw mill.

Keywords: quality, forest inventory, sawmills, economics

5.04.00 Wood processing into the next millennium. II

Performance of Coated Carbide Tools in Cutting Wood-Based Materials (The Effect of Coating Materials and Cutting Speeds on the Wear, Noise and Forces Characteristics of the Coated Carbide Tools)

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Keywords: coated carbide tool; tool wear; cutting speed; turning; wood-chip cement board

Introduction

Machining wood-based materials such as particleboard or wood-chip cement board causes cutting tools to wear out much faster than machining solid wood. Rapid dulling of cutting edge of steel router bit, saw teeth, or other cutting tolls when machining particleboard is well-known occurrence. Furthermore, the use of tungsten carbide tool, which is widely used in the wood working industry for cutting particleboard is also limited because of relatively high rate of wear. An effort of coating the surfaces of the carbide tool with a hard coating material has been already developed in order to increase the wear resistance of carbide tool.

Experimental procedure

This paper presents the performance of coated carbide tools when turning wood-chip cement board. Coating materials studied were titanium, carbonitride (TiCN), titanium nitride (TiN), chromium nitride (CrN), and titanium aluminumnitride (TiAIN), which were synthesized on the P30 carbide substrate. Cutting tests were performed in turning at cutting speed of 30, 40, 50, and 60m/s and feed of 0.05mm/rev.

Results and discussion

The results of the study that the coated carbide tool provides better performance especially in reducing the progression of tool wear and in retaining lower cutting forces and noise level compared to the uncoated P30 carbide tool at every cutting speed performed. The TiAIN coated carbide tool could be the best in retaining a gradual increase in these values with an increase in cutting speed. Furthermore, the results in Table 1 will suggest that the TiAIN coated carbide tool will provide wider ranges of cutting speed in its application. TheTiCN coated carbide tool was the lowest both in amount of wear and rate of wear cutting speed of 30 m/s, however these values after cutting speed of 50 m/s increase drastically and matched with those of the CrN and TiN coated carbide tools investigated. Therefore, the TiCN coated carbide tool would be suitable to be used only for low cutting speed, by considering that the TiCN coated carbide tool retain hardness at the low cutting speed due to the cutting tool temperature (435°C) fell under its limit oxidation temperature (435°C).

Table 1. The amount of clearance wear (μm) at final length (5 km), the rate of wear of the tools investigated and cutting temperature during cutting at four different cutting speeds

Tools	**Cutting speed (m/S)**			
	30	40	50	60
Uncoated P30 carbide	125 (39.0)	247 (118.0)	289 (167.9)	399 (276.5)
CrN coated carbide	112 (37.3)	228 (112.9)	283 (159.8)	335 (241.5)
TiN coated carbide	90 (35.0)	169 (76.6)	278 (163.3)	324 (242.7)
TiCN coated carbide	76 (24.2)	139 (61.6)	270 (164.5)	343 (276.1)
titian coated carbide	78 (25.7)	83 (33.4)	104 (47.4)	110 (52.2)
Cutting temperature (°C)	435	630	800	1010

Values in the brackets determine the rate of wear.

Both the cutting forces and noise level of the tools investigated increase with an increase in cutting speed, and could show the same behavior during the progression of the tool wear. High cutting forces generated during turning with high cutting speed are probably causes by more wear attained by the tools for the high speed turning. Then, the high noise level for the high cutting speed is probably due to high impact force to be imposed on the cutting tools.

An overview of the light organic solvent preservative (LOSP) treating of *radiata* pine: Modelling of solvent loss, residual solvent composition, and paint adhesion

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Radiata pine boards were treated with a light organic solvent preservative solution, placed in a randomised manner in a timber stack of five layers and the residual solvent loadings in the boards were monitored over time by measuring weight change. An exponential model was fitted to the residual solvent loading data, expressed as a percent of the initial solvent loading, to allow calculation of solvent loading, at any position in the timber stack at any time, over the 108 day trial period. The exponential model was linearised by a natural log transformation in order to estimate parameters of the involved variables in the model, i.e. time and the x, y and z positions of each board in the timber stack. A stepwise multiple regression procedure was used to select the significant variables in the model. The coefficient of determination (r2) for the fit of the model to the data was 0.88.

Solvent uptake, rates of solvent evaporation and consequent change in the composition of the residual solvent in another set of LOSP treated pine boards were examined. The variability in LOSP uptakes in timber was large and was attributable to the natural heterogeneity of timber.

There was a measurable difference in residual solvent composition in samples taken from the centre and from the outside of treated boards. The solvent composition of samples taken from the boards at various stages of ventilation shows, as expected, a relative increase in the concentration of the higher boiling alkylbenzene components.

The control of residual LOSP solvent content appears to be the single most important factor affecting paint adhesion on *radiata* pine wood and its impact is seen strongly with a paint system combining oil-based and water-based paint layers. Results show the average residual LOSP solvent after ventilation was 51 % of initial uptake at 13 days, 36 % (22 days), 23 % (41 days) and 18 % (92 days). Blocking (sticking together of paint surfaces) was high for the acrylic primer and low for the oil-based primer. Acrylic layers dried rapidly through water evaporation while oil-based paint layers cured slowly through solvent evaporation and paint resin oxidation. Adhesion failure was highest where acrylic undercoats or topcoats were applied over an oil-based primer/undercoat when the initial LOSP solvent uptake was 30 L/m^3 or higher. Adhesion failure, while decreasing 92 days after painting, was still significant.

High-Temperature Drying of Black Spruce for Value-Added Products

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High-temperature (HT) drying in eastern Canada has been so far mainly applied to softwood lumber used in construction. The lumber is thus dried to an average final moisture content (MC) of about 15% with an allowable fairly large variation in the MC between boards. The export markets for dimension lumber becoming more and more competitive, and because of the imposed quotas on Canadian softwood dimension lumber exported to the US, the lumber industry in eastern Canada is looking for ways to diversify its production. The remanufacture of lumber into value-added products such as doors, furniture and windows appears to be a very attractive alternative. A great proportion of the dimension lumber manufactured in eastern Canada comes from high-temperature kiln dried black spruce (*Picea mariana* Mill.) B.S.P. This species is in general fairly easy to dry although its tends to show severe warp when being dried at MC's below 10%.

The ultimate goal of this project was to develop a HT drying strategy for black spruce lumber with respect to the production of value-added products dried at low moisture contents. The specific objectives were to develop: 1) a HT drying strategy that leads to a final MC of 10% with 90% of the boards between 8 and 12%; 2) a HT drying strategy that minimizes warp and check formation; and 3) a HT drying strategy that minimizes residual stresses and final MC gradients.

Dimension stock of 2.4 m in length and 42 mm x 69 mm in cross-section (2x3) was kiln dried using two different drying schedules and two levels of top-load restraint. Eight matched batches of 182 studs each were dried in a 2.5 m^3 capacity HT steam-heated laboratory kiln. All the required measurements were taken before drying (width, thickness, weight, twist, bow and crook). The same measurements were repeated after drying and the final MC was measured in two locations of each stud with a resistance-type moisture meter. Warp was assessed after planing the lumber to a final size of 38 x 64 mm. A sample of 25 studs was resawn across the thickness and another one across the width into two identical pieces which were measured for warp again. Internal checking was assessed from the resawn face of each of these pieces. Profiles of residual stresses across the thickness were also determined on some of the studs. The results showed that high quality products can be obtained from black spruce dried at low moisture contents by the high-temperature drying process. The drying strategy has, however, to be adapted accordingly and the drying time increased substantially. Presteaming and top-load restraint were shown to be effective ways of controlling warp in both the raw product and the resawn lumber, although a good proportion of the pieces with diagonal grain or spiral grain were affected by internal checking.

Measurement of Internal Features in Logs

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Today many sawmills strive for an increasing amount of customer adapted products. in a customer adapted production it is crucial to be able to select the right logs for a certain product, i.e. we must be able to predict the properties of the sawn products before the actual sawing operation.

There are several systems used in sawmills for the scanning and automatic grading of logs. These systems use either optical scanners or gamma-ray scanners. The optical scanners used for grading logs measure the log diameter every 10 mm along the log in two or three directions. From these consecutive diameter values new variables such as taper, butt taper and bumpiness are calculated.

With the aid of these new secondary variables, statistical classification algorithms can be developed. The gamma-ray scanner called Tina is principally used in the same way, but Tina is using green density variables together with the outer shape variables for prediction of the internal log quality.

The log-grading scanners described above have so far been more or less focused on normal export grades for commodity products. in the future it is anticipated that the selection of sawn timber for a specific customer will be more and more based on a specific feature or some specific features. in order to be able to measure specific internal features of logs an industrial X-ray LogScanner has been developed. The measurement performance for this X-ray

LogScanner has been studied. The objective with this investigation was to determine if it is possible to develop accurate models for knot volume, knot type, annual ring width and distance between whorls using a LogScanner with two modern industrial X-ray sources. The study was based on simulated signals from the LogScanner.

The study shows that when the different models were tested against a test set the strongest model had a R2 =0.95 (the distance between whorls for Scots pine) and the weakest model R2 = 0.66 (the annual-ring width for the twenty innermost annual rings on Norway spruce). The results indicate that a two-direction X -ray LogScanner can be a good tool for control of a customer adopted production.

Analysing the Efficiency of Norwegian Sawmilling

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Norwegian commercial sawmilling consists of about 200 units (5 employees or more). Its annual production amounts to approximately 2.5 million m^3 sawnwood and planed sawnwood, equivalent to a gross value of about NOK 5.6 billion ($ 750 million). Even though the size of the sawmills differ, production ranging from < 10000 m^3 to 140000 m^3 per year, the output is relatively homogenous.

In this paper the efficiency of Norwegian sawmilling will be examined using Data Envelopment Analysis (DEA). By the means of linear programming efficient production units are identified, and, when assuming convexity, an efficient ("best practice") production frontier is fitted. The inefficient units' distances to the frontier are minimized with respect to input saving or production expansion regimes. Thus, corresponding efficient peer units are identified, and the relative efficiency of the units located inside the frontier can be measured.

The analysis will be carried out on an extensive panel data set consisting of 3101 individual sawmill observations over the period 1974-1991. Several input and output variables are available - physical quantities as well as economic measures. The DEA approach is cross-sectional by nature. Using panel data adds the dimension of time to the analysis, making it possible to investigate the development of Norwegian sawmilling (for example technical change and production efficiency) throughout the period. For this purpose, the Malmquist productivity index will be used. This index corresponds to the efficiency measure originally developed by Farell (1957). It distinguishes between technical change and changes in production efficiency.

Production Structure in the Swedish Sawmilling Industry

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Wood products face market competition from a range of materials, *e.g.* plastic, concrete, steel. These materials are furthermore constantly being improved and adapted for different end-users. On the other hand, wood products have important competitive advantages-especially aesthetical and environmental qualities -- that need to be recognized and better exploited. One way for the sawmilling industry to meet the market challenges is to diversify and adapt the production according to the needs of different customers. This involves for example more drying to orders, length trimming, stress grading, finger jointing, surface treatment-and less bulk production.

For the sawmills this approach requires more efforts and investments in training, computers, drying technology, and other equipment to add more value to the product. in this way a mutually beneficial situation could be reached, where the customers of wood products receive a higher grade good and sawmills -- and the whole forest sector -- receive better prices for their products.

However, more advanced and specialized production can also increase risks as investments increase and niche markets sometimes are rather volatile. Therefore the production structure and market conditions of the sawmilling industry have to be thoroughly analysed in order to allow the industry to identify feasible strategies and to find factors for success. What characterizes, for instance, the technologically advanced sawmill and how do different types of sawmills perform concerning value-adding processes? One step in this analysis is to conduct systematic empirical studies of the sawmilling industry.

In this study, production strategies by Swedish sawmills today are described and analysed. The focus of the study is on input factor use, innovation and value adding processes. We compare different categories of sawmills and describe the most frequent ways to organise the production. Plant level data from 1995 about the Swedish sawmills is used in multivariate statistical analyses.

The results include a description of the general situation of the production structure of the sawmilling sector. Relationships between plant size, ownership, productivity, log handling, saw type, value-adding processes, drying, and computer use are investigated. Moreover, different alternative ways to organise a sawmill today, especially regarding technology adoption and value adding processes, are identified.

The adoption of different value adding processes is fast in the industry. It follows different dimensions, which reflect the technical and the market orientation of the enterprise. Value added shares of the total production depend generally on ownership, location and size of the sawmill.

Still, however, an important share of the sawmills treats only small quantities of lumber in value adding processes. Many sawmills apply 'standard' value adding processes based on planing and extra drying to orders. Smaller groups of sawmills have a more specialized production where the lumber is treated for specific uses.

Sawmills are classified in different strategic types along the axes: size, value added share and labour productivity. A number of strategic groups in the Swedish sawmilling industry can be identified. The implication of the results for the competitiveness of the sawmilling industry will finally be discussed in the presentation.

5.04.00 / 5.05.00 Innovations in wood bonding and utilisation of wood residues

Composting of Furniture Manufacturing Woodwastes and Phenolic-bonded Softwood Plywood Sawdust

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Two six-month outdoor studies were conducted to evaluate different amendments for composting of furniture woodwastes and sawdust from phenolic-bonded plywood. in the first study, furniture wastes were amended with 5% and 10% horse manure with the unamended wastes as controls. All treatments and controls were replicated three times. Moisture was provided through precipitation and substrates were aerated once or twice weekly. Samples were collected at 30-day intervals and analyzed for pH and toxicity. All treatments showed a significant reduction in dry matter by 180 days. The treatments containing 5% and 10% horse manure showed nearly twice the weight loss as the controls but there was no significant difference between 5% and 10% manure treatments. A reduction in toxicity occurred in all treatments and all treatments maintained neutral pH after 30 days.

In the second study, phenolic-bonded plywood softwood sawdust was amended with 5% chicken manure, 5% cow manure, 5% horse manure, 3% cotton gin trash, and 500 ppm inorganic fertilizer solution with the unamended sawdust as control, and three replications per treatment. Sampling, watering, and aerating was done as described for the first study. All treatments showed a reduction in toxicity and maintained a neutral pH after 30 days. All treatments showed almost double the percentage of weight loss compared to unamended control.

The composted sawdust was also evaluated in a greenhouse study to determine its effect on the growth of row crop plants. Twenty-five percent by weight of the composted sawdust was mixed with potting soil, in which corn, soybean, and cotton seeds were planted. The pots were watered daily and allowed to grow for 55 days. The chicken manure treatment showed no significant difference in mean weight of the plants when compared to potting soil only. Other treatments were comparable to chicken manure, except gin trash, which showed significantly less plant weight compared to the others.

Aspects et tendances concernant l'utilisation des lignosulphonates techniques dans les adhesifs pour l'industrie du bois

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On connait le fait que la lignine technique est obtenue dans la phase industrielle, comme un sousproduit à la désincrustation alcaline ou acide du bois de résineux ou de feuillus et par la hydrolise de celui-ci dans le milieu acide. Jusqu'à présent, les tentatives de créer une industrie pour valorifier la lignine résiduelle ont eu des succès partiels, pour les produits obtenables, en employant, en général, des quantités réduites de trois types de lignines techniques.

On y ajoute aussi certaines difficultés dans la transformation des lignines, liées à une connaissance insufisante sur la nature et sa structure chimique complexe, la diversité de ses unités structurales, des liées avec les autres composants chimiques du bois et surtout des aspects

économiques concernant la rentabilité de tels procédés.

Partant des considérations de ci-dessus et du fait que ce produit aromatique naturel qu'on isolé du bois, mais qui d'une facon où d'autre revient dans ce même bois, aurait une compatibilité meilleure envers les polymers synthétiques, nous avons étudie quelques posibilités de valorisation sous diverses formes des lignines techniques, comme produits chimiques employés dans le secteur de l'industrialisation du bois. L'emploi de lignosulphonates techniques d'amonium ou du calcium s'est realisé soit sous forme de poussières atomisées, soit sous forme de solution ayant des concentrations variables entre 35-45%.

Dans une prémière catégorie d'expériments ceux-ci ont étè employés comme de simples suppléments dans des adhésifs uréo-formaldéhidiques pour:

la fabrication des panneaux de particules de bois en substituant 25% de l'urée technique pour la couche extérieure ou pour celle de l'intérieure ;

la fabrication des panneaux type sandwich pour les meubles, en substituant intégralement la farine de seigle;

le placage des panneaux pour les meubles, en substituant intégralement ou en proportion de 50% la clorure d'amonium, 50% de l'urée technique et 75% de la farine de seigle.

Dans une autre catégorie d'expériments les mêmes lignosulphonates techniques d'amonium ou de calcium ansi que ceux qu'on à métalliquement complexes avec les cations mentionnés ci-dessus on a utilisé comme substituants en proportion de 15, 20 et 25% du phénol technique, utilisé à la synthèse de la résine phénol-formaldéhidique classique, en obtenant ainsi deux résines phénoliques modifiées:

résine lignin-phénol-formaldéhidique type P pour la fabrication du contre-plaqué pour d'extérieur;

résine lignin-phénol-formaldéhidique type F pour la fabrication des panneaux de fibres de bois.

En partant du lignosulphonate technique d'amonium et de calcium par des modifications chimiques adéquées, on a obtenu aussi deux produits tannants végétaux pour la tannerie et le retannage du cuir.

La lignine de hydrolise acide de la cellolignine en bois de chêne a été utilisée aussi comme un supplément simple à l'adhésif uréo-formaldéhidique pour la fabrication du contre-plaqué pour l'intérieur, en substituant totalement la farine de seigle.

On remarque le fait que dans toutes ces recherches expérimentales, les limites des suppléments de lignines techniques n'ont pas dépassées 20-25% des composants substituées.

Les essais d'augmentation de la proportion de lignine au dessus de ces valeurs n'ont plus conduit à des produits agglomérés ou stratifiés de qualité, ceux-ci présentant des caracteristiques physico-mécaniques inférieures aux éprouvettes témoins.

Pour accroître le degré d'emploi des lignines techniques, y compris dans le domaine des adhésifs pour l'industrie du bois, nous estimons résoudre deux problèmes importants à présent:
la réalisation d'une uniformisation du degré de polydispersion;
l'augmentation de la réactivité chimique des lignines techniques.

Dans la réalisation de tels désidérats il faut conjuguer les efforts de tous les chercheurs scientifiques qui travaillent dans ce domaine, par la réalisation des programmes communs de travail, des échanges d'expérience, des publications et, pourquoi pas, l'organisation d'une rencontre scientifique internationale dédiée à ce sujet.

Adhesive innovation and production of North American glued-wood and related products

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Based on 1998 estimated m^3 data, about 36% of the wood composites in North America were plywood and laminated veneer lumber products, 29% oriented strand products, 19% particleboards, 6% medium-density fiberboards and 10% a variety of other glued-wood and fiber products. The expanded array of glued-wood products has increased demand for a variety of wood adhesive resins and fostered adhesive systems with enhanced properties. in 1998 in North America, consumption of adhesive resin solids required to bond the glued-wood and related products were estimated to be about 1780 kilotonnes (kt). Considering the percentage of glued-wood products in North America as a basis, the calculated resin solids consumed by country were 1370 kt (77%) for the United States of America (U.S.), 374 kt for Canada (20%) and 36 kt for Mexico (2%).

In 1998 in North America, particleboards, fiberboards, and decorative and hardwood plywoods were bonded principally with amino resins (1060 kt). The ratio of resin solids consumed by the particleboard and medium-density fiberboard industries was similar to the ratio of production of the two products (76:24) since both industries add a similar amount of resin binder to the respective products. The vast majority of the amino resins are urea-formaldehyde based, however, METLAmine is added for some upgrades. METLAmine-formaldehyde resins in North America are primarily applied in overlay coating applications for wood products. Phenolic additions to amino resins are being explored.

In 1998 in North America, the quantity of phenolic resin solids consumed by the wood composite industries was 568 kt. The phenolics are primary binders for oriented strand products, construction plywood, and laminated veneer lumber. in addition, selective medium-density fiberboards and high-density compressed fiberboards (wet- and dry-process hardboards, including dry-process door skins) are bonded with phenol-formaldehyde (PF) resins, and other engineered lumber products are bonded with phenol-resorcinol-formaldehyde modified resins.

Over the past 15 years in North America, polymeric diphenyl methylene diisocyanate (PMDI) has established an entry into the glued-wood products industry. The consumption of PMDI for these products is estimated to be 90 kt with 90% of this volume being applied as binder in oriented strand panel and lumber products. About 18% of the binder requirements for oriented strand boards (OSB) are estimated to be PMDI with the balance OSB binders being liquid PF and powder PF resins. PMDI resins have been shown to be the preferred binder for agrifiber boards (wheat straw furnish, etc.) unless the agrifiber has been modified by mild chemical and steam pretreatment and fiber bundle refining.

Vinyl compounds (50 kt) for gluing wood in North America are consumed mostly as assembly glues, but some are utilized as adhesives for hardwood plywood and hardwood lumber flooring products (flatbed trailer and railway car flooring). The vinyl may be a homopolymer polyvinyl acetate or an upgraded cross-linked vinyl product. The vinyl upgrades may be based on phenolic, isocyanate or other thermosetting additions to the emulsion polymers.

Excellent historical data, including cost, have been published on many wood-based composites for Canada and the U.S. Substantial research and development on wood adhesives continues in North America, including amine, phenolic, polyurethane, vinyl, soya and accelerator modifications.

The Role of Temperature, Humidity and Fungus On The Adhesion Failure of Alkyd Paint On Timber Substrate

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During natural weathering opaque paint finishes on wood experience surface discolouration, checking and loss of finish adhesion. These effects are through to be due to the action of complex combinations of weathering factors such as moisture, heat and micro-organisms. The relative importance of each of these factors has not been well defined. The controlled laboratory experiment was then carried out to determine the importance of each of these weathering factors in the adhesion failure of paint on wood.

Painted Kempas (*Koompassia malaccensis* Maing. Ex Benth.) specimens were exposed to controlled environments in which each of the factors, temperature, humidity and fungus exposure, were held at pre-determined, fixed levels. Additional factors investigated were the effects of artificial pre-weathering of substrate and cutting of the paint finish. The ultraviolet light factor was not taken into consideration.

Results showed that a relative humidity had the most deleterious effect on paint adhesion, followed by the presence of the stain fungus. Loss of paint adhesion was further increased when pre-weathered specimens were exposed to a high relative humidity. The presence of a cut on painted wood surfaces increased the deleterious effect of the blue stain fungus on adhesion presumably because it allowed the fungus greater access to the underlying wood.

Application of Industrial Wood Waste for the Development of Multipurposes Glue

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It is known that environmental restrictions put sulfite pulps mills that produce industrial recovering lignin - lignosulfonates (LS), a large-scale wood waste, out of business. At the same time, a chemical modification of LS offers the great opportunities to produce novel polymer products on their basis. in such a way, environmental demands, economic reality and a high efficiency of the biomass conversation might be involved into producing of the multipurpose, environmentally friendly and high quality polymer products.

In this work, we would like to show how it is possible effectively modificate lignosulfonates and what the real applications of the polymer products formed are. Synthesis of lignin-based interpolymer complexes (LIC) is based on the interaction between the oxidized lignins and the water-soluble polymers or oligomers (Shulga et al. 1997). LIC obtaining proceeds, as a rule, in water media at room temperature, normal pressure, and without using of any catalysts. These polymer products exist both in water-containing solvents and a solid state. The main reason of LIC structure stability to the action of different outward factors (pH, elevated temperature, UV-radiation) is conditioned by a cooperative system of the macromolecules coupling that has entropy nature. The nature of linking between LS and synthetic polymer/olygomer can be different: ionic, donor-acceptor, covalent etc.

The established relationships and mechanisms of interpolymer reactions as well as the nature of the interaction with different interfaces have allowed to developed the new glues on the LIC basis with controlled adhesive properties.

LIC-based glues are able to substitute almost 45-55% of UF-resin in the fibres composite materials (Shulga et al .1990). Besides that, it is no any necessity in additional power consumption for their producing at an increased lignin-based glue content. The advantages of the composite materials obtaining are as follows: using of the significantly lower temperature for pressing and drying, no necessity of any curing agent. There are some advantages of the composite materials themselves in comparison with ones obtained with UF-resin such as a higher mechanical strength, a higher hydrophobicity, a significant lower evaluation of formaldehyde during the manufacture and in use as well as a lower cost.

LIC-based glues may be applied as ecologically friendly soil conditioners with pronounced structure-forming and adsorbing properties on sandy soils (Shulga et al. 1998). For their obtaining, the formation of LIC proceeds in the presence of salts of multivalent metals. It allows to approximate LIC-based conditioners to the structure and the properties of soil organic-mineral formations.

The soil structure obtained by LIC application has the important influence upon water-holding capacity, water transport, aeration and heat transfer in soils, and indirectly improves the conditions of the vitality of plants and microorganisms. Owing to structural peculiarities, LIC-based conditioners are capable of cementing the particles of sandy soil and forming a composite polymer-sand coatings, which are able to withstand wind and water erosion and prevent blowing off a fertile layer. Field tests have shown that composite coatings formed reduce the evaporation of moisture from the soil, but at the same time, do not prevent water and air transfer into the soil. Perennial grass seeds germinate easily through composite coatings, forming the turf of a good quality with a thick-branched root system.

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An environmental friendly composite made from hydrated lime, pozzolanic material, spent carbon dioxide and reinforced with recycled cellulose fibers

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The reasons why asbestos fibers reinforced cement composites are still used in many developing and less industrialized countries are briefly elaborated. A new kind of cellulose reinforced laboratory board was developed as possible alternative for non-compressed asbestos cement panels. *Pinus radiata* kraft cellulose (PKF), recycled newspaper (RNF) or oil palm trunk soda fibers (OPF) were used as reinforcement. The binder consist of slaked lime and ground rice husk ask (RHA) or pulverized-fuel ash (PFA), also designated as fly ash. The web was formed by mixing the reinforcement and the binder mixture with water and dewatering the slurry. It was then compacted by vacuum and pressure. The still soft board was placed in a pressure vessel. Pressurized carbon dioxide was introduced after vacuum treatment. The gas reacted with slaked lime to form calcium carbonate, which gave the panel its early strength properties. If the carbonated panel is cured in a moist cubicle for 14-28 days the uncarbonated slaked lime reacts with RHA or PFA to form calcium silicate hydrate. This binder contributed significantly to the ultimate strength properties and improved the moisture resistance and dimensional stability. The parameters influencing carbonation were examined. It was feasible to use a mixed gas with 15% carbon dioxide content. Such carbon dioxide enriched gases are emitted from thermal power stations fired with coal or liquid fuel, at calcination of lime stone or magnesite and in the fermentation industry. Carbon dioxide is one of the main green-house gases. in the new process this gas is recycled. The technological properties of the novel board are compared with those of asbestos-free commercial panels.

Utilization of residues at sawmills, plywood mills, and precut factories in Japan

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Japanese total timber consumption was 110 million cubic meters in 1997. of total timber are 44 % for sawn lumber, 40 % for pulp and papers, 14 % for plywood. We investigated how many residues were remained and how the residues were utilized at sawmills, plywood mills, and precut factories. of the residues at the sawmills, 10 % was bark, 20 % was slab, and 14 % was sawdust. The bark is utilized as fuel, livestock bedding, and fertilizer. The slab is utilized for manufacturing pulp chip. The sawdust is utilized as fuel, livestock bedding, fertilizer, and culture ground of mushrooms. Less than 10 % of the residues at the sawmills was thrown away or thrown into fire.

Plywood recovery was 64 %, and main kind of residues at plywood mill was green veneers (25 %), dry veneers (24 %), cores (16 %), and plywood edges (13 %). 76 % of the residues was used as boiler fuel for veneer drier and hot?press, and 20 % of the residues was reused as wood chips for particle board, MDF, fiber board, or fuel. Only 1.5 % of the residues, which contained 95 % of bark was thrown away or thrown into fire. Precut means machining of timber joints of building members for Japanese traditional wooden houses (post and beam construction) at a factory (precut factory) instead of hand cutting by a carpenter. We machined about 20 million cubic meters of timber at the precut factories in 1997. Five percents of odd, 0.5 % of sawdust, and 1 % of chip were generated from the total timber machined at the precut factories. The odd is utilized for manufacturing pulp chip, small size lumber, and glue laminated lumber. The sawdust and chip were utilized as livestock bedding and fuel. in Japan, almost the residues at the sawmills, plywood mills and precut factories are effectively utilized.

Production Technology and Advantages of Environment Protective Fibreboard

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In order to meet the requirement of environmental protection, the production of environment protective wood based panels will become a development trend. This paper introduces the production technology and advantages of environment protective fiberboard. On proper conditions, environment protective high density fiberboard (S2S HDF) can be produced, on the general dry-process hardboard or medium density fiberboard (MDF) production line, without adhesive and change of equipment.

The production process of environment protective fiberboard is as follows:

Raw materials - chipping - screening - refining (-wax addition) - fiber drying - forming - prepressing - cross- cut - loading - hot pressing - unloading - trimming - stacking - inspecting and grading - product storage.

The results studied show that the hot-pressing technique is the main key to produce environment protective fiberboard. The technological parameter of hot-pressing includes a temperature of 190 ~ 200°C and a pressure of 4.0 ~ 5.4 Mpa. The pressing time depends on the thickness of board to be made and wood species. Generally, the pressing time for each one millimeter board thickness does not exceed one minute.

After completing a technology study on the manufacture of environment protective fiberboard at the laboratory, a pilot-scale trail was conducted on the MDF production line with an annual capacity of 10000 cubic meter to examine further technological parameter obtained by a series of technology experiments and determine the physical mechanical properties of the commercial environment protective fiberboard is suitable and feasible.

5.05.00 Composite and reconstituted products

The wood- based composite industry in Chile: a general overview

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The wood-based composite industry in Chile has been playing a mayor role, in the forest product sector during the last 10 years. Growth has averaged 15% per year based on the volume produce. There is an installed capacity of 1.28 million cubic meters within 19 mills, which are producing particleboard, medium density fiberboard (MDF), hardboard, plywood and veneers. The Chilean wood-based composite industry is very dynamic, and is currently investing in other Latin American countries: Argentina, Brazil and Venezuela, to produce particleboard and MDF. in addition, several new plants are projected for the next five years.

The Chilean market account for 64% of the total panel products produced. The remaining 36% is exported mainly to Europe, America and Asia. Current and future new plantations in Chile assume the availability of commercial timber, which suggest significant increase of the panel sector over the next 10 years.

Developments in Composite Research and Industrial Manufacture of Composite in Japan

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Recent developments in the research on wood composite products and their applications in the industrial manufacture in Japan are being reviewed. Engineered wood products are playing an increasingly important role in timber constructions; glulam and laminated veneer lumber (LVL) are now widely accepted as timber construction members, and are already produced commercially by using domestic softwood species. Structural panels such as plywood and oriented strandboard (OSB) are often used, even as Japanese conventional post & beam housing structures for bearing wall panels. Medium density fiberboard (MDF) is used dominantly as a base panel for secondary processing.

More reliable and higher performance wood composite products are being developed by aligning the elements along the fiber direction; a cylindrical LVL made of helically wound veneer tapes provides a bio-mimetic structure of wood cell and proves to exhibit high bending performance despite its light weight. in panel products, an advanced OSB is manufactured with thin strands in order to achieve improved surface properties, dimensional stability and mechanical properties. This advanced OSB is now in the process of being produced on a commercial scale. High performance oriented MDF with long lignocellulosic fibers is now being developed, whereas vertically oriented fiberboard with an ultra low density has been marketed as a substitute to the foam plastic materials. A new technology for producing high-performance cement bonded particleboard by using rapid curing process of either super-critical fluid or gaseous state of carbon dioxide is now under development.

Currently, new concepts of zero-emission and recycling processes have been introduced to support the sustainable utilization of wood resources. New processing technology to convert forest residues, non-wood lignocellulosic materials, agricultural wastes, and recycled wood into new types of lumber and panel composite products is necessary to ensure sustainable utilization of the existing forest resources.

Jute Composite By Resin Transfer Moulding -A New Techno Economically Viable Product

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Various forms of jute reinforcement alone and alongwith glass were used successfully to reinforce composites moulded following Resin Transfer Moulding process using Unsaturated Polyester Resin as the matrix. Products include panels, chair seats, trays, angles, etc. Properties of these types of composites were evaluated. Advantages of using jute reinforcement include reduction of costs, lowering of density and the use of an environmentally friendly, renewable, reinforcement. The lower mechanical properties of jute composites could be compromised where higher mechanical properties of high value glass reinforced composites are not justified. Commercial viability of resin transfer moulded jute composites has been established from techno-economic feasibility studies.

Wood Modification Towards Practical Application: An European Perspective

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During decades, efforts are made by research organisations and industries to develop wood modification methods. Most of the efforts, however, were done on laboratory scale and never reached practical application. Whereas the research in the 1960's and 70's mainly concentrated to the US and Japan, during the last decades different European research and development programmes were directed to wood modification. Main goal in most of these programmes was the search of environmental acceptable modification chemicals and reactions with potentials for the European wood industries. As outcome of these efforts, the last few years some of the developed methods were yet introduced to practice or under pilot scale evaluation. This paper will give an overview on these technologies. State-of-art, problems and challenges will be discussed, for solid wood modification as well as composites modification treatments.

Wood/polymer composites - a state-of-the art review

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Interest has burgeoned in combining wood and other raw materials, such as plastics, into composite products with unique properties and cost benefits. The primary impetus for developing such products has come from one or more of the following reasons:

- Reducing material costs by combining a lower cost material (acting as a filler or extender) with an expensive material.
- Developing products that can utilize recycled materials and be recyclable in themselves.
- Produce composite products that exhibit specific properties that are superior to those of the component materials alone.

Composites made from wood and other materials create enormous opportunities to match product performance to end-use requirements.

The use of lignocellulosic materials with thermosetting polymeric materials, like phenol- or urea-formaldehyde, in the production of composites has a long history. The use of lignocellulosics with thermoplastics, however, is a more recent innovation. Broadly defined, a thermoplastic softens when heated and hardens when cooled. Thermoplastics selected for use with lignocellulosics must melt or soften at or below the degradation point of the lignocellulosic component, normally 200oC. These thermoplastics include polypropylene, polystyrene, vinyls, and low- and high-density polyethylenes.

Markets for these hybrid composites have expanded in the past 6 years to include a host of consumer products, components for the automobile industry, packaging materials, and now, products designed for building applications.

This paper reviews technologies used to produce these materials, reports on recent research accomplishments in the field, and provides a detailed review of products now on the market or being developed for commercial application. A look to the future will also be included in this review.

5.06.00 Properties and utilization of tropical woods

Wooden school furniture for underdeveloped and developing countries

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Keywords: school furniture, underdeveloped, developing countries, plantation thinnings, wood residues, cottage industries.

In many underdeveloped and developing regions of the world, school furniture is poorly designed, of low quality, and often unfit for school use, yet it is costly and consumes a disproportionate share of limited educational budgets. This situation need not continue. Our research indicates that attractive, well-designed, durable, maintenance-free furniture can be produced from locally available woody materials including plantation thinnings and semi-processed materials such as pallet deck boards by local industry. Only the simplest machining and joinery processes are required to construct the furniture. Cost of the furniture is generally less than that of competing products, yet performance tests indicate that the furniture produced is several times more durable than furniture currently in use.

Production techniques vary from those best-suited to cottage industries to those more appropriate for small factories in more developed areas. Small stems can be converted into squares or dowels that are subsequently cut into furniture parts, or the stems can be converted into small strips that are subsequently used to fabricate individual furniture parts or entire frames. Curved laminated construction can be used when woods can be easily steam bent. Creep bending with simple jigs can also be used to form parts with sharp corners and straight sides. Green bending can be used to form parts with mild bends such as seat and back slats. Simple chemical bending with household ammonia may also be used to form extreme bends in the ends of such items as seat slats.

Cross lap laminated construction can be used with those woods in which only short lengths of clear wood can be obtained or which have poor bending characteristics. This method of construction produces strong, durable, geometrically accurate frames with very simple equipment.

Round mortise and tenon construction provides a simple yet strong and reliable method of connecting members and side frames together. Round tenons may be produced on a conventional wood lathe or they may be cut with a simple hole saw.

In conclusion, preliminary results indicate that sturdy, well-designed school furniture can be produced from small woody stems and other wood residues by a variety of production processes -- some best suited to cottage industries, others to more developed industries. Thus, school furniture and the accompanying production processes can be matched to the level of development of essentially any interested country. Finally, none of the processes involved in the construction of the frames are inherently costly so that attractive, sturdy, easily maintained furniture can be produced at modest cost in any developing country.

Acacia mangium An Alternative Timber Building Material: A Case Study

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Keywords: glue laminated-*Acacia mangium*, alternative building material, engineered components

The diminishing supply of timber from natural forests due to increasing demand for forest products has stimulated interest in forest plantations. Natural forest takes considerable time to rejuvenate and compensatory forest plantations are seen as alternatives to fulfill the needs of sustainability. Among the fast growing tree species promoted in Malaysia is *Acacia mangium*. *A. mangium* plantations now cover some 80% of the total forest plantation areas (51,745 ha.) in Peninsular Malaysia. General aspects of research on this timber have been conducted but records and proper documentation on its potential usage are still lacking.

In order to assess the suitability of using *A. mangium* for construction, a house was built in 1998. The objective was to analyse the utilisation of *A. mangium* as a building material taking into account the preparation of raw material, drying and preservative treatment, timber engineering aspects and construction. This will be followed by monitoring the in-service performance to determine its performance under local environmental conditions. Special attention will be focussed on the structural performance of the engineered components. The economic aspects of the project will however not be discussed in this paper.

Logs of 1.8m and 2.4m lengths were obtained from 13 year-old thinnings. Owing to the inherent presence of heart rots in the logs, care was taken to exclude or minimize them when obtaining the sawn timber. The timbers were conditioned to about 10-12 percent and then cross-cut, planned, finger jointed and glue-laminated with PRF to obtain the required lengths for the construction. Each stage of production of the glue laminated members was monitored although it was not possible to strictly adhere to the established regimes in preparation of the material.

Various problems encountered during the preparation of the components and construction are discussed. However, the project has indicated the potential of using *A. mangium* as building components. Being able to control the sawing of the logs and the use of smaller size logs will help to optimise utilisation of the timber. The performance of the house constructed will be monitored and the data collected will contribute towards information on the use of plantation grown timbers for construction.

***Eucalypts* from South America: a sustainable raw material in the international market for solid wood products**

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South American countries, specially Brazil, Chile and Argentina, have a large experience in the production of *Eucalyptus* pulp and charcoal, but the use of *Eucalypts* as solid wood was somewhat limited to small companies. in the last years, due to a reduction in the offer of woods tradicionally used by sawmills and plywood industries, consumption of *Eucalypts* has been graddually increasing.

As this region has 4-5 million hectares of high productivity eucalypt plantation, it is expected that once *Eucalypts* solid wood establishes a domestic market and production scale grows, *Eucalypts* products will also be sold to the international market. Some large companies from Brazil as Aracruz, Klabin, CAF and Flosul are operating or will start to operate new saw mills using *Eucalypts*.

The same process is occurring in Argentina, Chile, Paraguay and Uruguay. *Eucalypts* wood present a series of problems for solid wood industry as it has a very strong tendency to log splitting, board splitting and warping during sawing process and collapse during drying.

Research on eucalypt wood properties and tree breeding has followed the same trend of its utilization, i.e. most early research was focoused on pulping and heat properties and only lately problems related to eucalypt solid wood production were seriously considered. Currently, utilization of eucalypt wood as sawn timber, specially the control of growth stresses through silviculture and genetic breeding and development of sawing and drying techniques are considered as a key point for forest research.

Lignin, cellulose and extrative contents and specific gravity are some traits usually considered by genetic improvement programs when final product was pulp or charcoal which are not of real importance when solid wood is considered, and log splitting, warping, shrinkage and collapse have been introduced as new variables of the breeding process.

This paper discusses the following topics:

- Current trends in reforestation in Latin America, with a special focous in Brazil is presented together and changes in the silviculture of *Eucalypts* required to meet solid wood industry requirements;

- Impacts of eucalypt plantations in Brazil;

- Wood quality for solid wood of E. *grandis*, *E. dunnii, E. urograndis, E. pilularis, E. saligna* planted in Brazil;

- Perspectives of using log splitting, board splitting, warping, shrinkage and collapse in breeding programs of eucalyps for solid wood, with basis on the analysis of *Eucalyptus pilularis, E. grandis, E. deanei* provenance and progeny combined tests, clones of *urograndis* hybrid and open populations of *E. dunnii and E. deanei*;

- Market possibilities of solid products of the main *Eucalypts* planted in Brazil based on a comparison of their wood quality and machining properties with that of tradicional tropical woods.

Selection of Pulpwood for Plantation Development for Pulp and Paper Making in Tropical Countrys - the case of Ghana

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Keywords: Selection, pulpwood, plantation *Musanga cecropiodes*, hardwood

An indication is given of ways in which wood species with properties suitable for pulp and paper manufacture can be selected. Before any such selection can be undertaken it is essential to know just what are the desirable characteristics from the pulp and paper aspect.

The present study was conducted on *Musanga cecropiodes* to determine the desirable properties and their influence, namely: longer than average fibre length, Runkel ratio less than 1, average basic density, low extractive content, low lignin content and suitable hemicellulose content. in addition to these the pulp characteristics were also determined.

Musanga cecropiodes was obtained from experimental plots in Kumasi, Ghana. The sample was debarked and sawn into discs of approximately 18mm thickness and then split along the grain with a knife to give a chip size of approximately 18 x 18 x 6mm. A portion of chips prepared for pulping was ground in a Wiley-Mill.

Chemical analyses were made on wood meal which passed a BS 40 mesh sieve (425µm) but retained on a BS 60 mesh sieve (250µm). For the chemical analyses an extractive: free sample of wood meal was prepared by successive extraction with alcohol/benzene, alcohol and water. The following analyses were also carried out: cellulose, acid insoluble lignin, 1% sodium hydroxide and hot water.

Preparation for fibre measurements were made according to Franklin's (1945) method. For the measurement one hundred fibres were made.

For the pulping trials chip samples (600gm) were weighed and placed in a 15 litre digester with internal electric heat exchanger. This digester slow but constant rotation when in operation. The cooking conditions adopted were the following:
Active alkaline (%) - 15, 16.5 and 17.5
Sulphidity (%) - 25
Time at maximum temperature (mins) - 90
Cooling time (mins) - 15
Wood to liquor ratio - 1.5
Maximum temperature (°C) - 170

The cooked chips were washed off black liquor and broken up in a disc refiner with a clearance of 0.5mm. The yield of pulp was determined by the dilution method. The physical characteristics of the pulp were determined by preparing sheets from the pulp in a British sheet mould. The sheets of approximately $60gm/m^2$ were tested after conditioning at 65% relative humidity. The following tests were made: Tensile index, tear index, burst index and Canadian Standards Freeness.

The results indicate that the density of *Musanga cecropiodes* 320 kg/m^3 oven dry weight/green volume was lower than that for some hardwoods, such as birch, beech and *Eucalyptus* commonly used for pulp; but similar to others, such as poplars and aspens. Fibres were slender (24.11µm) and thin-walled (3.00µm) and consequently flexible. Thus *Musanga cecropiodes* with Runkel ratio of 0.32 and co-efficient of flexibility of 0.75 stands out as having good fibre structure suited for pulp and paper-making. A high co-efficient of flexibility, like a low Runkel ratio is desirable in a fibre because this leaves a thin-wall material which is suitable for strong inter-fibre bonding in paper sheets.

The cellulose content of 53.7% for the species indicates that the pulp yield will be high. Compared with values usually found in temperate hardwoods used for pulp, the alcohol-benzene solubility (3.70%) and 1% Na0H solubility (13.1%) were average.

Using 15% active alkali for sulphate cook, a maximum temperature of 170°C with 1 hour to reach and 1 hours at that temperature *Musanga cecropiodes* yielded 55% pulp with a kappa number of 28.2. The burst strength of 6.8 $kPam^2g^{-1}$ and tensile index of 115 $mNm^2\ g^{-1}$ for a hardwood paper sheet of basis weight 60 gm-2 form at a pulp freeness of (Canadian Standard Freeness, C.S.F) 300 reported for M. cecropiodes are very remarkable paper strength properties for a hardwood whose average fibre length is 1.25mm. However, the tear index of 4.1 $mNm^2\ g^{-1}$ recorded for the species was low.

The fibre dimensions, chemical analyses and pulp evaluations show that it is possible to produce pulp from *M. cecropiodes* and that there is a need to study its silviculture for plantation development for the species for use as source of pulpwood.

Eucalypts, according to some literature reports, render the soil infertile after some period. This is attributed to the excessive intake of water from the soil which later on renders the soil unsuitable for cultivation of other species. To overcome this and other problems associated with introduction of exotic species emphasis should be placed on local wood species with characteristics similar to our superior to *Eucalypts*. One of such species is *Musanga cecropiodes*. *Musanga cecropiodes* is a tree species which grows in West Africa Central Africa and East Africa and extends to Angola. Its natural growth is very prolific. It is a small to medium -sized tree up to 90 feet high and has a girth of over 6ft at full maturity.

For pulp and paper plantation established species of fast growing species should be considered. Some of the other important characteristics to be considered include:
(i) fast growing species for economic plantation
(ii) longer than average fibre length
(iii) Rynkel ratio less than 1
(iv) average basic density
(v) low extractive content
(vi) higher than average cellulose content
(vii) low lignin content
(viii) suitable hemicellulose content

The features listed above indicate clearly that the anatomy of raw material as well as its chemical composition must be carefully considered in a plywood plantation establishment.

These various features which are the most desirable will depend largely on the product to be manufactured but for all products, long fibres high proportion of fibres in the wood volume, low extractive content, high cellulose content and low lignin are the most valuable characteristics.

Musanga cecropiodes as a tropical hardwood species satisfies most of the features listed and should be encouraged to be used for plantation establishment, especially in developing tropical countries for use as a

Woods from mediterranean and subtropical dry areas: possible uses besides fuel and charcoal

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Due both to climatic and human historical reasons, mediterranean and subtropical dry forest ecosystems are today rather poor, with low standing volume per hectare and mostly small diameter trees.

More often the demand in these countries is high both for energy and for wood material dedicated to a lot of domestic uses: tools, furniture, small carpentry, poles, .

Although the information about these woods are few in the classical wood data banks, most of them have interesting basic properties like fine grain, aestetical aspect, high hardness, high natural durability, so they can fit lots of uses for the local communities.

Besides the need for more information on these species, there is also a huge need of specific technology dedicated to small diameter logs.

After a short review of main dry forest species with their specific properties and of today available technologies in sawing or peeling and of today available technologies in sawing or peeling small diameter trees, a possible way of value added wood small industries as by product of fuel wood activity is looked at.

5.06.02 Quality teak timber from plantations

Non-destructive techniques for wood quality assessment of plantation-grown teak

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Keywords: *Tectona grandis*: Plantation wood; Quality, Technological properties

Teak (*Tectona grandis* L.f.), because of its outstanding technological properties, is one of the most preferred tropical timber in the world. For this reason and due to the depletion of its natural stands, teak is increasingly coming from plantations of much shorter rotations. It would therefore be of interest to determine whether the wood quality is similar when it comes from natural forests and plantations. After defining the method of wood quality assessment, results from the literature and from the teak wood research programme of CIRAD-Forêt indicate significant between- and within-tree variations in plantation-grown teak.

This need for assessing wood quality of plantation-grown teak has led CIRAD-Forêt to develop its own methodology and non-destructive techniques on standing trees, which are presented hereafter. The methodological options proposed here are specifically focused on teak, taking into account its financial value, its specificity in terms of colour and high oleoresin and chemical extractive content. But, basically, the same methodology could be applied to other plantation tree species, after some key adjustments (e.g.: in spectrocolorimetry or NIR spectroscopy calibration as described hereafter).

A new promising but more sophisticated technique, currently explored by Cirad-Forêt, is presented here, is fully justified by the high market price of teak wood as well as the high investments required for teak plantation establishment and maintenance.

Technology Packages for Quality Wood Products of Teak Plantations: Challenges and Promises for the 21st Century

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Keywords: Sustainable forest management; Tropical hardwood; Industry; Marketing; Regional network

Teak (*Tectona grandis* L.f.) appears to have the greatest potential as a hardwood for sustainable forest management (SFM) in the tropics to meet market demands for quality products in the new millennium. With an estimated area exceeding 3 million ha extending over almost all the tropical countries, teak - the world's most versatile and outstanding timber- accounts for 75% of high quality tropical hardwood plantations. Undoubtedly, it stands to gain as a product from new technologies and has a proven record of being managed successfully to the fastest growing economies. However, the current situation of teak producer countries calls for intervention of more appropriate rather than the traditional technologies in the production-processing-market linkage through research/ technology transfer/ training programmes. Forecasting the future trends in demand-supply, price and marketing system of small dimensional (SD) timber resource of teak plantations is a prerequisite for evolving suitable technology packages for the 21st century.

The challenges of plantation technology for increasing export market include genetic improvement, novel biotechnology as well as high input site management (shorter rotation, fertilisation, irrigation, wide spacing/thinning, pruning, etc.) practices that can modify tree form and wood. The newly developing technology packages should aim at:
- Improved log form (straight cylindrical bole with higher proportion of heartwood and desired dimensions) by minimising timber defects (bole taper, log crookedness, fluting/buttressing, proportion of knots, sapwood, tension wood, etc.)
- desired wood figure (colour, grain, texture)
- more durable and stronger juvenile wood with more uniform distribution of properties.

Optimising technologies to a great variety and combination of situations of producer countries will be another challenge for significant gains in processing (conversion, solar drying and preservation with environmentally acceptable methods) efficiency and utilisation of small dimensional timbers (SD). They also include utilisation of thinnings and SD materials for the manufacture of value-added products such as finger-jointed structures (acceptable to architects and building designers), decorative veneer, panel/composite products, furniture components, handicrafts/ toys/ souvenirs as well as potential new products to meet societal needs. Revisions of grading rules and evolving industrial codes of conduct are necessary for internal quality control and to assure the quality products as labelled commodities of SFM.

The new promises of recent teak wood research programmes include:
- The productivity of short rotation teak plantations is significantly high with mean annual increment of 10-20 m^3/ha.
- Without altering timber strength, plantation managers can now aim at producing larger diameter logs with greater yield (larger cylinder) of naturally durable heartwood per tree by accelerating tree growth with judicious fertiliser application/genetic inputs.
- Teak can produce the timber of optimum strength in relatively short rotations of 21 years.
- Fast growing provenance's/clones of superior genotypes can be selected for teak management without reducing wood specific gravity.
- Wider rings of fast grown teak generally yield higher proportion of more uniform Lakewood with greater percentage of fibres, making the timber more resistant to weathering/biodeterioration.
- Newly emerging processing technologies allow the use of smaller and younger trees.

Effective Regional / international networking, among the newly established institutions such as TEAKNET, IUFRO 5.06.02 (Teak Wood Working Party) and TEAK 2000, is suggested to pool the limited available resources for sharing technology/expertise that would avoid the duplication of wasteful efforts.

Quality Tropical Hardwood Sub-Sector in Crisis

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Keywords: Tropical hardwood; Sustainable Forest Management; Carbon sequestration; TEAK 2000

The greatest challenge of the 21st century is to find ways to achieve sustainable development. This is the wider canvas against which forestry must be viewed in future. To achieve sustainable forestry development it is imperative that the resource we hand on must be able to satisfy the widest range of needs conceivable so that the ability of future generations to meet their own needs is not compromised.

Unfortunately, an aspect of forestry that has been neglected is growing, on a sustainable basis, of quality tropical hardwoods. The paper shows that the sub-sector is far from sustainable - it is in deep crisis. Almost all of the supply of high grade tropical hardwoods originate from deforestation and degradation.

It will be difficult to bring sufficient areas of tropical forests under sustainable management to supply present and future needs. This is partly because management systems in natural forests, designed to supply timber, have had variable levels of successes. Most of these have been abandoned or are only applied on a minor scale. However, natural tropical forests have the potential to sustain, not only the output of timber, but a wide range of goods and services.

The annual allowable timber cut must, therefore, take into consideration the effects on the sustainable output of other goods and services and thus the allowable cut is less than the volume which could be removed if only timber had to be considered. Defining allowable cut, therefore, is a contentious issue and a spectrum of opinions have arisen, depending on viewpoints from a wide range of disciplines. Some conservationists question the wisdom of logging natural tropical forests that are not under immediate threat. Creating conditions for increased access may heighten the risk of destruction.

The level of disagreement around the subject of natural forest management and conservation demonstrates that we are on the slopes of a very steep learning curve and it may be some time before we know whether or not it is possible to manage tropical forests in perpetuity outside traditional methods.

Therefore supplementary sources of sustainable hardwoods will have to be found or extreme shortages are inevitable. Substitution may provide a partial solution but is an admission that a balanced output from forests as a whole is not possible. This is totally counter to most definitions of sustainable forest development. Besides, shortages will put increasing pressure on remaining sources and could lead to further deforestation. Supplementary sources may be developed by creating quality hardwood plantations and these could assist in the shift - in part or whole - from natural harvesting to domestic cultivation.

However, quality hardwood plantations experience considerable disadvantages compared to short rotation, high volume softwood and fast growing broadleaf species.

A solution is to discriminate positively in favour of quality hardwoods. One simple but effective way to achieve this is to allow advanced economies gain carbon credits in developing countries within the Kyoto Protocol, specifically and exclusively for planting quality tropical hardwoods.

A new initiative, TEAK 2000, has been designed to find ways of solving the present crisis in practical ways on the ground.

Fungal decay resistance of Brazilian-grown teak in soil-bed assay

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Keywords: *Tectona grandis*; Juvenile wood, Soft rot fungi; Natural durability; Soil exposure.

Teak (*Tectona grandis* L.f.) is one of the world's best known and most valuable timber. Generally, the heartwood of mature teak trees is graded as very durable. As experienced in field tests, teak has high reputation for its resistance to attack by wood-destroying fungi in ground contact.

Being native of South-eastern Asia (India, Myanmar, Thailand) and being planted extensively in many other tropical areas, the existing plantations in Brazil, the Southern part of the state of Mato Grosso near Caceres, are relatively less known. Data on the resistance to fungal decay of teak grown in Latin-America, especially Brazil are very scarce. For different reasons it is important to gain thorough knowledge about the natural durability of the wood from young plantation teak trees.

The natural durability of Brazilian-grown relatively young teak trees was investigated based on the methodology of the modified European pre-standard ENV 807-Test 2 (CEN 1993). The protocol is based on implementation of test procedures under soil-bed test conditions which promote soft rot decay. Mass and static bending (modulus of rupture and Young's modulus) losses were determined at periodical intervals of exposure in the soil-bed.

Material was investigated from three trees: two 22 year-old- and one 14 year-old-teak tree. The tests were conducted on heartwood and sapwood samples. Wood sampling was carried out in such a way that specimens of the same age were drawn from the different logs. By doing so, material was obtained from the real juvenile period of growth of the trees, viz. one age limit was at a few growth rings from the pith; the other age limit is formed by the last growth rings in the sapwood. in the two elder trees, two other sample locations provided material: one from the growth rings situated half-way, and the other in the outer zone of the heartwood. in the younger tree the half-way position in the growth ring was omitted.

The preliminary results demonstrate that teak from the middle West region of Brazil, grown in irregularly distributed trial plots of planted teak trees, shows fungal decay resistance comparable to that of naturally grown material in Asia. These findings enable a good and reliable relevant prognosis on aspects of the natural durability of the teak growing on the neighboring plantations.

The heartwood halfway its width and just bordering the sapwood in 22 year- old teak trees was ranked in the highest durability class (class 1). Heartwood from a younger tree (14 year- old) was also found to display high decay resistance (class 2). Even the first formed heartwood around the pith showed, in all trees, high decay resistance (class 2). To a certain extent it is surprising to record that the sapwood material was ranked in class 3 (moderately resistant to fungal attack). The high durability of Brazilian teak suggests that it can be confidently assigned the practical end-uses under the conditions of exposure involving high risk of fungal attack.

Cytological characteristics of heartwood formation in teak (*Tectona grandis* L. f.)

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Keywords: Heartwood formation, ray parenchyma cell, living wood fiber, starch grain, lipid droplet.

Teak (*Tectona grandis* L.) is one of the popular tree species planted in tropical countries. The characteristics of teak heartwood are considered to be the most significant factors that influence the high grade of wood quality. in this report, therefore, radial changes of cell contents from cambium to pith were cytologically observed. General characteristics relating to heartwood formation such as sapwood width, growth/annual ring, and wood color were also investigated. To understand the waxy nature of wood, chemical experiment was carried out.

Two plantation sites of different meteorological conditions especially of rainfall in Indonesia were selected. The plantations were located in Cepu (Central Java) which has relatively a dry season and Sukabumi (West Java), where precipitation in dry season is rather abundant. The age groups of sampled trees included 5, 25, and 80 years in Cepu while they were 21, 26, 36 years in Sukabumi. After felling, disks were collected from two different positions of the tree trunk representing tree base and clear bole height. One part of the radial strips in a disk was fixed with 3% glutaraldehyde for the cytological observations. Radial sections cut using sliding microtome were stained with Sudan IV, Nile blue for lipid droplets and I2KI for starch grains. Part of small wood blocks was embedded in Epoxy resin for the investigation especially of "living wood fiber". Transverse sections were also prepared to investigate growth/annual ring structure. The color of sapwood and heartwood was measured by a colorimeter (Nippon Denshoku Co. Ltd.). Wood powder was extracted with chloroform-methanol to evaluate the total amount of lipids.

Sapwood widths remained more or less constant in two vertical positions of the tree trunk in both the plantation sites. Except for the young 5-year-old trees, the sapwood widths remained almost same at the lower part of the trunk in all selected age groups of the trees. in the cytological observation, ray and axial parenchyma cells in the outer part of sapwood showed greater amount of starch grains as a reserve substance. To the direction of inner sapwood the amount of starch grains decreased. Coupled with the decrease of starch grains, lipid droplets gradually increased towards heartwood region. in addition to parenchyma cells, wood fibers contained both starch grains and lipid droplets in the sapwood. These fibers were considered to be "living wood fibers". in the heartwood, ray and axial parenchyma cells as well as fibers showed no trace of starch grains. The amount of lipid droplets, on the other hand, was higher in the heartwood. Between the two plantation sites, there were no significant differences in cytological features.

Chloroform-methanol extractives showed about 5 and 8% of extractive content in sapwood and heartwood respectively. Lipids were found as the major components of the extractives, which appeared to be responsible for the waxy nature of teak wood. The samples from Cepu showed more distinct growth ring boundaries than those collected from Sukabumi. The former had large sized pores as characteristics of "ring porous wood". The growth ring structure had the influence of rainfall in each site. From the measurements of a*, b*, L*, it was clarified that sample from Cepu had more yellowish brown heartwood while that from Sukabumi had dark brown color.

Based on the above results, the characteristics of heartwood were discussed in relation to wood formation in teak.

Growth Stresses and Some Wood Quality Attributes in Planted Teak

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Keywords: Teak; Growth rate; Wood quality; Growth stress; Girdling

The tropical man-made forest has been recognized to achieve the global environmental stability by way of carbon sink as well as by the sustainable supply of forest resources. Increase in the teak forest aiming at timber production rises the value of tropical man-made forest and realizes the above objectives. Natural old-growth teak is widely accepted as a high grade timber because of its desired colour and luster, moderate wood density, high dimensional stability and good processing properties. However the trade of natural teak is being prohibited with some exceptions. in order to promote timber production in fast growing teak plantations, assessment on the qualities of planted teak in relation to the growth conditions is important to maximize the potential of the trees by genetic improvement as well as silvicultural control.

This paper discusses some of the results of our on-going research program that aims to elucidate the relationship between growth rate of planted teak and the wood qualities including growth stress. in addition, the effects of girdling treatment on the qualities of teak were investigated as well. Released strain caused by growth stresses was measured in teak stands in Central Java in Indonesia while some wood properties were compared between the plantations of Indonesia and India.

- Annual increment in diameter as taken from the count of growth rings showed that the diameter increased linearly up to 30 years. The diameter range of 30-year-old plantation grown trees was 30-50 cm in India in contrast to 15-25 cm for the same age stands of mountain sites in Indonesia. Teak from India with a dbh range of 45-88 cm at 60 years still continued its growth, while that in Indonesia of 16-34 cm dbh at 38 years did not show decline in growth.

- The relationship between the heartwood ratio (HR%) and the stem radius (R cm) is represented by two linear lines. For the younger stands with less than 10 cm dbh the value is HR = 9.2R while HR = 0.31 R + 84.0 was obtained for the older stands of 38-65 years with a radius of greater than 10 cm. That is, the heartwood ratio rapidly increases to 90% at the diameter of 15-20 cm during younger age.

- The density increased towards the bark by 5-6 cm from pith and then stabilized at the age 10 -12 years. On the other hand, the microfibril angle decreased towards bark until 10-12 years. From these observations, it is expected that the planted teak matures around 10-12 years. The density of 5-year-old fertilized teak in India was greater than the non-fertilized ones in spite of a faster increase in diameter in the former.

5.07.00 Energy and chemicals from forest biomass

Bioenergy production potential from Australia's forests, its contribution to greenhouse targets and developments in conversion

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Australia is highly dependent on fossil fuels for energy. Under the Kyoto Protocol, Australia was one of only three industrialised nations allowed to increase its greenhouse emissions by 2010 to 108% of 1990 emissions. This represents a major reduction as estimates for "business as usual" suggest emissions would rise to 128% of 1990 net emissions. The Australian Government has announced various measures to reduce Australia's emissions to meet the agreed Kyoto target. One initiative is a mandatory target for electricity retailers to source an additional 2% of electricity from renewables by 2010. With limited opportunities to expand other renewable sources, namely wind and hydro-power, and with technological and cost limitations on photovoltaics, wood has a potential to make an important contribution to both renewable energy supply and greenhouse gas mitigation by sequestering carbon in the wood of living trees. Energy from wood can be greenhouse neutral. Australia's consumption of energy was about 3,000 petajoules annually (PJ/y) producing carbon dioxide emissions of 275 million tonnes (Mt/y).

Of the 23 million cubic metres (Mm^3) of wood harvested from Australia's forests in 1996, the production of wood products, accounted for 15 Mm^3. The remaining residual wood of some 8 Mm^3 would be a potential source of bioenergy. There are also more than 3 Mm^3 of harvesting residues in the form of defective stems and branches which could be recovered. Significant areas of native vegetation are still being cleared from woodlands for conversion to grazing or cropping. The amount of unutilised wood was measured at 38 Mt (dry). in addition, there is on-going clearing of regrowth as part of normal grazing, which provides further resources. There are also opportunities to expand thinning programs in commercial forests to improve the quality of the growing stock to produce bioenergy from the young wood. These opportunities have not yet been quantified. Another major forest biomass resource, currently unquantified, is forest litter consisting of branches, twigs, leaves and bark. The quantity of this material is large and very rough preliminary estimates put it as high as 90 Mt (DW) yr^{-1}. When this material accumulates on the forest floor it can become a forest fire hazard. Even excluding forest litter and potential thinnings, the combined available bioenergy resources have a primary energy potential of 870 PJ/y of which 97 PJ/y is currently being used for energy purposes for domestic heating, cooking and industrial energy applications. The uncommitted wood could potentially supply 26% of Australia's primary energy needs.

New plantations are offering opportunities for carbon sinks and already, this has spawned a fledgling market for carbon futures trading. There is a national vision to treble the area of plantations to 3 Mha by the year 2020 - much of this will be private farm forestry for multiple benefits including greenhouse gas mitigation. Some of this wood could be used for bioenergy, and such markets could facilitate forest expansion. With expected growth rates for new plantations averaging 20 m^3/ha/y, this is equivalent to sequestration of about 20 t/ha/y of carbon dioxide. Thus one million ha of plantation could potentially sequester 7% of the national annual carbon dioxide emission.

To convert wood to energy, there are a number of technologies available or under development. These are classed into combustion, carbonisation, gasification and liquid fuels. Technologies in combustion are well developed using packed bed, fluidised bed and suspension combustion systems. Small to large systems are commercially available for home heating of several kW to large-scale industrial boilers up to 60 MW for process heat or power generation through a conventional steam cycle. Technology for charcoal making is mainly based on primitive, low-cost batch kilns that are labour intensive where cheap labour is available. Large-scale mechanised systems are used where there is a large production of wood feedstocks. in one efficient system the volatiles of carbonisation are burnt to recover energy for process heating and power generation. Gasification technologies have been commercially developed for heat production. Small-scale gasification technology is under development that should offer efficient electricity generation. Gas turbines are providing prospects of high efficiency. There is some interest in ethanol production by cellulose hydrolysis in Australia. Fast pyrolysis has been the centre of development attention in Europe to produce pyrolysis oil to run boilers and even diesel power plants. Some activity in this area is also commencing in Australia for chemicals.

With the availability of a large biofuel resource and emerging technology to make efficient use of it, wood as biofuel has enormous potential to contribute to Australia's energy supply and reduce net Greenhouse gas emissions.

The Use of Fuelwood for Energy in Rural Areas

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Fuelwood such as rubber (*Hevea brasiliensis*) is the dominant source of energy for many rural industries in Malaysia. Almost 85% of the energy source for numerous medium-scale industries such as for the smoking of rubbersheets, curing of tobacco leaves, firing of bricks and the drying of foodstuff comes from fuelwood. This paper therefore attempts to highlight some of the problems faced by these industries such as the lack of technical and scientific knowledge to improve existing energy conversion systems and the availability of fuelwood at competitive prices. It also focuses on the role of R & D institutions towards overcoming these problems through better process heat production such as gasification and improved heat exchanger systems. Special attention is focused on ways to reduce the specific fuelwood consumption (SFC) through better drying regime, better insulation technique and improved front furnace control. The technical and economic appropriateness of these measures in terms of combined energy savings and pay-back period for one of the system is discussed.

Public Perceptions to Wood in Energy Production - Does the Environment Matter?

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The Kyoto Agreement and energy related atmospheric emissions have been among the main topics in international environmental discussion lately. Common understanding is that emissions need to be reduced in order to preserve the environment. It can be assumed that consumers' interest towards bioenergy has increased due to the general concern about environment. But only a minor share of consumers are willing to pay a price premium for environmental product characteristics, and there is limited knowledge about other factors influencing the potential demand of bioenergy, such as consumers attitudes and interest toward bioenergy. This information is, however, of vital importance for promotion and thus development of bioenergy markets.

This study is conducted to describe consumers opinions and expectations related with energy, in particular wood based bioenergy, in Finland. The data for the study was collected in late spring 1997 through a mail survey to 1 200 households in three regions in Finland: an urban region in Southern Finland, and a small town and a rural municipality in Eastern Finland. A structured questionnaire was used, and 400 questionnaires were sent to each region. Response rate was 44 % and thus the data consisted of 524 accepted answers of consumers of age between 18 to 70. The data was analysed using multivariate statistical methods: factor analysis and discriminant analysis.

The results show that Finnish consumers emphasise safety as one of the most important characteristics in energy production. On average, consumers preferred that solar energy, wind power and wood based energy should be increased in Finland's energy supply in the future.

Consumers' demographic background seems to be linked with different energy attitudes. Persons being in high decisive roles in the society emphasise low priced energy as necessary for economic growth but they emphasise environment less than others. in contrast, high education and living in urban area seemed to be connected with more than average concern on environment. Female and young consumers were the most willing to reduce their standard of living and compromise the general economic growth in order to reduce harmful environmental impacts of energy production. Low energy price and continuing use of fossil fuels or nuclear power were seen necessary for economic growth most often by male and relatively aged consumers and those in high professional positions.

Consumers in rural areas regarded domesticity and low price somewhat more important in energy choices than consumers in urban areas.

Overall, price seems to be a very important criteria in consumers' energy choices. But most consumers assume that they would change to use "green" electricity if this would be available without extra cost in comparison to other alternatives. About half of respondents think that they would choose "green" electricity also if the price is a few percents above other alternatives.

Even though the results of this study are limited to three regions in Finland, it can be assumed that Finnish consumers, on average, would like to see increasing use of biofuels in energy production, and a few might even pay a small premium in energy price for this. But probably increase in price competitiveness is still needed before bioenergy production grows in large scale. However, environment can be expected to matter in energy choices: Bioenergy may reach considerable market share as soon as it becomes fairly price competitive and is available for the majority of consumers. Currently there may be special market segments for bioenergy even with some price premium. The general preference of renewable energy sources gives also a reason to assume that consumers might support society's investments in bioenergy.

5.07.01 Fundamentals of wood carbonization

Effluent gas analysis as a tool for studying wood carbonisation processes

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Wood carbonisation, or charcoal-making, is an ancient process. Historically, its main use was in the recovery of metals from their ores. This remains its most important use today; however, charcoal also finds widespread use as an urban fuel and in specialised applications such as silicon metal production.

Charcoal is produced by a variety of techniques. The efficiency with which these convert wood into charcoal varies widely. The most efficient approach would appear to be thermal decomposition under pressure, a technique developed recently at the University of Hawaii. Retorts are also comparatively efficient. However, both these approaches require a level of technical sophistication beyond the reach of many small to medium scale charcoal producers. For these producers, kilns are likely to remain the predominant means of charcoal production.

Whilst some of the smaller kilns are decidedly inefficient, some of the more established designs perform quite well. Undoubtedly the present designs of such kilns and current operating practices are the result of much hard won practical experience and a good deal of on-site research and development work. However, it now appears as if further gains in efficiency are most likely to come from a better understanding of carbonisation process fundamentals. These fundamentals, as they relate to a charcoal kiln, can be divided into two groups. There are the microscale processes, or the processes that occur within or adjacent to individual wood pieces. Then there are the macroscale processes, i.e. the fluid flow, heat and mass transfer and reaction processes that occur in and around the stack of wood as it slowly decomposes into charcoal.

There has been considerable research undertaken into the processes occurring within individual wood pieces during carbonisation. Since these normally occur in the absence of air, methods for the study of these pyrolytic decomposition processes usually involve maintaining the wood pieces under study in an inert gas environment. Following the process of decomposition is usually done by thermogravimetry, which has the disadvantage that it sheds little light on the chemical changes occurring in the wood. It is possible to study the off-gases from the pyrolytic decomposition process using sophisticated instrumentation employing one or more mass spectrometers. Such instruments provide a wealth of information but the costs are high.

An alternative and more affordable effluent gas analysis approach is being tested at the University of Melbourne. in this approach, a mixture of sand and the material under study is heated at a constant rate in a controlled flow of some oxidising gas, usually dry air. The O_2, CO_2 and CO content of the effluent gas is measured. Experience to date has shown that the levels of these components exhibit peaks and troughs that appear closely related to the decomposition peaks identified using thermogravimetry. in addition, information can be obtained on the rate of evolution of carbon and other elements at different stages along the heating process. With the addition of instrumentation to measure the moisture content of the exit gases, the above technique should yield quite detailed information on the types of chemical changes occurring at different points along the decomposition pathway.

To date this technique has been used solely to obtain information on the processes that occur within individual decomposing particles. However, the conditions in the reactor where the wood or other biomass is heated have a number of similarities to conditions in the wood stack of a charcoal kiln during the preliminary heating stage, when air is being admitted. It would seem possible that the effluent gas analysis technique can be used to obtain information related to this phase of charcoal kiln operation, and the prospects for doing this are examined.

Keywords: Analysis; carbonisation; charcoal; gas; pyrolysis; wood.

Energetic valorisation of wood wastes and by-products by staged pyrolysis

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New European regulations will forbid the disposal of wood wastes (waste wood from demolition, framing, packing, pallets, etc.) or wood processing wastes (particleboards, wood composites, varnished and painted woods, etc.). in these wastes wood is associated with other, different materials (glues, paints, preservatives, paper, etc.). Their recycling is not always feasible and presently the preferred method for their disposal is energetic valorisation. This last option can be achieved in two ways, by direct combustion or by pyrolysis in the absence of oxygen; both approaches yield a solid and a gas phase, both fuels.

The direct combustion route produces a large volume of hot flue gas containing not only the main products of wood combustion (CO_2, H2O) but also several undesirable pollutants such as nitrogen oxides (NO_x), volatile organic compounds, and volatile metals (mercury, lead, etc.). The most recent European Community accord on environmental preservation requires that the combustion gases should be treated before their release to the atmosphere. The volume of gas to be treated is significant but it can be decreased if the energetic valorisation process is split into two or more stages.

For several complex wood wastes, the thermal degradation of the materials present in association with the wood (urea-formaldehyde resin, polyurethane varnish, etc.) takes place at temperatures different from the ones at which wood constituents degrade. So, by operating at temperatures between 250°C and 280°C, it was possible to achieve substantial degradation of the urea-formaldehyde resin (53%), while at the same temperature level only 20% of the wood was degraded. As the volume of gases produced at this temperature level is limited (30% of the total possible), treatment of these gases to remove pollutants is economically more feasible. Moreover, the solid residue obtained is practically free of polluting elements. Similar approaches have been used for two other wood additives, polyurethane varnish and preservatives based on chrome, copper and arsenic salts.

In this paper only the pyrolysis of wood wastes associated with UF resin is considered. The optimal conditions for their treatment by pyrolysis are given, specifying the compositions of the gas phase and the solid residues. After that, the pyrolysis stages are modelled in order to get relevant kinetic models that can be used to design an industrial pyrolytic unit.

Keywords: Analysis; carbonisation; charcoal; gas; pyrolysis; wood.

Destructive distillation of wood

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Keywords: Distillation of wood; *Aspidosperma quebracho-blanco*; Pyrolysis; Charcoal; Fixed carbon

The charcoal that is produced in the Province of Chaco, Argentina comes mainly from wastes from sawmills and carpenter's shops. This charcoal is made from different species such as: *Aspidosperma quebracho-blanco, Schinopsis balansae, Astronium balansae, Patagonula americana, Prosopis sp*, etc.

The species *Aspidosperma quebracho-blanco* is the most abundant in the region of Parque Chaqueno and the charcoal, which comes from it, is the best paid in the market. The production of charcoal from this species is made in typical kilns, like the ones used in the building industry, with a charcoal yield of an approximately 25 % and a fixed carbon content of 74 %, both percentages on a dry basis.

Because of the above mentioned, the purpose of this paper is to propose a more efficient alternative for the use *Aspidosperma quebracho-blanco*, namely producing charcoal by destructive distillation.

To do so, charcoal was produced from *Aspidosperma quebracho-blanco* through destructive distillation. This raw material, which came from waste from sawmills of the whole province, was processed in a Destructive Distillation Pilot Plant which has a vertical retort, with enough room for 50 kg of wood, with indirect heating; an air condenser and a cross-current water one, a multiple temperature meter connected to a thermocouple type "K".

The destructive distillations were made according to a Central Composites Design for heating rate between 60 °C/h and 120 °C/h and final carbonisation temperature between 450°C and 550 °C.

The wastes used for the destructive distillation and the charcoal obtained from it were analysed under specific Argentine Institute of Material Rationalisation (IRAM) standards.

The results obtained show a charcoal yield of approximately a 48 % by weight and a fixed carbon yield of greater than 82 %, both calculated on a dry basis. To sum up, the charcoal yield, on a dry basis, produced from wastes by destructive distillation of the species *Aspidosperma quebracho-blanco* is enlarged in a 49 % as regards the typical kilns, operating at a heating rate of 60 °C/h and with a final carbonisation temperature of 450 °C. The fixed carbon yield, on a dry basis, achieved through dry distillation of wood wastes under conditions leading to greatest weight yield, was 83,9%. This is 13 % greater than the corresponding figure for conventional kilns.

5.08.00 Production and utilization of bamboo and related species. Challenges for the new millenium

Increasing the Service Life of Bamboo

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Bamboo is one of the fastest growing plants in the plant kingdom. Bamboo clumps can be established in 5-6 years from the time of planting. Culms reach maturity in about three years. Once the clumps are established mature culms can be harvested every year. Bamboo, because of the fibrous root system, is well-known for its soil binding property. The potential of eco-friendly bamboo for various applications is now being realized throughout the world. Unlike some timbers which are naturally durable because of the presence of toxic chemicals, any species of bamboo is naturally non-durable. in South and Southeast Asian countries, where bamboo grows naturally there is a 'bamboo culture'. Bamboo is referred as 'poor man's timber' and for centuries has been meeting the society's need for low value products like mats, baskets, agricultural implements, constructional material (scaffolding, rafters), etc. Most of these products could afford to be replaced after a short use. However, to ensure sustainable availability of bamboo resource to meet the society's needs, the service life of bamboo should be increased. Whether bamboo is used as 'poor man's timber' or as value-added products for various applications like furniture, building components like flooring, trusses, etc., treatment with preservative chemicals becomes essential.

Depending on moisture condition of bamboo (in green or air-dry); hazard condition of application (in ground contact, out-of-ground contact exposed or under cover); method of treatment (pressure or non-pressure) and type of material (in round form, split form or slivers), different preservative chemicals are suggested. This paper reviews critically the advantages and disadvantages of the different treatment techniques available (like sap displacement, steeping, hot-and-cold, pressure impregnation, etc.) and the different preservative chemicals (coal tar creosote, copper-chrome-arsenate, boric acid, sodium pentachloro phenoxide, etc). Also, the traditional methods evolved in different bamboo using countries for providing protection to bamboo are also critically reviewed.

Bamboo as a housing material

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Bamboo has been a valuable material for housing for centuries. The tradition shows many good examples how people could solve their own need for housing and other type of building. Unfortunately also many examples can be seen of short durability, lack of resistance to disasters, etc. Here results of applied scientific research and good engineering practice can improve the use of bamboo towards a proper engineering material with a status equal to recognised materials like steel, concrete, brickwork and timber. Local traditional knowledge is limited to the region of origin; this knowledge cannot be transferred to a different region or climate. A knowledge based system as a decision support during the design process can improve this considerably. Standardisation of test methods can improve the level of testing in local laboratories, and can allow the comparison of test results from all over the world. Next to such an international standard, a manual with simple and clear explanations about how to do tests can be a great help for laboratory staff. For engineers and architects, national building codes are lacking with respect to bamboo as a building material. An international model for national building codes might be helpful. The said documents will be treated in the paper, as well as simple handbooks for field practitioners.

Self help will remain very important in housing, not only to save costs but also to be sure about the involvement of the future inhabitants. This self help can be supported with a balanced aid by prefabricated and industrialised housing systems. Evidently, joints are the key problem, but a considerable progress can be seen. in modern bamboo housing, not only full bamboo culms are being used, but also sawn or split bamboo strips, and panels made of bamboo. Roofs mainly are supported by trusses, in which field considerable development towards good engineering applications will be reported.

Houses have to be resistant against disasters like earthquakes and hurricanes. Applied scientific research has made good progress; evaluation reports made after disasters give also guidelines for improvement. Emergency shelter, or prefabricated or by self help, is also an aspect of bamboo housing related to disasters. The paper will highlight the said items.

China Bamboo Industry: Comparison Study on Socio-economics, Marketing and Policy in Some Main Production Areas

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China bamboo industry is now contributing USD 1.5 billion annually to its economy development. For its clear understanding and further development in the region and the world, a cooperative project among two Chinese institutions, CIFOR and INBAR was laid out recently. From east coast to south-west marginal areas of China, totally 500 farmer families, 69 factories and 77 traders, which are located in 6 main bamboo production counties with various levels of intensive management for bamboos, have been surveyed. Based on data assessment and analyses, the production-to-consumption system has been made, the partaking main bodies in bamboo sector and their systems, major running departments and their interests/conflicts with the partaking main bodies and the running mechanism of activities have also been identified. It is found that bamboo sector is really important to farmer's and county's economy in all main production areas, particularly to the potential target groups such as poverty rural people and disadvantaged group, for the income from which can occupy more than 60% of their total family incomes. The socio-economic environment of bamboo sector's development, such as policy, marketing mechanism and scientific technology, is described, from which both problems/constraints and potential/opportunities faced to the local farmer, factory manager, trader and government officer are

identified and discussed. Finally, the main measures which could overcome those problems and constrains for leading to sustainable bamboo sector are put forward for discussion.

Bamboo Aesthetics: New Dimensions of Form and Function

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Bamboo Aesthetics: New Dimensions of Form and Function introduces a brief historical glimpse of the rich tradition of bamboo craftsmanship in Malaysia and in the region. It describes how bamboo, as an indigenous raw material, has had an immense impact on the economic, social and cultural life of the community, the artisans and the craft industry. It also highlights the influence of bamboo on the development of concepts and design issues related to the world of interior design and its imaginative and creative application and usage in the design of living spaces of modern homes and institutions. To illustrate this, a special collection of images (slides) will be presented to illustrate the variety and diversity of its form and function that has evolved in the last hundred years. It would include the use of bamboo as a traditional and contemporary product.

The paper will also discuss the areas of concern and issues relating to bamboo as a material, the use of technology and tools, design development and socio-cultural factors that have contributed to this process. More importantly, the primary concern is to focus on the plan for the future use of bamboo: to explore how bamboo as a vital source of indigenous raw material to the craft industry could be sustained: to ascertain how efforts in research and development, product development, promotion and marketing of bamboo products could be further enhanced.

Finally, in the context of the spirit of cooperation, it would be essential to explore and determine a strategy, direction and methodology which could foster regional as well as international collaboration for the development of bamboo for the future. In this context, what programmes, initiatives and incentives for example, should be developed to encourage a greater effort in tapping the potential usage of bamboo within the next five years. Suggestions will be offered with a view to develop specific proposals and recommendations at this discussion of international gathering.

Bamboo as raw material for wood processing in Europe

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Bamboos are endemic in all parts of the world except in Europe where they did not survive the last glacial period. The most northern natural distribution limit is the North of China, corresponding to the latitude of south of Europe. Since the first introduction of Bamboo in Europe (1827), about 400 different genotypes have been imported. The actual annual production of bamboo plants in Europe is estimated in millions units nearly exclusively for ornamental purposes. Europe is technologically more advanced in areas like micro-propagation and the selection of superior genotypes of bamboo. The bamboo plant producers envisage at long term the industrial transformation of bamboo.

Co-ordinated by the industry a group of research institutes and universities have been working on the evaluation of bamboo as a large-scale crop to be used as alternative raw material for wood processing industry in Europe. Some 10 different bamboo species, mainly of the genus *Phyllostachys* were selected and evaluated on their production and adaptation parameters in plantations representative for western and southern Europe. From additional research work on harvesting techniques and corresponding crop management systems it seemed that bamboo has potential as an alternative crop for the agricultural sector in Europe.

Growing bamboo, taking into account the European economic structures, is however not feasible without major industrial applications. Within the framework of the research project called 'Bamboo for Europe' financed by the European Commission both production criteria and market potential were taken into consideration. The goal of this project was to consider the use of bamboo as alternative raw material to wood however without changing wood processing. It is generally accepted that at this moment no industry in Europe will invest in processing techniques specific for bamboo. Furthermore labour costs in Europe do not allow input of extra manpower in production processes.

Different industrial uses were considered, tested and evaluated. The possibilities for large-scale utilisation of bamboo as additional or alternative raw material for the wood processing industry range from low quality commodities to highly developed

engineered products. The main areas for potential use in industrial wood processing techniques in Europe are particleboard, medium density fibreboard and laminated products. Although several production problems needed to be solved and some limitation have to be taken into account, it can be stated that the wood processing technology can use bamboo. The successful introduction of bamboo in Europe as alternative crop for the agricultural sector will need the additional support from European policy makers. The result of this research proves however that the forest sector could well profit from an alliance with the agricultural sector in producing additional high quality lignocellulosic raw material.

Properties of Exterior Grade Particleboard from Bamboo: Influence of Age, Particle Size and Wax Addition

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In the study of exterior grade particleboard from bamboo, homogenous and three-layered METLAmine urea-formaldehyde particleboards were produced. For the homogenous board, the effect of age was found to affect the board properties significantly but since the differences between actual mean values were rather small, it can be assumed that the particles from any age group are suitable for particleboard manufacture. The increase in resin content was observed to be accompanied by a significant increase in the mechanical strength, reduction in water absorption and thickness swelling properties. By varying the particle sizes, the mechanical and physical properties behaved significantly different. Wax used significantly increased the water resistance but reduced the mechanical properties. For the three-layered particleboard, the mechanical properties and dimensional stability of the sample were found to decrease with the increment of core particle sizes. Wax addition, on the other hand, increased the board stability towards water exposure but decreased the mechanical characteristics. Comparison between homogenous and the three-layered board were also discussed in this paper.

Bamboo Silvicultural Theory and Practice in China - Review and Prospect

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China has a long tradition of cultivating bamboo resources and using the resources as materials for housing, tools, furniture, pulping, medicines, and foods. in China modern cultivation theory and technical practices started in late of 1950's. Based on the research progress in bamboo atonomy, resource inventory and zoning, biology, physiology, and ecology, a systematic bamboo silviculture has been developed, which includes theory and technology of bamboo seedling propagation, afforestation and high-yielding cultivation and management obviously characterized by Chinese features. These bamboo silvicultural theory and technology have greatly promoted resource cultivation and management, in which bamboo productivity has been greatly raised. The achievements and development of silvicultural theories and practices in China are unique in forest silviculture in the world. of the bamboo silvicultural theory and technology, the high-yielding cultivation theory and technology to improve stand productivity is a very important component. Based on the research findings in experimental trials in comparison between technical practices, the technical prescriptions on control of bamboo community structure and soil management have been developed. From late of 1950's to 1970's, the theoretical research and practices were concentrated on improvement techniques for low-yielding stands aiming at raising productivity of low-yielding natural bamboo forests, in which the techniques progressed and were implemented slowly. in 1980's, a high-yielding cultivation technical system, to achieve high-yielding products in edible shoots and timbers, have largely progressed and been implemented in extension practices. in 1990's, a high-yielding technical system on high-yielding, good-quality, high-benefits with oriented cultivation goals and techniques, in terms of principles of forest management by categories, have been developed and implemented in a large scale, in which bamboo forests are managed in 13 types of 4 categories such as timber-producing stands, shoot-producing stands, ecological maintenance stands, as well as landscaping and reservation stands, to exploit the potential of bamboo forests in economic, ecological and social benefits.

By the brief review of the bamboo silvicultural theory and technical practices in the past 40 years in China, it is found that there are many limitations in existing silvicultural theory and technology and some important issues should be addressed to meet the increasingly demand for bamboo resources and ecologically sustainable management in the coming new century.

Firstly, the limitations exit in theoretical foundation of forming present high-yielding cultivation techniques, which are mainly characterized by lack of understanding of the unique mechanism on bamboo self-crowed generation and propagation and bamboo physiological integrity in culm-rhizome systems in synthesis, consumption, transportation, and storage of nutrients and physiological matters, which results in lack of control mechanism of bamboo stand productivity. The future research should aim at simulating and modeling physio-ecological process to control productivity process at a mechanic level. Secondly, the existing techniques have a poor capacity to control productivity process-based at quantitative level. As a fact, existing techniques were based on the experimental trials, which lacks of modeling and controlling management techniques based on growth and yield simulating models with emphasis on quantitative relation in/between well-organized rhizome-culm systems. The future research should aim at simulating and modeling dynamic growth and yield and management models reflecting the impacts of management practices. Thirdly, there is no quantitative site evaluation and classification and the evaluation of capacity and potential for bamboo forests which has no secondary meristem growth in diameter and height once they matured in relative short months. The future research in this aspect should aim at matching site with management practices for specific management-oriented goals. Fourthly, future research should aim at the maintenance of long-term site productivity to overcome the negative impacts of existing silvicultural practices on sustainable site productivity and to rehabilitate degraded site. Fifthly, the existing silvicultural practices produce some negative impacts on the function of conserving water and soil of bamboo forests. The future research should aim at develop a technical system to a achieve harmoniously the economic, ecological and social benefits from managed bamboo forests.

Studies On Fertilizer Requirement of Culm Cuttings, Seedlings and Cultivated Stands of Bamboo (*Dendrocalamus hamiltonii* L. Munro)

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DendroCalamus hamiltonii L.Munro is a versatile bamboo of Hilly state of India, Himachal Pradesh. The planting material is a major limitation in its rapid multiplication and plantation. Organised nurseries and plantations are extremely rare hence awareness in their management is lacking which restricts the potential bamboo productivity in the State which otherwise has least area under bamboo plantation among other States of India. We are involved in raising its planting material through various vegetative methods and supplying the same to foresters. An organised plantation has also been raised in about 25 ha of wasteland, which acts as a source of resource material for its further propagation. in separate experiments, fertilizer requirements of juvenile culm cuttings, transplanted saplings, seedlings and cultivated stands of local bamboo "Maggar" were investigated to improve its productivity. Single nodal juvenile cuttings (I-year old) of uniform size (5.0 cm) and age were planted in March in the field in 3 replications in a field plot size of 1.0m x 0.30m. Nitrogen as urea was applied in different doses viz. 3.0(N1),6.0(N_2),9.0(N3) and 12.0g(N4) per culm cutting in combination with 5.0(P1) and 10.0 g (P2) of phosphorous as single super phosphate(SSP). Nitrogen was applied as half dose during planting and another half at rhizogenesis stage. SSP was applied as single dose at the time of planting. The days to sprouting of these cuttings was reduced by all the treatments over the control but the reduction was most significant with N2P2, N2P1, N3P1, N3P2, N4P1 and N4P2 treatments. These treatments were, however, insignificantly different from each other. Days to rooting was significantly reduced over the control by N1P2, N2P2, N2P1, N3P1, N3P2, N4P1 and N4P2treatments. Out of these treatments, N3P2 was most observed to be most effective. The days to rhizogenesis were reduced significantly over the control by N3P1, N3P2, N4P1 and N4P2 treatments and N3P2 was found to be most effective among these. The differences among these were, however, insignificant.The rooting % was increased significantly over the control by N2P1, N3P1, N3P2, N4P1 and N4P2 treatments. N3P2 and N4P2 caused maximum rooting among all the treatments though the differences between them were insignificant.Though all the treatments increased the sprouting % but the increase was non-significant. N1P1 was particularly effective but the difference from the control and other treatments was insignificant.A significant increase in survival % over the control was observed with N3P2, N4P1 and N4P2 treatments while other treatments resulted in insignificant increase in survival %.The saplings generated from cuttings were transplanted in the field in subsequent year in March and fertilizer doses were applied as Farm yard manure @ 5 Kg/pit/sapling(T1), FYM+15 g N+10g P+5g (T2), FYM+30 g N+20g P+10g K(T3), FYM+45 g N+30g P+15g K(T4), FYM+60 g N+40g P+20g K(T5).A significant increase in tiller height was observed over the control with T3, T4 and T5 treatments with T3 as the most effective one. T3, T4 and T5 resulted in significant increase in internode length over the control. T3 caused maximum and significant increase among these treatments. T4 resulted in a significant increase in the no. of tillers over the control. Adult clumps of uniform age and dimensions were selected for the experiment and fertilizer doses were applied as Farm yard manure 10 Kg/Clump (T1) FYM+100 g N+ 50 g P+25g K (T2), FYM+200 g N+100 g P+50 g K (T3), FYM+300 g N+150 g P+75 g K (T4). A significant increase in the production of new culms was observed with T4 over the control while other treatments caused a non significant increase over the control. Internode length and culm height were increased significantly by application of T4 in comparison to control. A significant increase in culm girth was observed with T2 over the control while the other treatments caused a non significant increase. The no. of nodes was increased significantly over the control by application of T2, T3 and T4. Among these T4 was observed to be the most effective treatment.

5.09.00 Tree ring analysis

Dendroecology of *Fagus grandifolia* var. *mexicana*, a beech species growing in an extinct volcano in Mexico

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Fagus grandiflora var. mexicana has a very restricted distribution in the montane cloud forests of Mexico. It occurs in five small stands in addition to the population we studied, which is the southernmost *Fagus* forest in the world, at Acatlan in the state of Veracruz. This stand is inside the crater of a volcano with a conical shape and very steep slopes. On the rim and inside the volcano, *Fagus* is the only canopy species, while it is codominant with *Quercus* spp. on the edge of the crater. Few saplings are present in the forest, but seedlings occur. The volcano is in a valley that is almost completely deforested; even the flanks of the volcano have been converted into cornfields and pastures.

We collected cores from the *Fagus* population at Acatlan. We prepared the cores using standard dendrochronological techniques and developed mean chronologies for the cores from the crater, top and rim of the volcano. We examined the individual chronologies for periods of suppression and release. We analyzed the chronology from the crater with temperature and precipitation data from nearby Xalapa, Veracruz, recorded since 1920. We screened all possible climate models by computing least-squares regressions of the standardized chronology against all the climate variables, and then fitted climate models to the beech chronology. We also collected seedlings, counted their bud scars, then cut several disks from the base of each one and counted the rings.

The oldest core from the crater dated to 1877. The oldest trees were growing in the crater, and it appears that the beech trees spread from the top to the rim of the volcano. The cores were taken at DBH so the trees are likely older than our samples. The seedlings we collected were 16-46 cm in height and had as many as 13 rings and bud scars. Current February mean temperature and February and July precipitation of the previous year were the best predictors of growth of the *Fagus* population in the crater, but the variation explained in the chronology was only 16% ($R2=0.16$, $p.=0.006$). Similar results have been obtained by other researchers for *Fagus* spp. in other parts of the world. Apparently growth of beech is affected more by other factors than by variation in precipitation and temperature. The individual chronologies showed that the trees experienced long periods of unrestrained growth with fewer periods of suppression than *Fagus* spp. that have been studied in other areas.

We will discuss the arrival, establishment and permanence of *Fagus* in the volcano. We will consider periods of growth and suppression in the individual chronologies, and the factors that influence ringwidth of the trees. We will compare growth of trees in this population with that of other *Fagus* populations.

Interregional comparison of long-term growth variability, growth responses and growth controlling climatic forcings in Finland using millennial chronologies of Scots pine

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The number of tree-ring chronologies built in Finland is increasing as research interest is spreading from the open canopies of the northern forest limit to the closed and more complicated stand structures of the south. We have built ring-width chronologies of Scots pine for the northern and southern parts of the boreal forest belt, covering the last 7500 and 1300 years respectively. The present work focuses on long, high-resolution climatic proxies during the Holocene. These records provide *e.g.* an indication of natural, pre-anthropogenic climate variability, either singly at specific geographical locations or in combination on continental and perhaps even hemispheric scales. We have applied means of measuring the strength of the common 'signal' both within and between the two millennial chronologies. in addition we have estimated chronology reliability, as Expressed Population Signal, and as a function of time. Overall correlation between the two chronologies, over the last millennia, is 0.32, and significant at the 0.01 level, when both chronologies were standardised the same way, using 67 % n splines. The present work shows evidence that a common climatic forcing influences the northern and southern pine stands. Interestingly, the signals show opposite features as well, which is evidence for growth inversions, caused possibly by climatic inversions. During some periods, growth conditions seem to have been favorable in the south, while they have been unfavorable in the north.

Using various response function approaches, we have confirmed that growing season temperatures govern the growth rates of northern pines. We have also demonstrated that towards south, tree-growth becomes less effected by temperatures, and more effected by *e.g.* precipitation. Going from the north to the south, the variability of radial growth clearly decreases, and the variance of ring-width series becomes smaller.

The spectral densities of the northern and southern chronologies were also compared as functions of frequency, viz. cycles per year. Very generally, there is more periodic behaviour in the north than in the south in high, medium, as well as lower frequencies. in the north there are concentrations of variance clearly evident corresponding roughly to periods of 2.5, 3, 4, 11, and over 33 years. in the south the peaks in spectral density occur at about 3.3, 5, and 10 years. A most remarkable feature of the two chronologies is their remarkable spectral dissimilarity. However, the two chronologies vary similarly around several pointer years, *e.g.* 1050, 1075, 1210, 1350, 1395, 1550, 1770, and 1840.

The periodicity of growth of tropical trees for dendrochronological studies: the genus *Cedrela*

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The genus *Cedrela* is constituted by 7 species widely distributed in the tropical and subtropical american forests. Three of them occur in Brazil: *C. odorata*, the amazonian forest's cedar; *C. fissilis*, the dry land forest's cedar and *C. angustifolia*, the atlantic forest's cedar. Among the tropical genera, *Cedrela* is potentially one of the most important for dendrochronological studies.

In the present paper, some aspects related to the growth periodicity of these species and *C. lilloi*, which occurs in Argentina, are discussed with emphasis in research done in America Latina. Results refering to the phenological rhythm (leaf fall and flush, flowering and fruiting), seasonality of cambial activity by dendrometer measurements and cambial marking are shown and related to climatic conditions, mainly rainfall. Descriptions on the microscopic wood structure of these species of *Cedrela* are also presented. The appearance and nature of the growth rings show distinct and well-defined annual growth rings, which are delimited by a thick band of initial parenchyma partly including the wide earlywood vessels forming a semi-ring-porous probably arised in the beginning of rainy season. The X-ray densitometry analysis of the intra and inter growth ring density variations normally showed that the minimum density values were coincident with the initial parenchyma bands, marking precisely the growth ring boundary. The growth ring analysis on cross section of the disc taken from the base of the trunk allowed the dating and growth rate determination of *Cedrela odorata* trees.

Dendroclimatic network throughout Russia

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There are several main purposes of establishing dendroclimatic network over whole Siberia: 1)creating of dense net of sites to design the long tree-ring width and density chronologies for analysis of tree growth response to climate change at local, regional and global scales; 2)quantitative reconstruction of temperature and precipitation variation in different parts of Siberia based on tree-rings and dendroclimatic zonation of territory; 3)using statistical and simulation models which describe the relations between tree growth and climate in evaluation of net primary productivity of wood component of ecosystem and carbon budget both at regional and global levels; 4)comparison of supra-long temperature variations during several last millennia of the Holocene inferred from tree-rings with other indirect indicators of temperature change; 5)to extract the tree growth response due to anthropogenic changes from natural ones.

Dendrochronological material was collected from more than 240 sites in Siberia. The densest network covered the Subarctic (64 sites), Middle Siberia (Enisey meridian)(52 sites), Altai mountains (22 sites), steppe zone in Buryatia (18 sites), the region around Lake Baikal (28 sites). The oldest living trees (*Larix cajanderi*) which own age reaches 850-880 years were found in the low part of the Indigirka river. Most of the tree-ring chronologies based on living trees has a length between 300 and 850 years. For some remarkable sites with abundant dead and subfossil wood the chronologies with length more than 2000 years were built. These sites are located in subarctic region (lowland of the Taz and Indigirka rivers, Eastern Taymir) and in timberline of the Altay mountains. in addition to tree-ring width the tracheid radial size and wood density chronologies were measured which allows to analyse the tree growth response to climate change with high resolution in time (seasonal, monthly).

In Subarctic the main climatic factor affecting radial tree growth is the early summer temperature. The synchrony of the year-to-year tree-ring variations in different parts of Subarctic was used for dendroclimatic zonation of subarctic belt and 6 subdivisions were revealed with common interannual variations of summer temperature anomalies. Analysis of supra-long chronologies clearly shows the coherence of long-term temperature and tree growth changes in different parts of Siberian Subarctic. That long-term change agrees well with temperature changes in the northern hemisphere inferred from other indirect sources (as for example, from Greenland ice cores) and shows the constant appearance of cycles with 180, 76-78, 22 and 11 years length. For instance, tree growth increases during the Medieval Warm Period (900-1200 A.D.) as well as in the middle of the current century.

At a regional level there is a regularity in tree growth response to climate along the temperature gradient from northern timberline to steppe zone in Middle Siberia. Limiting effect of the early summer temperature in northern taiga is replaced by effect of winter precipitation (negative) and June temperature in middle taiga, and spring precipitation (positive) and early summer temperature (negative) in the forest-steppe transition zone. But the conditions at the beginning and in the first part of a season (soil moisture and temperature) play the key role for annual radial tree growth and wood productivity along the meridional transect. This conclusion was also tested using statistical and simulation models. The high relationship between limiting factors and tree growth allows to reconstruct summer temperature, winter or spring precipitation based on regional tree-ring chronologies. The reconstructions reveal weak positive trend in summer temperature in Subarctic during the last century and clear decreasing summer temperature and increasing winter precipitation in the middle taiga of Central Siberia. If such trends relate with documented warming in the northern hemisphere it means that at the regional scale climate changes show their own regularities and tree growth responds to regional combination of temperature and moisture more than to the global trends.

Dendrochronological data are used to evaluate the long-term basal area increment of trees in different parts of Siberia. Only in Subarctic the long-term changes of basal area increment correlate well with the northern hemisphere temperature, but in the more southern areas of Siberian taiga they do not. So, in the first approximation the annual primary productivity of wood component of forest ecosystem doesn’t increase due to global warming trend but depends more on regional changes of temperature and precipitation. The same results were obtained from the reconstructed fire history in different taiga zones using absolutely dated fire scars and tree-ring chronologies. in the northern taiga the fire frequency agrees well with summer temperature changes (similarly both at the regional and global scale), but in the middle taiga the fire frequency is determined more by moisture changes and during the last several centuries completely disagree with northern hemisphere temperature changes. The ways how tree-ring data use in carbon cycle models of forest ecosystems are discussed.

How useful are wood anatomical features in tree-ring analyses?

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The most frequently used variable in tree-ring studies is ring width, including that of the earlywood and latewood separately, as well as the relative proportions of the two zones. Other studies include tracheid dimensions in softwoods or vessel size and arrangement in hardwoods. Wood density profiles have been frequently measured in softwoods and also in hardwoods. Most studies consider usually a narrow selection of tree ring features rather than comparative studies using a large set of features; this research, however, includes 16 anatomical parameters measured in dated tree ring series from twenty spruce trees from the Eastern Ore Mountains, Germany. .The purpose was to show differences in climate sensitivity inferred from the tree rings features, as well as possible effects of features upon wood properties.

Ring width and latewood proportion did not show significance relationships to monthly climatic data, whereas maximum density, latewood cell wall percentage in latewood density both were highly correlated to temperature and precipitation. The climatic signals expressed in resin duct density, ray height, tracheid length and microfibrillar angles were less pronounced and therefore only of limited importance. of 16 tree ring parameters, densitometry - as an indirect measure of xylem anatomy - seems to have the greatest potential to indicate climatic conditions.

5.10.00 Forest products marketing

Environmental activity and timber certification in marketing of forest products

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Keywords: Environmental marketing, Timber certification, Marketing of forest products

Environmental and social concerns in the society will set new challenges for companies. in this new age of environmental consumerism, products are being evaluated not only on performance or price, but on the social responsibility of manufacturers. This may create strategic marketing opportunities for manufacturers who can demonstrate strong environmental performance. However, marketers may feel unsure how environmental issues should be integrated into traditional marketing. One specific and currently topical issue for forestry industry is the potential of timber certification as tool of environmental marketing. Implementation of timber certification could be considered as an example of marketing function that could be a reflection from environmentally oriented strategic decisions.

The purpose of the study is to describe and compare how environmental issues are emphasised in the marketing planning of European forest related industry. The countries surveyed are Finland, Germany, Sweden and the UK. Theoretically, the concept of environmental marketing was examined.

The cross-sectional data for the study was collected by using standardised personal interviews with sample size ca.100 in all countries. The Finnish, German and UK data was conducted in 1997 in the context of an EC-FAIR research project on potential of timber certification. Equivalent data from Sweden was collected in autumn 1998 in order to get another big European producer of forest products for comparison. The industries / marketing channels surveyed were the following: Pulp and paper industry, Sawmills and panels, Joinery and other secondary wood processing, Marketing channel intermediaries, and Paper buyers. A special measure instrument was constructed by using multivariate methods to assess environmental activity of the industries of each country. The summated scale was done by focusing how environmental issues are emphasised in three hierarchical decision levels of marketing: strategic, structural and functional level. The validity of the scale was tested by examining its relationship with the importance of timber certification in marketing. Thus, the potential of timber certification as a marketing tool was assessed.

Most of the European forest industries are relatively well prepared for integrating environmental issues in their marketing. Environmental issues are central in the marketing strategies of the European forest industries. On the other hand, it must be said that they are not the most central ones. Integrating environmental issues in marketing planning is not a genuine proactive strategic decision. The industry has been forced to do it. The development of integrating environmental issues into marketing planning could be even deeper if genuine environmental responsibility is regarded important.

The companies also regard timber certification as a necessary tool for marketing of forest products. The results show that the level of environmental activity varies between countries and industry sectors. Finland seems to be the country where environmental issues are emphasised most in marketing of forest products. in the UK these issues were emphasised less than in the other countries. From the industry sectors, pulp and paper industry seems to be the most active in environmental issues. Generally, two thirds of the forest industries in all countries thought that a widely used certification system is needed. However, German forest industry had most reservations towards certification. Regarding the importance of certification as marketing tool, the level of greenness of the companies seems to have significantly more explanatory power compared to the background factors such as country or industry sector. The more environmentally active the companies are the more important marketing tool they regard certification.

The Development of an Effective Marketing Communications Network for Successful Technology Transfer: An Empirical Study Based on the Diffusion of Portable Timber Bridge Technology

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Keywords: IUFRO; Technology transfer; Communication channels; Timber bridges, and Marketing

The ability to use scientific or engineering advances (new technologies) to meet market needs has become a primary business success factor. New technology is also a major factor influencing growth and productivity within a firm. However, the forces that lead to technological innovation are not always from within. Often a company receives technology push from outside sources. However, the transfer process is not always smooth. Public sector research represents an important source of technology. in the major Western industrial countries, government and university research organizations account for over 40 percent of the national research and development (R&D) expenditures. However, many technology transfer efforts between public (federal government) and private sectors have been disappointing.

Like all businesses, government organizations buy, sell, provide, and deliver ideas, services, and goods. Government organizations today face limited funding and personnel. But they must grapple with growing needs for their services. Public organizations often find it necessary to seek help from other organizations and individuals to achieve their objectives. in the case of diffusion of government-sponsored innovations, it is challenging to find parties who can facilitate technology transfer, and once the parties are identified, elicit the necessary assistance from them. Numerous research efforts have been conducted on the technology transfer efforts between government-sponsored innovation and private sectors. However when researchers try to gain an understanding of the efforts, they primarily look for end-results and tend to neglect the information flows and communication processes that lead to these results.

The Wood in Transportation Program, USDA Forest Service, has put considerable effort in transferring timber bridge technology to the private sector. However, much of these efforts have focused upon permanent timber bridge structures for highways or pedestrian use. Another potential large market may exist for portable timber bridges for use in forestry and logging operations. and little research has been conducted on how to facilitate technology transfer to the target users (loggers).

The main goal of this study was to evaluate information flow through the entire communication channel to logging operations and identify key intermediaries who can help the USDA Forest Service - WIT Program facilitate effective technology transfer. This study utilized a unique backward-trace method to gain an understanding of how innovations (portable timber bridge technology) are diffused. The research consisted of the following steps to attain the final goal of developing strategies to successfully diffuse portable timber bridge technology from public research sectors to private sectors. First, the research evaluated how the end-users (loggers) receive information, why they prefer certain channel(s) to others, and how they make decisions to use or not use technology from developers (WIT). Second, the intermediaries were identified by loggers and were evaluated on how they receive information from technology developers; how they evaluate the information; how they currently promote; and diffuse ideas or innovations. Finally, the technology developers were evaluated on how they currently promote and diffuse ideas or innovations. Upon analysis of the network of information flows, a strategic marketing plan for successful transfer of portable timber bridge technology was developed.

Method For Forecasting Demand and Profitability of Wood Products On Market - Wood Product Analysis

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Keywords: wood, wood products, demand, demand analysis, profitability, profitablity analysis, forecasting, forecasting demand, quality, quality estimation, price, price estimation

The research aims at developing a method for forecasting wood product specifications, amounts, qualites, and prices.

The method opens an opportunity to analyze profitability, competitiveness, and strategic position on market for wood products, e.g windows, doors, and other wood construction products. The method enables reseach scientists and companies to estimate future's wood product volumes, product specifications as well as to create products' price estimates. The method combines product's technical specifications and market factors related to product competitiveness. This kind of wood product analysis model has never before been developed. The goal for this research project is closely linked with total goal of adding value for products of wood industry.

In the first phase we have chosen a group of wood products and created a method of definition for all needed product properties. The choice of the wood products is based on the specific needs of the wood product industry as well as the computer model the wood product analysis is closely linked with. The wood product analysis covers a wide range of products of solid wood, engineered wood as well as products of pulp and paper industries. However, in the first phase we have studied products like windows, doors, various glued wood products, panels and different components of wood housing products. The method for wood product analysis has been created with a perspective of gaining advantage of computer optimization modelling and economical analysis, which are closely linked with this area of research. For instance a process of designing new wood products for a new customer group will sig-nificantly benefit of this kind of method.

In the second phase we have collected detailed source information of various wood products for the analysis. This started with a litterature analysis, databases as well as material given by research organisations and companies. Besides we collect information by interviews from product and market areas, which are essential for wood product competitiveness.

In the third phase we develop a method for forecasting wood product specifications, amounts, qualites, and prices. The use of this method combines product qualities, costs, volumes, and other factors related to product competitiveness. Likewise this method can be used in a new way to seek new value added products or product specifications for a company. This forecasting method for instance helps a company or other user of this method to define a potential position for a wood product on markets, which opens a new information decision level for wood product development and investments.

The Internet: Implications for Business Practices in the Forest Products Industry

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Keywords: Internet, forest products, eBusiness, North America

eBusiness is the application of Internet-based technologies for conducting business. eBusiness offers revolutionary tools for business development and management. Through the Internet, many barriers that were once roadblocks to new markets, resources and competitive positioning can be reduced or even eliminated. in addition, the Internet levels the playing field by allowing small companies to be as visible and accessible as the largest companies. Although businesses vary greatly, along with their depth of participation on the Internet, their goals are often the same: to find new customers; new sources of profit; and new ways of doing business in a global marketplace. Technology, while important, is not the limiting factor in eBusiness. What is difficult is managing the changes in business strategies and internal corporate processes that must take place for a company to take advantage of eBusiness.

eBusiness was studied in the context of the forest products industry in the United States and Canada. One thousand solid wood products and 300 pulp and paper companies were surveyed. The sample frames included the top 100 companies (by production volume) in each sector (solid wood products, pulp and paper). The remaining companies sampled were randomly selected from the population.

Overall, respondents were asked to discuss their current or planned eBusiness strategies and the impacts that have on dealings with customers and suppliers. Specifically, the study objectives were to: Examine the current and future uses of eBusiness in the industry and to identify how the forest products industry is investing in and leveraging eBusiness.

Mail questionnaires were used to conduct the study. A list of questions was generated for the survey instrument drawing from constructs and measures developed by the researcher in previous studies or adapted from other sources. The survey was reviewed and revised by the researcher, a pre-testing sample of five companies and the research client. An iterative process resulted in the final instrument.

Results indicate that 40 percent of respondent companies are conducting some type of eBusiness. Implementation of eBusiness by respondents has taken place in the recent past. Nearly ninety percent of respondents developed eBusiness in the past three years. Earlier implementation (before 1996) was done by larger companies, typically lead adopters of technology. The primary reason respondents implemented eBusiness was as part of an overall corporate strategy (mean of 3.5 on a 5-point Likert scale of agreement). These technologies are well-planned activities that are meshed into the corporate fabric as opposed to being independent or non-integrated. Second, and the only other reason ranked above neutral (3.0 on the 5-point scale), was the goal of retaining customers. Respondents registered a number of general concerns they have about conducting eBusiness with concern about security of information ranking highest.

Companies seek products, processes, and technologies that add value to their offerings in an effort to become or remain competitive in the marketplace. Firms that consistently deliver superior benefits are highly valued by business partners. This also helps to establish, develop and maintain strong relationships. eBusiness is one means for developing such a competitive advantage.

5.11.00 Non-wood forest products

Wild sago palm and the role it plays in the culture of Papua New Guinea

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Spontaneous occurrence of sago palms (*Metroxylon*) in the swamp forests of Papua New Guinea has created vast reserves of this natural resource in the country. The world's largest contiguous swamps and forests of sago palms are found in Papua New Guinea. These forests cover an estimated area of one million hectares spread over different provinces. The people of Papua New Guinea consider sago socially important as they use it extensively on special occasions, rituals and feasts. It constitutes a staple food and an essential building material. Sago forms the backbone of rural economies in many provinces. There are numerous ways in which sago palm has become a part of people's daily life. Unfortunately, forestry literature of this country often lacks mention of sago palm as a resource.

There are five species under the genus *Metroxylon*, of which two occur in PNG. *M. Sagu* is found on the main land and *M. Solomonense* grows on the Bougainville and Solomon Islands. Both species vary considerably in general characteristics as well as growth habit. Locals consider *M. Solomonense* a better yielding species that is easier to work with. While the paper discusses the biological and ecological differences between the two species, it also highlights some reasons why there has been no effort to cultivate *M. Solomonense* on the mainland.

Sago is a tree of tropical low lands with high irradiance and humidity, and an average temperature of 26oC. Its natural distribution is confined to SE Asia and nearby Pacific Islands. Aerial and ground surveys conducted in Papua New Guinea show that sago palms grow here till 1200m above sea level. As sago palms grow on a range of soils that vary from the land inundated with water most of the year to drier and less flood prone areas, vegetation types in which they grow vary accordingly. The paper makes an effort to provide a description of these vegetation types. It also discusses the effect of traditional social forestry practices on the distribution of sago palms.

Sago is a staple food in Papua New Guinea, yet its cultivation is not a common practice. The ease with which it grows in the forests of PNG enables the people to meet most of the daily needs of palms from the wild. Locals have planted some palm trees in the past but left them unattended after planting. These so-called cultivated areas acquire a wild appearance after a few years.

Cultivation of this kind has been motivated by either scarcity or the need to bring palms closer to dwelling areas. in order to benefit the large populations living in other remote locations, cultivation of sago needs to be spread to other swamplands and potential sites. To them sago can provide a good supplement towards food and a better substitute to kunai grass or coconut thatch for constructional purposes.

Finally the paper concludes that sago is a vital resource for people of Papua New Guinea. Sago palm as such may not be contributing to the cash economy of the country, but its significance in the subsistence economy can't be ruled out. At present, sago palms are in abundance in the forests of PNG and not much attention has been paid towards its management. However with increasing population, demand for sago palm is steadily rising. Therefore it becomes necessary to develop sustainable management systems for sago palms that will not only rehabilitate some of the unproductive swamps but will provide a sustained supply of sago in many years to come.

Marketing of Non-Timber Forest Products: A Key to Conserve Natural Tropical Forests?

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Expanded and improved commercialisation of non-timber forest products (NTFP) will increase cash incomes of rural households in tropical countries, thereby motivating local actors to conserve forests through sustainable management. This expectation has recurrently been raised by environmentalists and development professionals over the past 15 years. But does the very nature of NTFP markets and marketing underpin this expectation? This paper reviews the main features of NTFP markets and marketing based on experiences made in the past and current market trends. Particular attention is given to the role of rural households in the marketing chain and how their economic position could be strengthened.

Notwithstanding the scarcity and erratic nature of global NTFP data, there is evidence that NTFP represent an impressive economic asset in many tropical countries. The overall value of NTFP extracted from tropical forests is estimated at US$ 90 billion per year. The trade in the 150 most significant NTFP alone amounts to around US$ 11 billion per year, with the major part being exported from tropical countries to the northern hemisphere.

Nevertheless, some researchers question the viability of NTFP economies. They conclude from experiences made with individual NTFP traded on international markets, such as rubber or rattan: once NTFP become high value goods in international trade they are believed to suffer from economic pressure to overexploit the resource base, or face competition from plantation products or cheaper substitutes. Thus, it would only be a matter of time until NTFP from natural forests lose their market shares and, consequently, plant extractive economies would disappear.

It may be doubted that substitute-induced market collapse is a distinctive feature of NTFP markets. That products become obsolete should rather be viewed as a typical feature of any commodity traded on whatever market. Marketing and related policies typically aim to extend the life cycle of products and to prevent substitution. If this challenge has not been met in the past concerning important tropical NTFP, this may be understood as a consequence of lacking marketing strategies and poor resource management rather than being a distinctive feature of NTFP markets. It should also be borne in mind that reported examples for substitute-induced market collapse primarily concern international markets while there are numerous examples of NTFP which long have been sold successfully on local and national markets despite the modern substitutes available. Even on international markets declining demand for certain NTFP must not be conclusive, as consumer preferences may shift back to products that had lost significant market shares in the past.

There is evidence that negative examples of extractive economies primarily result from the lack of even basic marketing strategies. This is partly due to low accessibility of adequate market information, in particular as regards demand for NTFP traded on international markets. in addition, actors on NTFP markets face uncertainty when land tenure is vague and, hence, NTFP are open access resources. The development of medium-term marketing strategies is further hampered by the at times ephemeral nature of consumer preferences, poor post-harvest treatment, lacking processing facilities to meet consumer needs, and low investments in customer relations.

At the very beginning of many NTFP marketing chains are rural households. When involved in the mere collection of NTFPs, they typically receive a nominal portion of the final sales price. Their bargaining power tends to be weak and, worse, the poorest among them may be deprived of lucrative NTFP resources by external forces. To change this situation, improved marketing alone is insufficient. Providing extractors with the control over NTFP resources and acknowledging the crucial role NTFP play in rural economies is also indispensable when rural households are to be empowered. Based on such general pre-requisites, specific steps to develop NTFP marketing in favour of rural communities are to be made , *e.g.* encouraging co-operative processing and sale, introducing appropriate market information systems, and promoting the access to promising segments of national or international markets through preferential chains.

Management and production of NTFP and the commercialisation/conservation proposition

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Central in much of the discussion on NTFPs is the proposition that their commercialisation will lead to biodiversity conservation. This proposition has several problems. The theory of the historical cycle of extractive economies predicts that when a NTFP becomes demanded widely, this eventually will lead to its cultivation or the production of substitutes. in addition agricultural transformation theory predicts a diminishing role of NTFP extraction when rural economies expand.

This paper is based on research on local forest management among Dayak farmers, and ribere¤o farmers in Peru and extensive literature review. It concludes that when NTFPs become economically more important, swidden agriculturists who rely on the forest for an important part of their livelihood needs, will produce NTFP through some kind of forest management. As a result, managed forests are common in among many swidden agriculturists. These forests often maintain important levels of species diversity and structure, sometimes similar to the natural forest that they replace. If some NTFPs become the major source of income, intensified production may develop. This will lead to changes in local land use, with consequent impacts on the cover, structure, and floristic composition of the forest. However, in some case this may lead to an increase in forest cover, rather than the opposite.

These findings justify speculations on alternative development options such as estate crop development, as currently is taking place. Oil palm, for instance, originally an NTFP, is currently a prominent plantation crop in Sumatra and Kalimantan, the two largest islands of Indonesia. Especially when local incomes are considered the most important, NTFP development may lead to smallholder production with much less impact on biodiversity, carbon storage, and other environmental features.

These findings suggest that the commercialisation-conservation proposition needs to be broadened to account for changes as described in this paper. Natural forest conservation as opposed to converting for agricultural use is only one effect of NTFP commercialisation. This effect can be expected to occur only under a limited number of circumstances. in other cases, NTFP can be commercialised in a way that it can be produced by smallholders and become an alternative for large-scale estate development. Such NTFP development will also have a beneficial effect on biodiversity and other environmental functions of the forest landscape.

NTFPs and rural poverty alleviation: the economics of scepticism

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Non-timber forest products (NTFPs) have been embraced by the international community as a means of simultaneously promoting the economic development of poor, rural households and of conserving forests and woodlands. This paper uses the perspective of household economic analysis and data results from various sources to suggest that much of this enthusiasm is misplaced.

First, there is nothing special about NTFPs from the perspective of rural households. They are simply goods and services with particular economic characteristics, and their use can only be explained with reference to the constrained economic choices faced by most rural households. The typical rural household is extremely poor; faces very high transactions costs of trading in formal markets and therefore extensive formal market failure thanks to a poor infrastructure; faces considerable production risk against which it is hard to insure; has only partially monetised economic activities; has low levels of education; and has low levels of financial and physical capital.

There is much evidence that poor, rural households rely heavily on NTFPs for economic goods and services, so that these resources are a critical - though often hidden - source of welfare for rural households. However, this heavy reliance on NTFPs is a function of the poverty and economic constraints of rural households rather than free choice. Indeed, it is the economic characteristics of NTFPs that makes them attractive to poor households. NTFPs are usually derived from commons areas and are collected and consumed rather than purchased with cash; as open access goods they are low value and can be consumed by the poor; NTFPs are collected using unskilled labour, in which rural households are abundant; NTFP processing requires low levels of education and physical capital; and NTFP use can help offset production risk. So NTFP economic characteristics match the economic constraints of the rural poor.

In consequence, there will be many problems associated with the commercialisation of NTFPs to drive rural socio-economic development. in particular, there is little evidence that as households get richer they still wish to consume most NTFPs. Most NTFPs are inferior goods so that demand will fall as incomes rise. There are considerable problems overcoming the high transactions costs of trading in NTFPs and the lack of storage facilities for perishable goods. If an NTFP is commercialised, high demand levels have led in the past to rapid extinction of the resource, especially where held under open access, and can trigger the process of resource privatisation. Higher prices for NTFPs will also trigger investment in domestification or the search for technical substitutes.

Non-wood Tree Biomass - a Raw Material of Coming Century

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The commercial stem wood harvesting is a dominant method of forest utilization today. The utilization of knot wood and small sized items from thinnings for energy is developed only in countries with intensive forest management.

The forest biomass studies show that 5-20 % of tree biomass is a tree foliage (succulent tissues or living part of tree biomass) - i.e., leaves, needles, twigs, flowers, nonlignified shoots, called "loging residues" today. A lot of investigations show a great concentration of biologically active substances and nutritions in the tree foliage and possibilities to utilize it as a raw material for animal feed (mainly broadleave foliage) and for obtaining hight quality natural substances for pharmacy, cosmetics, food industry and other branches of economy (mainly coniferous and some specific broadleave species foliage). The another non-wood part of tree - bark also content many usable substances. A large number of such natural substances urgently needed for insuring of peoples and animals vitality, but we can't obtine its by modern technologies of synthesis. The many of them is founded only in the tree foliage, for example different terpenes, polyprenols a.o., but not founded in agricultural crops and other flora.

The genetic older gymnospermous species contain more specific biologically active substances to compare with angiospermous trees. The risk to decrease the forest productivity by tree foliage removal from forest area simultaneously with final cutting is minimal for boreal forests. The harvesting of tree foliage may be done on the basis of modern tree harvesting technology and technic using in forest industry, for example, "green chips technology" and other. The environmental friendly technologies for tree foliage processing and obtaining more than 30 commercial products are elaborated and tested. The new profitable product lines for replacing synthetic substances in pharmacy, food industry, pesticide industry, fodder and other branches of economy are tested, the market of natural substances is rapidly growing. The most popular today is different solid extracts form tree foliage on the basis of polar and nonpolar solvents as well as concentrates or pure compounds obtained from extracts. The present knowledges about tree foliage and bark chemical composition of *Pinus*, *Abies*, *Pices*, *Betula*, *Ginko*, *Eucaliptus* and other species is a good basis for development of utilization but for many species we need additional investigations. The expierence of different countries show that utilization of non-wood tree biomass, mainly tree foliage, will become a very important part of forest economy, especially in the agroforestry, forest plantations and boreal coniferous forests in the early of 21st century.

A comparison of theories on institution relevant to non-timber forest products development

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Besides the resource base and markets the institutional environment in which NTFP are collected or produced is of crucial importance for any successful exploitation. Institutions are understood here as property rights, rules of conduct, more formalised regulations and laws, in short instruments that condition behaviour in the economic and social sphere, but also the organisational structures that govern resource use. This paper compares five important theories that relate to institutional issues in the NTFP under situations where NTFP based development is an option to understand their scoop and compatibility, and to understand under which circumstances the framework of a particular theory is the more appropriate one for analysis. These theories are: new institutionalism; common property theory; political ecology theory; new social movements theory; social capital theory.

New Institutionalism theory explains the historical processes of institutions to reduce transaction costs, and so to optimise economic gain for society at large. Common Property theory takes a specific case of tenure, namely common property and explains under what conditions common property will emerge and are viable. On the other hand Political Ecology theory Social Capital theory and New Social Movement theory explain contested access to natural resources, for instance NTFP that have become economically attractive. Political ecology theory describes vagaries of NTFP exploitation for local social groups as part of wider power networks. Social movements theory highlights the processes of formation of these groups and what defines their success in claiming access or local ownership. Social Capital theory explains why groups are successful in organising themselves, why they are successful to build social control mechanisms, or concerted efforts in achieving sustained NTFP based development. These theories, when compared, appear to complement each other as they explain different aspects of the institutional dimensions of NTFP based development processes. New Institutionalism and Common Property theory are closest related as they explain the rules aspects of institutions, being Common Property a more specific case of tenure rules that new Institutionalism explains more broadly. Opposite these two theories are Political Ecology theory and New Social Movements theory that focuses on the actors and their group formation and action. in between these categories is Social Capital theory that explains why groups become successful in building common property regimes, why they are successful in building united efforts to benefit from economic opportunities or engage struggle for rights to resources. Social Capital theory may also explain why previously contesting groups may find common ground and engage in concerted efforts to address mutually identified conflicts of development or environmental problems.

These five theories, when compared, for a large part complement each other in explaining the several processes that take place when NTFP based economies develop. They therefore, are each important when addressing institutional issues in NTFP based development efforts.

Conservation Protection and Sustainable Use of Medicinal Plants

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Keywords: conservation & protection, genebanks, bioresources, threatened plants, medicinal plants

The last decade has witnessed skyrocketing interest in herbal medicines. At present, 95% collection of medicinal plants is from the wild using unsustainable practices of collection/harvesting. Indiscriminate exploitation of natural resources to fulfil escalating consumer demands besides other anthropogenic activities have led to the decline of natural and wild populations. Current rate of species extinction coupled with inter alia ravages of diseases/insect pests has made conservation of medicinal plants, an urgent activity. There is a global recognition of safe conservation of bioresources of medicinal plants. These resources can be conserved employing holistic approach of amalgamating both in situ and ex situ methods using new emerging technologies to ensure sustainable use.

In situ conservation approach allows for continued and dynamic adaptation of plants to environment. Contrastingly, ex-situ conservation requires maintenance of germplasm outside their original habitat. Plant diversity is being conserved in field gene bank, seed gene bank, in vitro gene bank and cryobank. Among the ex situ methods, rare and curious plants can be conserved as living collection in field genebanks, arboreta, botanical/herbal gardens etc. Conventional conservation of seeds in seed genebanks is the most popular strategy. However, it sometimes poses problems in case of threatened species, as the seeds may be inadequate and/or recalcitrant. in vitro genebanks are increasingly being used as an alternative to conserve such species. Cryopreservation offers the possibility of conserving germplasm under suspended growth for indefinite period in a limited space with minimum inputs. DNA storage also needs to be integrated in conservation programme in a planned manner.

The comprehensive and safe conservation of available diversity including medicinal plants is the major aim of conservation efforts at National Bureau of Plant Genetic Resources (NBPGR). The collection, conservation, documentation and scientific management of the precious biowealth has thus emerged as a priority area. in this endeavour, considering the need to survey enormous genetic resources and their distribution, priorities have been worked out, keeping in view the relative degree of threat. Attention is given to adopt different conservation methodologies available in a complementary way to conserve the collected germplasm.

The precious germplasm has been collected at NBPGR through explorations from different phytogeographical zones of India. The germplasm is collected from forests; villages and herbal gardens in the form of live plants, seeds, fruits and other plant propagules. of these, over 100 species are maintained in pots and under field genebanks at its regional stations. Seed samples of 579 and 220 accessions are conserved in seed genebank and cryobanks, respectively. in vitro techniques have been used as an aid to clonal propagation and conservation especially for threatened species. The application of tissue culture techniques for multiplication and conservation of these plants appears a promising option. Employing these strategies, cultures of a few medicinal plants such as *Kaempferia galanga*, *Rauvolfia serpentina*,*Tylophora indica*, *Picrorhiza kurrooa*, *Rheum spp* and *Gentiana kurroo* have been conserved for varying periods. in vitro repository maintains 60 collections comprising 20 threatened/important species as shoot cultures.

Many important forest medicinal plants like Sandalwood (*Santalum indicum* and *Santalum album*), *Eucalyptus* suffer from infection with *Phytoplasma* (earlier designated as Mycoplasma like organisms, MLOs). Raychhaudhuri and his group worked on 'Spike disease', which has devastated the chief sandal growing areas of South India. Temporary remission of the disease symptoms by tetracycline treatment and electron microscopy confirmed Phytoplasma to be the causative agent. The present paper will elaborate on the above activities.

The significance of NWFP for tropical societies: an analysis of statistical data on NWFP utilization in East and Southern African countries

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Accurate, reliable information on non-wood forest products (NWFP) utilization and trade is an essential tool for forest management decision-makers at all levels. in most tropical countries, the current coverage and quality of existing information at a national, sub-regional and regional level is inadequate for policy analysis and decision making.

By compiling national reports on the importance of NWFP in tropical countries, FAO aims to improve the availability and dissemination of statistical data on NWFP. in this effort, the major NWFP are identified by country, and their utilization and source, as well as production system, are described. Key findings are presented in a summary by region.

For countries in East and Southern Africa, preliminary results indicate the following regional patterns: in East Africa, gums and resins, medicinal plants and bee products are the main NWFP; whereas in Southern Africa, edible plants, medicinal plants and bushmeat are the NWFP of major importance.

The analysis of available production and trade data on NWFP revealed that they are often mixed with statistics on agriculture crops and that, although not always easy, a proper segregation between agriculture crops and NWFP is required. Internationally agreed-upon terminology, concepts and definitions on NWFP, combined with improved methodologies for the regular collection of statistical data and for monitoring of NWFP use, are essential for a better understanding of the significance of NWFP to tropical societies.

Peoples Dependence on Forest and the Changing Legal Profile

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People in India are dependent on forests for the goods and services produced since time immemorial. Apart from timber poles, and fueldwood which were classically categorised as "major forest produce", the dependence is also and even to a larger extent,on several other produce which were referred as "minor forest produce". Though the nomenclature for the later has been changed in the recent years, as "non timber forest produce" (NTFP), dimension and magnitude of the problems remain unchanged. Present paper opts for two such produce viz., Bamboo and Tendu leaves (*Diospyros melanoxylon*) to elaborate people's dependence and the changing legal profile in the country. As per the Indian Forest Act, the prime act regarding forest, bamboos are classified as timber. Poor forest dwellers use bamboo in the construction of their huts though the other modes of use vary from eating young bamboo rhizome, fencing their field to making mats, baskets and various other artifacts and selling them in the market to earn livelihood. "Nistar rules" (rules for concessional supply of forest produce to the villagers) at many places have provisions for supplying bamboo to the villagers though due to shrinkage of forest resources provisions can hardly be followed.

Tendu leaves on the other hand, are used in the large scale "Bidi" manufacturing process (Bidi is country cigarette prepare by rolling tobacco within the dried tendu leaves) and forest dwellers/villagers come in the picture in this regard, as labourers to collect the leaves from the forests and to sell it to the contractors. As per the Minor Forest Produce (Regulation) Act in most of the cases, trade in tendu leaves is a state monopoly. An amendment to the Wildlife (Protection) Act, in the early nineties has created distinct hardship in the life of the people collecting tendu leaves from the wildlife sanctuary areas. Though National Forest Policy and various Acts did not provide an important status to the NTFPs, various management systems partially recognised its value. in "coppice with reserve (CWR)" system of management, which is an Indian modification of "coppice with standards (CWS)", the need of the local people particularly for NTFPs has been given due weightage.

In the present philosophy of forest management, in the participatory line, people's dependence on NTFPs is being considered as a crucial determinant for the success. Forest Protection Committees (FPCs) constituted by the villagers for protecting and regenerating the forests as per the standing order of the government, have been given the 'usufructary rights' on the NTFPs. However, "Panchayat Extension to the Scheduled Area Act (PESA, 96) empowered 'Gram Sabha' (i.e. village committee) members with the ownership right on the NTFPs. This underlines the conflict between the usufructory rights and the ownership rights being enjoyed respectively by the Forest Protection Committee and the village committee members, in case they are not exactly the same. Forest play an immensely important role in the ecological security of the country. However its contribution as a natural resource being used by the people, most of whom stand below the poverty line, cannot also be undermined. An apt forest policy therefore should maintain a balance.

Strategy for Sustainable NTFP Management in India

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Non-timber Forest Products (NTFP) play increasingly greater role in the social and traditional lifestyle of millions of forest dependent population particularly the tribal, landless, women and other rural poor. in view of increasing realisation for ecological, socio-cultural and economic dimensions of forests, the Sustainable Forest Management has come to be reckoned as most important management innovation for ensuring sustainable development. Similarly, participatory forest management, popularly known as Joint Forest Management in India, is an important forest management intervention to attain the goal of sustainable forest management. and, to ensure successful implementation of Joint Forest Management, flow of benefits through production of Non-timber forest products (NTFP's), offers the best incentives to the participating communities on sustained basis. in order to sustain the interest of the participating communities in forest conservation sustainable NTFP management assumes key role. However, the current NTFP management practices are ecologically and socially unsustainable. This paper attempts to highlight the current management practices and presents strategy for sustainable management of NTFP in India. Although, NTFP's have been providing subsistence to the forest dependent communities since time immemorial, it came into great prominence in the last decade due to preference for natural product based medicines, cosmetics, dyes and chemicals, pesticides, food, fibre etc. Importance of NTFPs as a source of revenue to forest department also increased due to restrictions on timber harvesting for environmental-reasons imposed by Supreme Court of India. Joint Forest Management (JFM) arrangements, that is the management of forest resources by govt forest department and local communities with the explicit understanding for sharing of products (timber and non-timber), responsibilities, control and management decision making. Due to uncertainty in getting benefits from timber harvesting being a long-term proposition, NTFPs for their capacity to yield year round benefit starting from first year of protection is an important incentive to the participating communities. There is thus a need to strengthen this useful links between NTFP management and Joint Forest Management so that the synergy of their linkage can be profitably channelled for the well being of the forests and the dependent communities. Although no precise estimate of the total amount of NTFP extracted from the natural forests is available according to a guestimate, it could vary between 10,000 to 50,000 tons annually providing earnings that runs into billions of rupees each year. About 60 percent of NTFPs go unrecorded and are consumed or bartered by about 15 million people living in and around forests. Large revenue flowing to the state exchequer from NTFPs have given the state the vested interest in marketing the produce with huge costs both to the poor who rely on gathering them for their subsistence needs and to the users of NTFPs. Most of the products are sold in raw form and therefore it is not remunerative to gatherers. After walking long distance and spending several hours the gatherer is able to get less than minimum government prescribed wages. Thus, they try to collect as much as possible to maximise their earning from day's collection. in the process they resort to destructive harvesting. As a result of this many important NTFP species are getting depleted in the natural forests. in several studies it has been shown that processing and value addition at primary collector's level increase the earning from NTFP by 4-5 times. Simple value addition measures such as cleaning, washing, air drying, grading, packing etc., which can be carried out at household and community level, without any investment can also result into remunerative returns to gatherers by 2-3 times. Institutional support for awareness and training for value addition process and marketing can motivate collector's to adopt sustainable harvesting practices. The NTFP gatherers have traditionally been conservationists and in normal case would not resort to destroying the natural resource base that their forefathers protected and worshipped for generations. The middlemen and contractors operating in and around forest areas have been exploiting the gatherers taking the advantage of absence of local level institutions, credit facilities and value addition options. Organising the communities through joint forest management (JFM) offers best option to reduce the exploitation by middlemen and ensure better returns from the collection and sale of NTFP.

Community's interest in sustainable production of NTFP may sustain Joint Forest Management and ensure sustainable development of forests and the people dependent upon them.

NTFPs Pivotal for Sustainable Forest Management to Solve Global Forestry Probelms and Society Needs

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Human and cattle population explosion, urbanization, land grabbing for agriculture, grazing and industrial development have resulted in sick biodiversity, disturbed ecosystem, depletion of natural resources, environmental pollution and natural calamities. As a result, the very existence of life on earth has become at stake. Since, problems are being addressed by different agencies for a particular strategy in isolation, no headway could be achieved. To meet this global challenge, it is suggested that holistic multi disciplinary integrated approach should be adopted. Forest Management which is still mainly timber dominated should be transformed into Non Timber Forest Products (NTFP) oriented need based sustainable forest management as NTFP species play pivotal role in different forestry programmes, viz., Joint Forest Management (JFM), Joint Rural Development (JRD), Watershed Management, Global Warming, Environmental / Biodiversity Conservation and all society needs.

Understanding the global need, the author conveys how the task of global importance can be implemented by the modern information technology to acquire primary or site information on NTFPs, which in turn may serve as a basic tool to support the forest managers, foresters, policy makers, scientists, entrepreneurs and other user groups for the utilization of Minor Forest Products (MFPs) or Non Timber Forest Products (NTFPs) or Non Wood Forest Products (NWFPs) for socio-economic development as well as for the maintenance of vegetal biodiversity and ecosystem / environmental conservation because lack of information has hither to been the major obstacle to the NTFP oriented forest management.

COMFORPTS is the only institute in India and abroad, specifically and exclusively devoted to the pursuits of NTFP, which has evolved a "Standard NTFP Classification and Documentation Manual" in 26 categories for universal use by Shiva & Mathur (1997). The paper explains how the Manual can be used by India and other countries also in selecting the species of NTFP importance according to their edapho-climatic situations for various purposes.

COMFORPTS is acting now as a Resource Centre for NTFPs and the author is the Contact Person and Dy. Coordinator of IUFRO network for NWFPs with the help of MFP Database evolved by the author.

The Web Site address of COMFORPTS is: http://www.angelfire.com/ma/MinorForestProducts and that of IUFRO is: http://iufro.boku.ac.at "Inventory of Forest Resources for Sustainable Management and Biodiversity Conservation" by Dr. M.P. Shiva, with lists of multipurpose tree species yielding both Timber and Non Timber Forest Products (NTFP) and shrub & herb species of NTFP importance has been published and released in second South & East Asian Countries NTFP Network (SEANN) workshop on 27th October, 1998 by Dr. Barry Deren of the World Bank.

The author has suggested in his paper how Research and Community Development Projects can be executed through indigenous NTFP species by raising mixed crops of multipurpose tree species yielding both wood and NWFPs/NTFPs and shrub and herb species of NTFP importance.

About five propagation methods have already been perfected by the author and his co-workers. A book on "Plant Biodiversity for Sustainable Community Development" by Dr. M.P. Shiva & S.S. Bartwal, has also been published and released in second SEANN workshop on 27th October, 1998 by Dr. Ana Doris Capistrano of The Ford Foundation.

The paper conveys how COMFORPTS can offer expertise globally on the following aspects of NTFPs to tackle forestry problems and society needs.

1. Mechanism for making choice of suitable species based on edapho-climatic conditions including forest types etc.
2. Standardizing propagation methods for massive afforestation on land husbandry programmes, on forests and other vacant lands.
3. Evolving harvesting techniques for optimum productivity and biodiversity conservation.
4. Determining marketing and trade channels for NTFP based enterprises for socio-economic development and equitable distribution of profits particularly to disadvantaged groups of both men and women dwelling in urban, rural and forest areas.

Research for a) Augmenting regeneration of mixed NTFP species of trees, shrubs and herbs for biodiversity conservation and socio-economic development. b) For ensuring increased productivity of NTFPs. c) Marketing research for equitable distribution of profits, upliftment of disadvantaged groups of people; study of marketing channels and price regime; assess and regulate demand and supply of NTFP for enterprises according to trends.

6. Strengthening information for generating training material to create awareness among all user groups.

The overall impact will be sustainable forest management of existing resources with replenishment of naturally regenerating forests and extending man made forests, which would ultimately result in conservation, enrichment of biological diversity and socio-economic development of village community and forest dwellers including tribals globally.

Contributions of NTFP-based economies to development - a conceptual framework between growth and distribution

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It is widely believed that use and trade of NTFP do contribute to economic development, being both, ecologically and socially sustainable at the same time. Over the last years, many scholars and practitioners have adopted this suggestion. But, as much as being tantalising this thesis is unspecific and lacking conceptual clarity - this explains, in parts, it's widespread support. The conceptual understanding of what development is remains obscure.

The concept of development can be traced through history. in antiquity, development originally had a clearly the character of a procedure of unfolding an idea or an argument. in a larger sense development stood for any unfolding of potentials, generally following a given (but mostly hidden to the observer/audience) finality. Since the eighteenth century, this understanding was translated to human society: mankind as a whole, specific societies or individuals were meant to unwrap their intrinsic potentials, thus fulfilling a prescribed (but not known) agenda established by god or nature. Advances in the natural sciences, especially evolution biology, lead to the recognition that development is not linear, not moving neither nature nor society straight towards a given destination. Development, it became clear, does not have a goal, yet it has a direction. Since its beginnings shortly after World War II, development assistance has followed an end-vision: so called underdeveloped countries were to follow the example of the industrialised world. Economic growth would be the starting point for their take-off. It was believed that once entered this road, any underdeveloped countries would follow a given sequence of steps, ultimately reaching the state of being developed. The primary sector of national economies was seen as the key to ignite development, with agriculture and forestry as key economic activities. This rather simplistic view has been questioned and reconsidered in the political discussion of the last five decades. Today, a consensus has been reached over a set of components that do not serve as goals to development, but rather as a direction for international development assistance. The five key components of development comprise Work, Growth, Participation, Equity, and Independence.

Since UNCED these elements have been complemented by a temporal dimension: only activities that sustain the development potential of a (natural or social) system in the longer run, can be perceived as developments (otherwise contributing to the development of under-development). Development of society is today seen as the process by which endogenous potentials are being unfolded leading to an ever more complex system, without narrowing future options for further changes.

Following the contemporary understanding of development, the benefits and contributions of NTFP-based activities have to be valued not only in terms of economic wealth and growth, but in the light of the other components of development, as well. Interdependencies between contributions attributed to the five elements have to be taken into account. It follows that economic growth does not necessarily lead to development. Growth without distribution can be seen as underdevelopment, as a narrowing of future options to a society. Any assessment of the contributions that the NTFP-based economies make to the development of a society has to take into account potential benefits of all five development dimensions. They need to be valued with their interdependencies and their being sustained over time. So far, the support for the thesis that „use and trade of NTFP favours economic and social development“ is due in parts to it’s vague and thus indisputable conceptual founding.

5.12.00 Sustainable wood industry

Sustainable production of forest products in Southeast Asia: what products and production systems?

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Keywords: Sustainable production; Forest products; Production systems; Southeast Asia

Forest lands and their associated resources have played significant roles in the socio-economic development of most of the Southeast Asian countries. Much of these forests have either been converted into other land-uses such as agriculture, mining and settlement or disturbed due to harvesting of wood and various other products in support of the forest product industries. Apart from these industries, large proportions of the rural populations of these countries are dependent on the forest resources for their livelihood. The forests supply the basic needs in terms of energy, shelter, food, medicines and water of these rural dwellers.

There are varying degrees of advances in technologies, utilization and market development in these different countries. Sustainable management of these resources will therefore have to take into consideration these different stages of development, and the ecological, economic and social dimensions of the production and other uses. It must adopt a holistic approach and research must be strategic in nature.

Past supplies of forest products have come mainly from the harvesting of the natural forests. Today much of these forests have been exploited or converted into other uses. They are fast diminishing or degraded. However, attempts are being made to put the remaining forests under an appropriate management system with sustainable objectives. Other strategies are also being adopted to meet the expected shortage of supplies due to increased demand following population increases.

The increasing reliance on other production systems is emerging in many of these countries. For example interest in plantations, both on a small or industrial scale, has grown in recent years. However, the number of species used is limited to a few, mainly those with fast growth rates. Likewise, increasingly more products are being produced from community forests or on small farms of individual farmers. Various models of agroforestry practices are in use. Other nontraditional sources of cellulosic materials such as oil palm fibers, bagasse and Hevea wood are also fast becoming important particularly in composite industries.

Similarly, the utilization pattern has evolved from the selective harvesting of a few limited species of only large dimension to a wide range of species including those of small dimension. Improvements in processing technologies and market development have produced new products and opened more opportunities. Solid wood utilization is giving way to composite products. More uses are finding their way for each species. Besides wood, other parts of trees are being more intensively researched for complete utilization. Multipurpose species are becoming increasing popular. The products obtained can be used for subsistence or cash income, hence growing trees on farm is becoming more attractive.

Sustainable Forestry and Wood Production. Common Ground and Conflicts. the Mission of Research Group S5.12.

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Keywords: sustainable forestry, forest products, silviculture, wood

The concept of sustainability in the context of forest management holds a different meaning to almost every group that espouses it. Many of these differences arise because of the varying goals and objectives of those who promote the idea of sustainable forest management. When discussing this topic, the question of "sustainability of what" must be answered prior to reaching a common understanding of goals and objectives.

In general, a sustainable approach to forest management uses new strategies to conserve biodiversity, improve the balance among alternative forest values, and sustain healthy ecosystems. It is often also expected to retain the aesthetic, historic, and spiritual qualities of the land. Various silvicultural techniques may be used to alter the developmental trajectory of existing stands to provide this range of values.

In some cases, management strategies include removing wood as a primary goal. in other cases, wood is removed as a secondary objective during treatments to improve forest health, restore wildlife habitat, create recreational opportunities, mitigate impacts of forest pests, or alter the vegetative mix for increased biodiversity.

Forest management strategies that aim to produce wood on a sustainable basis take many different approaches. A common model is one where the tenets of conservation biology are implemented on parts of the managed landscape, often as a network of reserves, or near reserves, on the areas considered most biologically sensitive, and management for wood occurs on adjacent, less sensitive and often less productive lands. Another less common approach, is to attempt to mix production of wood and other resource values on the same piece of ground under the doctrine of management of ecosystem processes. in these cases, forest managers must either have the trust and confidence of members of the public who advocate sustainable forest management or they must have sufficient autonomy to avoid or ignore public scrutiny.

These sustainable forest management strategies are usually implemented on large landscapes and judged using broad indicators of success. They are, however, implemented on a project-by-project basis often at the stand or watershed level. It is important to be able to link activities at all scales and through time in order to understand the implications of activities at each scale to outcomes at other scales.

The Division 5 Research Group S5.12 Sustainable Production of Forest Products was created in 1998 to: 1) promote research on the sustainable production of wood products; 2) encourage communication between IUFRO Division 5, other IUFRO Divisions, and other organizations that are concerned with sustainable forestry. These goals are described in the context of real and hypothetical examples of production of forest products under sustainable forest management objectives.

The Role of Wood Removals in Sustainable Forest Management in the United States: the Contribution of Federal Land.

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Keywords: Sustainable forestry, ecosystem management, fire, biomass

Forest ecosystems are dynamic; they do not maintain balance in a "steady state." Sustainability of dynamic ecosystems means that, over the long-term, growth and loss will be about equal (the "loss" can be from human use as well as natural decomposition.) For the past 500 years, the human elements of Earth's ecosystems have not been in steady state; growth has far exceeded loss. That growth has consumed ever-increasing amounts of land, water, energy, crops, wood, and biodiversity. Regardless of desires for sustainable forests, we will not achieve forest sustainability without simultaneously reaching reasonable sustainability in the human component of Earth's ecosystems. Thus, the grand experiment in sustainable forestry cannot stop at the forest border; it must encompass the human enterprise as well.

Conserving and restoring diverse forest ecosystem composition, structure and function while producing wood resources requires an understanding of both the biophysical and socio-economic dimensions of forest management. Among society's desires from forests are diverse opportunities for recreation, clean water from productive aquatic systems, wood, wildlife, fish, livestock forage, and a sense of place coupled with the knowledge that those forests remain healthy, productive, and pleasing to look at. This set of potentially conflicting desires is what constitutes a sustainable forest in the eyes of many Americans. in the United States, many of these social values are reflected in legal mandates, such as Federal and state laws and regulations concerning endangered species, water and air quality, and how citizens may participate in forest decision making. These mandates provide guidance for management of public and, to a more limited extent, private forestlands. in the past four decades, substantial areas of federal forestland has been "set-aside" through reservations for uses and values other than wood removal. These reservations have not been matched by a commensurate reduction in domestic wood consumption, thus, U.S. wood demand and production has shifted to U.S. private lands and forests in other countries. This raises the question of whether U.S. federal forest policies contribute to or perhaps detract from the sustainability of forests and forestry at the global scale. The United States Forest Service manages 31 million hectares of forestland in 42 states, and 73% of the major vegetation types in the country. The USDA Forest Service can play a major role in advancing knowledge about sustainable forest management by using this land to test new ideas. This paper describes part of that role.

The USDA Forest Service adopted ecosystem management as a guiding philosophy in the early 1990's. Ecosystem management blends the resource needs of people with the protection of wildland environments to sustain diverse, healthy, productive and adaptable ecosystems. Wood utilization under ecosystem management is based on the integration of objectives for fiber production with desired ecosystem conditions at scales ranging from sites to watersheds to landscapes to whole regions of the nation. in one example, natural fire cycles have been disrupted for nearly a century on many national forest lands, especially those in the Interior West. Biomass harvest has also been much less than annual growth for the past 50 years, resulting in increased stand density. These densities cannot be sustained nor can intensive fire be safely returned to these forests without mechanical removal of some of that biomass. Developing economically feasible and socially acceptable silvicultural techniques to restore healthy forest ecosystems, through removal of smaller, under story trees, is the major challenge we face in nearly 17 million hectares of federal forests.

Sustainable Production of Forest Products in Australia

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Keywords: Sustainable Forestry, Australia, Montreal Process

The sustainability of production from Australia's forests - especially but not exclusively its native forests - has been a strongly contested issue for the past three decades. Australia's first National Forest Policy Statement in 1992 committed Australia to the goal of sustainable forest management in the context of a broader commitment to ecologically sustainable development. It is being translated from policy to practice by - for the first time in Australia's history - a suite of nationally-coordinated processes consistent with international initiatives. Although progress towards sustainability in forest management far exceeds that in other Australian natural resource sectors, the sustainability of production from Australia's forests remains both contested and challenging.

Over the perhaps 50000 years of their settlement, the land management practices of Australia's aboriginal people - principally their extensive use of fire - altered the distribution of Australia's forests, ecosystem structure, and the forest fauna. The European settlers' displacement of aboriginal people, and their conversion and use of forests, both had profound impacts. The fragmentation and conversion of forests to other uses, and European farming practices have adversely affected for the sustainability of Australian agriculture and its rural landscapes, including their forest and woodland remnants. These impacts have generally been most severe in the widespread broad-acre cropping and grazing regions; it is not yet clear whether production from these ecologically-degraded landscapes can be sustained.

The historical focus, and continuing emphasis, of Australian native forest management has been on the closed forests; their discontinuous continental distribution coincides with the distribution of the majority of Australia's population near the southern and eastern coasts. With the exception of forest-rich Tasmania, the majority of these forests are in public ownership; their principal products and services are biodiversity, recreation, a diversity of wood and non-wood products, and water. Whilst the economic importance of wood production from these forests remains significant, the relative value accorded it by the majority of the Australian population has been progressively diminishing. Continuing community conflict over the management of these forests led, in 1995 the Australian governments to institute a Regional Forest Agreement process, first mooted in the National Forest Policy Statement.

Australia's Regional Forest Agreement process is the first nationally-coordinated attempt to assess the diversity of Australian forest values - economic, environmental and social - and agree forest allocation and management based on this information. Regional Forest Agreements are being negotiated between the Commonwealth and respective State governments for each commercially-important native forest region. The goals of the process are expressed in terms of greater certainty: for biodiversity conservation, based around establishment of a national reserve system with a target of incorporating 15% of the pre-European extent of each forest ecosystem, and around the development of ecologically sustainable forest management regimes in forests outside reserves; for the forest-based industries, based around secure access to resources outside the reserve system; and for indigenous and European heritage, based on explicit recognition of those values in forest allocation and management decisions. Concomitantly, Australia's wood production has been shifting progressively from native to plantation forests. Most existing plantations were established on sites converted from forest; almost all new planting is established on farmland, much in partnership with farmers. This expansion poses both challenges and opportunities for enhancing the sustainability of production.

The Montreal Process is providing the framework for the development of criteria and indicators of sustainable forest management for all Australian forests. The formulation and testing of criteria and indicators are paralleled by the development of Codes of Forest Practice and by institutional reform in which State regulatory and management roles are separated. These measures are relatively well-developed for State forests, but are – with the exception of Tasmania – as yet poorly developed for the increasingly important private forest sector, including its extensive woodlands. Substantial research and implementation challenges remain in improving, monitoring and communicating the sustainability of production from all Australia's forests.

A conjoint analysis of New Zealand consumer preference for environmentally certified forest products

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Keywords: Environmental certification, conjoint analysis, cluster analysis, forest products, marketing

One of the major challenges facing the forest products industry over the past ten years has been how to address consumer concerns about the environmental impact of forestry activities. One strategy suggested by the environmental community and some industry groups is to provide certification for forests and the products from those forests where forest management practices meet particular environmental standards. Many concerns have been raised by the industry about the wisdom of companies pursuing certification. A particular question is whether consumers are really interested in certification and in turn, whether they will be willing to bear the additional costs associated with certification activities. A number of studies have examined this issue; however these studies have only looked at consumers making a trade-off between price and environmental certification and have not examined all of the relevant trade-offs consumers may have to make when purchasing certified wood products.

This study was designed to address the question of how consumers value environmental certification when combined with a number of other wood product attributes. The particular example used to look at the relative importance of environmental certification was the purchasing decision for wooden outdoor furniture by New Zealand consumers. The method used in the study was conjoint analysis, a recent development in mathematical psychology that has been applied extensively in the marketing field. Conjoint analysis measures the joint effect of two or more independent variables on the ordering of a dependent variable. in the area of market analysis, it relates the buyer's preferences to a set of pre-specified brand attributes. Using a survey, consumers were asked to rate a label outlining the attributes of a wooden outdoor furniture. Each label had a different set of combinations of attributes, including, price, length of product warranty, the country of origin of the wood, and forest type that the wood came from (plantation-grown versus natural forest). For each attribute, there were two possible values or levels.

For wooden outdoor furniture in New Zealand, the conjoint results indicate that environmental certification ranks highly as a product attribute, but is just one of a number of important product attributes. Other important attributes include the country of origin of the wood, with New Zealand wood being preferred over imported wood, and forest type, with plantation grown wood preferred over wood from a natural forest. Price and length of warranty were less important attributes. Cluster analysis was used to segment the respondents based on the relative importance they attach to each product attribute in the conjoint analysis. The cluster analysis results indicate that there are six market segments with unique furniture attribute preferences in New Zealand. Three segments, comprising 56.4% of the sample, view environmental certification as the most important attribute, preferring certified over uncertified wood. A fourth segment, comprising 16.3% of the sample, indicated that they were most concerned with where the wood was sourced, preferring wood sourced from New Zealand. A fifth segment, comprising 14.8% of the sample, was price sensitive. The sixth segment, making up 12.4% of the sample, indicated that forest type is the most important furniture attribute, preferring wood harvested from plantation forests over natural forests. in terms of profiling these segments, results indicate that common demographic variables, such as age, sex, and education, do not provide a basis of description.

Wood Products Research for the 21st Century in China

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Keywords: carbon sequestration, wood supply, China, value-added processing, wood based panels

Wood is wonderful and it is the most important and widely used raw material on earth except water. It is renewable and beautiful, with a high strength to weight ratio, and it is easy to process with low energy consumption. Further more, the growth of wood and wood utilization reduces CO_2 emissions which makes wood an environmentally friendly material. As the economy and population grow, the demand for wood and wood products will also certainly continue to increase. The future of the wood products industry largely depends on the stable supply of wood resources from sustainably managed forests. China holds the potential develop a sustainable wood supply because of its favorable climate, vast land area, and the abundant workforce. Wood currently plays an increasingly important role in the economic and social development in China where the annual consumption of timber (250 million m^3) equals to the sum of that of steel, aluminum and plastic. Further research is, however, needed to support the sustainable development of the wood industry in the 21st century.

The major objective of forestry has shifted from simply supplying timber products to providing multiple functions including ecological, environmental, and social benefits while still supplying timber and timber products. Under this sustainable development principle, the wood products research in China should further develop the cultivation and utilization of industrial plantations environmentally compatible technologies and products that meet the needs of the markets, and to improvement in the competitive capabilities of the forestry and wood products industry.

Many timber-producing countries have restricted or decreased their exports of logs and sawn timber to encourage developed down stream value added wood processing. Malaysia is a good example of a country where the government policy of restructuring for down stream value-added processing has reduced the export of raw logs and primary wood products. These policies will influence the availability of raw material supply for countries like China. It can be concluded that the future of wood products industry in China largely depends on a stable wood supply from sustainably managed forests.

To meet the demand for wood products, the Chinese industry has made remarkable improvements in technology in recent years. This is especially evident in the in the wood based panel industry in 1997, the production of wood based panels in China reached a ranking the 2nd in the world at 16.48 million m^3. As the wood resources available for industrial purposes shift from the natural forests to plantations, the industry needs technical support from research institutions in developing technologies for establishing plantations and utilizing the fast growing and high quality trees from them. Effective value added processing of environmental friendly products requires R&D conducted to address issues specific to the conditions in China. A proposed set of topic areas is as follows: wood properties, wood drying, wood and the environment, wood preservation, wood composites, pulp and paper, economics and policy.

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6.01.00 Tools to integrate nature conservation and recreation for landscape management

Prospect of Community-Based Ecotourism in the Sundarbans Mangrove Forest in Bangladesh

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Bangladesh is one of the densely populated country in the world. The economy of the country is mainly dependent on agriculture and the country faces enormous constraints for the development of itself. Sustainable development in Bangladesh needs a strategy which would accelerate economic growth with equitable distribution of benefits across different segments of population without harming the environment. Planned and ecologically sound utilization of natural resources is a prerequisite for sustainable development. The government has taken different policies for sustainable development.

Ecotourism, as a logical component of sustainable development, requires a multidisciplinary approach, careful planning and strict guidelines and regulations that will guarantee sustainable operation. The focus of this paper is on achieving sustainable development objectives through the development of Community-Based Ecotourism in the Sundarbans, the largest mangrove ecosystems in the world, is situated in the southwest coastline of Bangladesh. Sundarbans forest is the natural habitat of the world famous Royal Bengal tiger, spotted deer, crocodiles, jungle fowl, wild boar, lizards, rhesus monkey and an innumerable variety of beautiful birds. Migratory flock of Siberian ducks flying over thousands of sail boats loaded with timber, golpatta (round-leaf), fuel wood honey, shell and fish further add to the serene natural beauty of the Sundarbans. All of these are good potentials for ecotourism development in this area to become a significant revenue and income generator.

According to a survey of ESCAP 500,000 to 600,000 people of local areas directly depend on Sundarbans for their livelihood. The Forestry Department (FD), the government agency, is in charge in management of the forest and forest resources. The FD is established in 1989 and after the creation of FD there is conflict between the FD and local communities. There is also very negligible relationship between the tourists and the local people.

The domestic market for tourism in Bangladesh is very small and largely independent on small unorganized groups. A very low number of foreign tourists arrive to visit Bangladesh and the national tour operators are also very small in number. These indicate that the service sector is not well established in Bangladesh. At present there is little involvement of local communities but there is the potential. Local involvement will be essential if tourism is to meet conservation objectives.

The premise of the present paper is that if properly planned, ecotourism has the potential to generate a reasonable return on investment and offer substantial community benefits. The successful Community-Based Ecotourism initiatives are supported by partnerships between communities and government, non-government and private sectors.

This objective of the paper is to find out the way to develop the relationship between the FD and local communities by using primary data collected from face-to-face interviews with tourists, tour operators, FD and the community people. The community leaders are asked about tourism activities in their area, giving emphasis to the community role in each. It will also examine the possibilities of community-based ecotourism in the Sundarbans area and will try to find out the proper policy for the expansion of ecotourism in Bangladesh.

Planning for recreational forest. Is there an optimal distance to forest

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Keywords: forest recreation; visiting frequency; distance; urban

This paper presents a study of the relationship between the time span since a person's last recreational visit to a forest, the size of a municipality and the distance between the place of residence and the closest recreational forest. The study was carried out as a mailed inquiry distributed to 2500 randomly selected Swedish citizens, aged between 16 and 75 years. The response rate was 52 percent.

The time since the last forest visit varies from 0 to 365 days with an uneven distribution largely dominated by low values. The distance to the forest affects the time since last visit. The longer the distance between a residence and the closest recreational forest, the larger the time span since the respondent's last recreational forest visit. When distance exceed 2 km a large increase in time since the last forest visit is observed.

Visiting frequencies is grouped according to respondents' present distance and comparisons are made between groups. For the lower quartiles, i.e. the quartiles where respondents state the shortest time since last visit, visiting frequencies are similar irrespective of distance. For the upper quartiles, however, where respondents state the shortest time since last visit, visiting frequencies increase significantly with the distance to the forest.

Results show fewer forest visits for respondents living in an urban environment compared with those living in a rural context, here defined as municipalities larger than 90,000 and smaller than 5,000 inhabitants, respectively. Also after correction for distance to the closest forest, results show fewer forest visits for respondents living in an urban environment compared with those living in a rural context.

Benefit-based recreational forest management in Corea

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Benefits-based management seeks to provide recreation benefits for recreation participants by managing the physical environments in which recreation occurs. This study investigates the relationship between benefits desired by visitors and the physical, social and managerial characteristics of settings that facilitate realization of recreation benefits. Data were collected from 370 visitors to Sorak-san National Park in the eastern part of the Korean peninsula. Cluster analysis was used to group visitors desired benefits into twelve domains: relationship with nature/scenery, escaping pressure, learning about nature, family togetherness, introspection, exploration, autonomy/achievement, being with friends, leading others, skills/learning, risk taking, and meeting/observing new people. Multiple regression was used to link benefit domains with the characteristics of settings. The social attribute of recreation settings was found to be linked to eight of the ten benefit domains. There were two strong multiple regression correlations:(1) between "relationship with nature /scenery" and the attributes "forest/water", "attractive nature", and "facility/maintenance" (R .40) and (2) between "escaping pressure" and the attributes "attractive nature" and "social" (R.386). The paper discusses how the findings can be used to develop recreation services and marketing strategies to respond to client needs and preferences.

Keywords: benefits-based management, Sorak-san National Park, recreation benefits

Motorized Access Control as a Wildland Recreation Management Tool: Access Changes and Visitor's Behavior at Daisetsuzan National Park

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Keywords: Wildland recreation; Motorized access; Access control; Daisetsuzan National Park

Environmental deterioration triggered by overuse is a common issue in wildland recreation. There are several ways to minimize the problem such as law enforcement and regulation of visitor number. However, these approaches require a certain budget and staff, both of which are often under supply. On the other hand, controlling motorized access to wildlands seems more practical as well as economical, while enhancing the visitor experiences.

In order to clarify the feasibility of the motorized access control method in wildland recreation management, the authors studied the relationship between access improvement and visitor increase at Daisetsuzan National Park, Hokkaido, Japan. This park, with the area of 2,300 km^2 including vast wilderness, is the largest in Japan. Still, previous studies indicate increasing impacts on vegetation and soil erosion. The authors first analyzed visitor statistics since the 1960s when road improvement and tramway service began. Second, with GIS data including the information from previous research results, changes of the walking rigor were evaluated at the major trails. Third, visitor's preferences of hiking routes and opinions on access improvement were analyzed from mountaineering plans submitted in past few years and from on-site surveys to hikers.

First, historic statistics revealed that motorized access improvement rapidly increased the number of visitors to Daisetsuzan area, especially to trailheads at higher altitude with connection to other sightseeing routes. Second, such improvement also changed walking access patterns. Areas required over-night stay disappeared, and day-use areas expanded. Most of core areas of the park with fragile alpine vegetation fall under the category of day-use areas now. Third, almost 70% of visitors come by their own cars and tend to prefer short and easy walks. Such day-use visitors expect more access improvement, while overnighters welcome longer walking access. Fourth, more than 20 % of tramway users mentioned willingness to walk paralleling trails, but those who really walk such trails are very small. This gap between intention and behavior implies that they know more walking give them deeper experiences and other benefits, but cannot resist the temptation of tramways.

From these analyses, we suggest that motorized access should be regulated and walking access enhanced. From the point of nature conservation as well as rich visitor experience, closing mountain roads and suspension of tramway service is ideal. But, we should not ignore local economy. Visitors will walk longer if motorized access is regulated by economic incentives such as higher tramway tickets and introducing parking fees at high seasons. Such extra revenue should be directed to improvement of public transportation service and existing trails. Especially, interpretational activities on trails supported by such fund will enhance the visitor experience. Higher cost may divert some visitors to other areas. Even if the total visitation decreased, increased overnight visitors contribute more to local economy than passing-by day-use visitors. Eventually the impact on the natural environment will be reduced. Thus, motorized access control can be a powerful and effective tool to wildland recreation management.

Recreation monitoring at the Dutch Forest Service

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In 1996 the Institute for Forestry and Nature Research started to develop a system to monitor the recreational use of forests and other grounds owned by the Dutch forest service. The aim was to determine the number of visitors, their activities and the percepted quality. This information provides a valuable management tool for targeting of resources. The systems uses three methods to gather the information:

1. Monitoring vehicle and bicycle use at the sites by using traffic counters with induction loops installed in the road (all year round).
2. Visual counting of visitors at all entrances (on 12 days during the year).
3. Survey of visitors (on 12 days during the year).

When the system is fully implemented their will be a network of 48 sites. All of these will be monitored by using this method once in every 10 years, on average 5 sites a year.

ad. 1 The use of traffic counters enables one to gather information about the number of passing vehicles and bicycles all year round. The counters automatically register the numbers and also provide other details such as date, time and speed. With this information it is possible to see the variation in use throughout the year.

ad. 2 Counting all the site-entrances visually is essential for determining the exact number of visitors. With traffic counters is it impossible to cover the complete site, only cars and bicycles can be counted and you don't know how many people are for instance in the vehicles. in combination with the figures from the traffic counters it is possible to calculate the number of visitors during a certain period of time.

ad. 3 With the visitorsurveys information is gathered among other things about activities, use of facilities, number of visits a year, place of residence, duration of visits and last but not least the percepted quality of the site.

The qualityscore is generated by asking the visitors their opinion about 17 items concerning outdoor recreation. First through 17 thesis about recreation in general in which the visitors are asked about the importance of the items (general importance), in the next question the same thesis are asked in connection with the visited site (verdict). Then the questions are combined, the answers about the site itself are weighted by the answer about the general importance of a certain subject. The next table shows the weightfactors.

		General importance				
		Very unim-portant	Unim-portant	Neutral	Im-portant	Very important
Verdict	Very negative	-1	-2	-4	-6	-8
	Negative	0	-1	-2	-3	-4
	Neutral	0	0	0	0	0
	Positive	0	1	2	3	4
	Very positive	1	2	4	6	8

When an item is being considered as very important by the visitor, then his verdict about the item in the visited can raise a score between -8 and +8. However, when an items is qualified as unimportant then score is between -2 and +2. When an items raises a total average score of more than 1 the quality is qualified as being sufficient.

Since this system of monitoring is only carried out in 48 sites, there was a need to get information about all the other grounds of the Dutch forest service. Since counting is too expensive to be done in all sites, in the sites not covered by the monitoring network visitors are going to be given a questionnaire which they can fill out and send back by mail. Through extrapolation we try to predict the unknown factor, the number of visitors. Test are carried out in 1998 en 1999 and the first results look promising.

6.01.00 Nature experiences and sustainable management of landscapes and recreation resources

Visitors' perceptions on the management of recreation forests - a qualitative case study in southern Finland

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Keywords: perceptions, experiences, forest management, recreation areas, qualitative research

The aim of this study was to explore how visitors perceive and experience the management of recreation forests. A recreation forest in southern Finland was chosen for a case study area. This area's primary use is to provide recreation for visitors, and the forests are managed to some extent. There have been conflicts concerning the management of the areas; nature conservationists demand that these forests should be left untouched, while other visitors' needs remain unknown.

A qualitative study was needed to meet the aim of the research, although results do not represent all visitors of the area. During the summer, 1998 a total of 22 visitors were interviewed. The researcher walked together with each visitor a path one kilometer long, and each visitor was allowed to comment freely about the environment. Interviews were audio-recorded and tapes were transcribed. Transcripts were analyzed using a qualitative content analysis.

Visitors were very knowledgeable about forest management and the biological processes going on in nature, as well as the processes caused by humans. They mentioned that trees grow, die, fall down and decay, and different plants and trees fight for living space. Respondents had clear understanding that narrow paths are formed by people walking a certain route, and that these paths would disappear if people did not use them any more.

The following ways of perceiving forest management were identified; aesthetic and experiential perceptions (exploring), safety, possibilities to move, educational perceptions, impacts on nature and economic perceptions. When visitors' perceptions on the paths were studied additional dimensions of perceiving and evaluating were found; social relations, maintenance of the area and the activities one can perform.

Visitors supported the current soft forest management; there are uneven-aged forest stands with many tree species and undergrowth, no clear-cutting, and some of the fallen and dead trees are left. Respondents compared this area to commercial forests and appreciated that there are mixed forests and no large openings in this area. Some visitors also preferred this area to forests in their natural state. They agreed that there could exist small pieces of untouched forests so that people can see how nature develops. Visitors suggested that some of the forest stands should be thinned or appreciated thinned forest sites, because after thinning forests become more spacious and light, and trees have more space to grow. However, some respondents did not like when they saw that trees were cut. in general, visitors thought that logging residue should be removed because it could be used for firewood and it looks ugly. Several respondents thought that dead standing trees and fallen trees belong to nature, while others were worried that dead standing trees could fall over someone.

Application of Sustainable Development Concept to Recreation Resource Management in Forests

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In 1987, the World Commission on Environment and Development broadly defined sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs and the term became widely adopted within the international community related with economic development and environment conservation. Since then, many argue for the development of sustainable economies as the new guidepost to deal with issues of growth, economic and community development, and environmental protection. The concepts of sustainable development has been incorporated into forest management and it became known as the sustainable forest management. There have been, therefore, many initiatives towards implementing sustainable forest management at the international and regional level. The sets of criteria and indicators have been developed through the initiatives to enhance the awareness and improve the understanding of forest sustainability as well as to specify the fundamental elements of sustainable forest management. in the paper, criteria and indicators for tourism and recreation in forests are discussed as developed by several initiatives for sustainable forest management and in this context recreational forests managed mainly for recreation activities in Korea are analyzed for sustainable forest management. Due to the socio-economic changes in recent years in Korea, demand for recreation and tourism has been steadily increased and thus forest resources play an important role in the provision of various outdoor recreation opportunities to meet recreational needs of the society. The sustainable forest management has become a main goal of forest policy and relevant criteria and indicators have been developed for implementation at the international, national, and forest management unit level. The criteria and indicators on recreation and tourism developed by international initiatives are discussed, including the Montreal and Helsinki Processes. The recreational forests designated and developed for general recreation and tourism in Korea started in 1989 and since then attracted many visitors into forest environments across the country. Based on the specific indicators related to recreation and tourism, the management of recreational forests are discussed in this paper. The number and area of recreational forests has increased up to 60 and over 110 thousand ha, respectively, during the past decade. As of 1997, recreational forests accounted for about 1.71% of total forest land and attracted more than 2.6 million persons accounting for over 5.5% of total population. The facilities in recreational forests, as suggested by an indicator, are discussed and future directions suggested.

The Experience of Forests

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This project, commissioned by Simon Bell, The Forestry Commission's Chief Landscape Architect, was undertaken as a pilot study on peoples' experience of forests. Its objective was to contribute, along with other parallel studies, to design theory & applications which relate to the restructuring of production forests for recreational purposes.

The two sites selected for the study were:

1. The Waterfall Walk at the David Marshall Lodge Queen Elizabeth Forest Park near Aberfoyle

2. The Allean Walk near Queen View, Loch Tummel, Pitlochry

In investigating forest experience we wished to tap multisensory experiences (not solely visual) in an unconstrained way. As a consequence the study was in two parts. Firstly, an open ended qualitative and flexible approach was used with minimal intrusion. Walkers were invited to make a self-directed film of their walk (with comments) using a hand held digital camcorder. No guidance was offered other than to film anything of interest or anything which they liked or disliked. The second part of the project was essentially a de-briefing in the form of a short questionnaire. Data was gathered mainly at weekends between the 11th July and 8th August 1998.

The weather was mixed to fine on the walks. The gender split of walkers was approximately 60:40 in favour of men and at each site there were relatively few walkers over 50 years of age. It was of interest that most people had travelled from 10-50 miles in order to go on the walk with relatively few 'locals' i.e. within a 10 mile radius participating.

RESULTS

A total of 37 people participated at both sites.

Video Data

A content analysis of the video data identified 6 general categories of interest. These were:
1. Objects (*e.g.* sculpture, building, waterfalls)
2. Aspects of path (*e.g.* waymarking, surface, width)
3. Views (*e.g.* panoramic, scanning)
4. Human Interest (*e.g.* other people)
5. Flora and Fauna
6. Human Intervention (*e.g.* litter, pylons)

The degree of attention given these categories was estimated from the frequency of stopping points to film each category across both walks.
1. The rank order of stopping point frequency was consistent over both walks
2. Objects had the highest frequency, followed by views. Next were paths, then flora & fauna. The lowest frequency of interest was attached to human activity and interventions.
3. Only 50% of views and 50% of spaces identified by the landscape architect research assistants were found to be of interest to the lay groups.

Questionnaire Data
1) Approximately half the sample went for forest walks more than once every two months.
2) Approximately 40% of walkers had travelled over 50 miles to visit the site, with a further 40% travelling between 10 & 50 miles.
3) Approximately equal numbers of walkers were either with or without children.
4) Nearly all participants reported enjoying the walk experience. Approximately 50% reported the experience as moderately exciting (pleasant and aroused). The other 50% reported the experience as relaxed (pleasant and unaroused)
5) Sight was recorded as the most important of sensory information. Sounds in the forest were ranked second in importance. Most participants were neutral about the role of smells and touch.
6) Most walkers commented that a central function of the walk was to have contact with nature and not be reminded of people. This reinforces the low levels of interest in human activities shown in the video filming.
7) Likes:
a) spatial change clearings & views
b) narrow paths, enclosed by the forest
c) waterfalls/water flora & fauna
Dislikes:
a) crowded places
b) uphill sections & clear felling
c) signs of human intervention

DESIGN IMPLICATIONS

The context data and the stated preferences of the walkers provide some useful information for the design process. One special challenge for designers emerges from this study. The walkers clearly want wayfinding information and facilities (*e.g.* seating, shelters, WC's) to be marked. These are seen as necessities. At the same time the walkers want this information in a way which minimises indications of human intervention. A major function of forest walks appears to enable visitors to get closer to their idea of nature.

Sustainable Management of Natural Resources: Is It Possible at the Urban-Rural Interface?

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Keywords: Sustainable Landscapes, Land Use Planning, Urban-Rural Interface

Despite the vast landmass of the United States, resource managers, landscape architects, and planners are becoming increasingly aware of the difficulty in protecting natural resources at the urban-rural interface. Part of the problem stems from the fact that a comprehensive national land use plan has not been forthcoming from the federal government. Thus, state, county, and local government bodies have been left to determine priorities in land use as well as preservation and/or protection strategies for properties under their jurisdiction. Because each of these layers of government has different agenda, oftentimes, a coordinated, effective land use planning effort that could protect natural resources, especially at the urban-rural interface, is impossible to develop.

This paper examines historic land use management tools in the United States from a planning perspective, and it provides insight to the political and economic factors that determine the success or failure of these tools to create and/or enhance sustainable landscapes. Suggestions for alternative land use planning strategies in the face of urban sprawl are provided. A case study using a rapidly growing area in Michigan (USA) will be used to illustrate the need to integrate some of the old planning strategies with the new alternatives to be effective deterrents to uncontrolled growth and lost sustainability of our natural and agricultural landscapes. A brief discussion on how this new approach may be used to overcome some of the governmental barriers of the past will conclude the paper.

Assessment on Recreational Impacts in Malaysian Recreation Forests

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Keywords: Recreation, impacts, eco-tourism

A study was conducted at three Recreation Forests near Kuala Lumpur to assess impacts of recreational activities on the natural resources of the area. This paper mainly reports the results of the study and suggests a management action to be taken.

Recreation Forests in Malaysia are usually scenic forests with rivers where the most popular activities conducted are picnicking, swimming and relaxing under the forest shade. Camping, trekking and photography are also carried out but to a lesser extent. As owner of the Recreation Forests the Forestry Department usually manages the areas. However, some areas are fully or partly privatised where the management of certain facilities or the whole area is given to private concessionaires.

Visitors to Recreation Forests have been shown to in be great numbers especially during weekends and school holidays. Studies showed that visitation to each Recreation Forest often exceeds 100,000 a year. The majority of visitors to the Recreation Forests are the Malays who are also the major ethnic group in Malaysia, from the middle and the lower income group, and with highest education attainment of secondary education.

Impacts of recreational activities on the natural resources of the three Recreation Forests, namely Sungai Chongkak, Lentang and Sungai Tua were assessed for soil and vegetation parameters. From this study it was found that soil compaction is always higher at recreation sites compared to control sites for all three Recreation Forests. For vegetation parameters, it was found that vegetation cover is greater and there are more mother tree species at the control sites. It was also found that, there is a domination of forest species at the control sites, whereas vandalism signs were found to be more common at the recreation sites. The results on soil and vegetation parameters show that areas used for recreational activities are losing their natural conditions whereas similar control areas along the river that was not used by visitors shows better regeneration and in more natural conditions.

Visitor's opinion on problems of the Recreation Forests was also evaluated to assess perceptions on the conditions of the natural resources. Out of several parameters tested, it was found that many visitors to the recreation forests are aware of the litter problem and many perceived it as a big problem. The conditions of tree vandalism and soil erosion are also considered as big problems to visitors.

6.03.00 Forest information services for foresters and society

Using Information Technology to Meet Changing Knowledge Needs in Forestry

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Keywords: information network; electronic publishing; bibliographic database; community of users

At a time when there are fundamental changes in the status of forests, in their perception by the public, and in forest-related environmental issues, there is an unprecedented need for sound decision making in forestry. This has led to a new requirement for knowledge, organized in a way that provides convenient decision support. Information Technology (IT) can greatly facilitate this process. Partnerships of people and organizations with common information needs and a mutually-dependent interest in facilitating information sharing and knowledge management can take advantage of the power of IT to realise their aspirations rapidly and effectively.

Bibliographic databases exemplify the power of IT to render huge volumes of facts accessible as useful information. This can be illustrated by a database, conceived and maintained by cooperative partnerships, containing over half a million abstracts and spanning more than fifty years of the world literature of forest science. It allows access through multiple routes, including CD-ROM and the Internet, and can be built into knowledge bases as required.

IT allows information to be presented to the user in a convenient and friendly way, so that knowledge results. Examples in the forestry context include taxonomic information systems, geographic information systems, and multimedia knowledge tools such as Electronic Compendia. The Forestry Compendium illustrates how varied information sources can be brought together to make a single coherent knowledge base.

The Internet, Intranets, the World Wide Web, CD-ROMs, and email provide unprecedented new opportunities for innovative approaches to meeting the need to conserve knowledge and pass it on. The implementation of electronic publishing and information dissemination presents new challenges in the achievement of efficiency, economy, convenience, and standardization. CABI believes that the Internet provides the medium for the provision of large bodies of related information to 'communities' of users with common needs. The creation of these bodies of information requires CABI to form alliances with and develop collaborations with organizations which can provide information and/or communities of users which complement its own; and create novel information products by combining primary, secondary and tertiary information in innovative ways. Central to Internet resource development is CABI's further belief that the future of information access on the Internet lies in developed networks of interlinked information. Internet sites of bibliographic data, with other information where possible, form platforms which provide the forum for combining with the information of other organizations through linkage. CABI's concept of linkage is that abstracts, structured within a database, provide the navigation to and from full text and other material, thus fulfilling the dual function of a searchable information resource and a powerful mechanism for locating information.

While the Internet is an extremely powerful enabling mechanism, there are still large areas of the developing world where connectivity is limited and access to the Internet is not available. CABI has proposed the establishment of "Knowledge Networks" that comprise moderated exchanges of knowledge using email between established groups of scientists working in a related field. Selected extracts from many of the above resources used for a virtual "community" can also be provided by email to these groups, and discussion papers summarizing the exchanges can be added to the Internet resource for access by a wider audience.

Capacity building through information: the role of international forestry research centres

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Keywords: natural resources management; forestry information; agroforestry information; capacity building; networking; international collaboration

The Consultative Group on International Agricultural Research (CGIAR) has largely neglected research on natural resources management until the system recognized the need to address this important area and expanded its membership. in 1991, the CGIAR admitted three centres into its fold, including the International Centre for Research in Agroforestry (ICRAF), and decided to establish the Centre for International Forestry Research (CIFOR). Since this change, a number of networks and system-wide programmes dealing with natural resources management, including forestry, have been launched. These networks and system-wide programmes provide not only a useful mechanism for international research collaboration, but as a major vehicle for information exchange and dissemination. Specialized information systems and services, developed at centres such as ICRAF and CIFOR, provide a useful source of information for network members and other users. Such services include specialized forestry databases, publications, CD-ROMs, modeling and decision support tools, web sites, and library/documentation services. The paper reviews some of these services and highlights their relevance to the forestry research community and explores avenues for enhancing their accessibility.

The paper also explores capacity building in information and its impact on the work of scientists, including foresters. Using the case study of the AfricaLink Project-aimed at providing electronic connectivity to several research networks in Africa-the paper explores problems national scientists encounter due to poor communication facilities and lack of access to relevant and timely information. It demonstrates how a modest effort in providing basic email connectivity-especially in remote research stations-can make a significant difference in enhancing information exchange and research collaboration among network members. The paper concludes by highlighting how the Internet and the World Wide Web can be used to facilitate collaboration and information access for regional and global research networks.

The Rainforest Interpretation Centre - A Contribution to Forest Conservation and Environmental Education in Sabah

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Keywords: information centre; extension service; teacher training; rainforest information

The Rainforest Interpretation Centre (RIC) is an Environmental Education facility located within the Sepilok Arboretum, Sandakan, Sabah, Malaysia. The Centre was constructed in 1995 with funds from the Deutsche Gesellschaft für Technische

Zusammenarbeit (GTZ). However, this facility is now run by the Environmental Education Unit of the Forest Research Centre, Sabah Forestry Department.

The RIC houses an exhibition that covers a wide variety of aspects of the rainforest (*e.g.* importance, characteristics, distribution, effects of their destruction) and a collection of artefact displays, ranging from dipterocarp seeds to traditional handicrafts made from forest products. Adjacent to the RIC is a 'Rainforest Walk'. The trail is guided by interpretative boards.

There are two main aims behind the establishment of the Rainforest Interpretation Centre:
- to increase public awareness of the rainforest, its importance and the consequences of its destruction
- to change attitudes and behaviour towards the rainforest and the environment as a whole.

The Environmental Education Programme at the RIC has been divided into three main components:

1. an environmental education component for visiting primary and secondary school groups. The aim of this component is to plan and conduct environmental education programmes for primary and secondary students using the RIC facilities.

2. an environmental education component for in-service and pre-service teachers and teacher educators. The aim of this component is to train teachers to implement environmental education and enable them to plan and conduct their own environmental education programmes at the Rainforest Interpretation Centre.

3. a public awareness component which caters for the general public and tourists. The aim of this component is to produce quality interpretive materials and programmes for the public.

In addition to the target components, there are two supporting components:

- an Environmental Education Resource Collection to establish a resource base for the sustainability of the environmental education programme.

- an Administration and Training component to establish procedures for the running of the programme.

Since the RIC opened for visitors in July 1996, over 3400 tourists have visited the centre. About 20 workshops for teachers and teacher trainers have been conducted. The workshop programmes contain a general introductory lecture on environmental education including the principles and a demonstration of some selected activities that teachers can do with their students. To support the workshops, a training manual for the participants was produced. The manual contains information on environmental education, the Rainforest Interpretation Centre, and sample activities as well as programmes that can be run with students. The main target group is school students for whom half day and full day programmes for both primary and secondary groups are conducted. So far about 50 schools visited the RIC. in many cases the programmes incorporate a visit to the nearby Sepilok Orang Utan Rehabilitation Centre.

The RIC is becoming increasingly popular with schools, tour operators and other visitors. The majority of the visitors is interested and eager to learn. Young students have expressed an increasing degree of awareness and concern about the state of the environment especially the forest. Thus, the RIC and the Environmental Education Programme of the Forestry Department is considered a small, but nevertheless important contribution to forest conservation in Sabah.

Developing an Integrated Protected Area Network (IPAN) System for Biodiversity Conservation: Lessons Learned

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Keywords: information system; information technology; resource management; modelling; GIS

With the rapid advancement in the field of Information Technology (IT), natural resource managers have become conscious of the need and utility of developing and managing databases in order to facilitate informed decision making. Likewise, advances in the field of Remote Sensing and Geographical Information System (GIS) technology provide natural resource managers synoptic, repetitive spatio-temporal coverage's for management and monitoring of complex and dynamic landscapes. Realizing the global as well as the national need for developing a rapid, transparent, participatory and informed decision making process in the field of biodiversity conservation, we developed an Integrated Protected Area Network (IPAN) System for the Maharashtra State Forest Department (MFD) India.

A generic approach, capable of evolving solutions in a participatory and transparent manner was adopted in the development of the IPAN system. The IPAN system is 'modular' and 'hierarchical' in nature. There are nine modules viz. (i) Biogeographic Zonation; (ii) Protected Area Resources; (iii) Human Resource Development; (iv) Research and

Monitoring; (v) Tourism and Nature Education; (vi) Finance and Budget; (vii) Supporting Institutions; (viii) Legislative Assembly questions; and (ix) Bibliography. Each module is further divided into several 'sub-modules'. Each sub-module contains information on various 'attributes'. The organization of information follows a 'nested architecture'. The system has a flexibility to increase the number of modules/sub-modules/attributes as per specific needs arising in future.

The IPAN system has been designed to operate at four functional/operational levels of management decision making. The IPAN system software has been developed using Visual Basic 4.0 programming language and is designed to handle both the spatial and aspatial data. The IPAN system provides outputs in a variety of formats viz. (i) tabular statements (ii) graphics, and (iii) maps. Most of these outputs conform to the existing procedures of providing information within the departmental hierarchy and wherever necessary modification have been made to optimize the reporting requirements.

The IPAN system facilitates: (i) storage, retrieval and query of large data sets; (ii) compilation of tabular, periodic statements/returns on staff position, offences, management activities routinely required for regional planning and management; (iii) providing of updated information on Protected Area (PA) resources required for preparation/revision of PA management plans; (iv) monitoring of trends pertaining meteorological variables, vegetation, animal populations, tourism, animal damage compensation, etc; and (v) resource map generation for better visualization, planning and decision making.

The integration of various modules in the IPAN system allows the users to query and generate information *e.g.* determining the visitor carrying capacity and ecotourism potential of a national park; calculation of biotic pressure indices; monitoring of trends in socio-economic dependence of rural communities living adjacent to the protected areas; identification of information gaps by searching the bibliographic database. The paper also summarizes the lessons learned in addressing complex data management issues viz. data custodianship, data validity, value addition and data updation, which would be very useful for handling similar tasks in a developing country situation.

Resource Sharing and Networking amongst Forestry Libraries in India

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Keywords: library networks; forestry databases, information infrastructure

For undertaking forestry research, carrying out literature searches and information consolidation, the resource sharing and networking is the most appropriate. in a country like India where the resources of most forestry libraries are inadequate and unbalanced, it is extremely important to pool the resources of various libraries together. As such the libraries of various institutes in the country set up by Indian Council of Forestry Research and Education (ICFRE) / Ministry of Environment and Forests and Agricultural Universities imparting forestry education were surveyed.

With the expansion of knowledge, a lot of literature is published and it is not possible for any of the aforesaid libraries to cater to the need of all its users. Several Commissions in India had recommended 6.25 to 10% of the educational budget alloted for expenditure on libraries. But it is disappointing to note that only 1.5% or less is spent on most of the libraries. To-day the effective library co-operation is still on idea plane in India. Only few libraries are developing ways and means to make efforts towards library co-operation. The areas where resource sharing has achieved partial success in India are:
- Inter Library Loan Services
- Co-operative Training
- Book exchange
- Co-operative Library Services (SDI, CAS)

Whereas in areas like Co-operative Acquisition, Co-operative Cataloguing, Co-operative Storage and Technical Processing the initiative is yet to be taken as far as forestry libraries are concerned.

The effectiveness of the system can be had only with the enactment of Library Legislation. It should also provide for finances and the way for conducting library services. in India there is still no agreement on Acquisition Policies, Bibliographical and Standardization procedures of various forestry. in the fact of the problems facing the forestry libraries, resource sharing seems to be the only solution. It is hoped that the use of computers, the modern networking systems, union catalogue and co-operative library services will provide effective resource sharing facilities in the near future. For a successful implementation of resource sharing activities, there is a need of creation of databases by means of computers at various levels. This in turn, may be combined into bigger data-bases of all materials available in participating libraries.

This paper discusses as to how the modern forestry researcher in India is confronted with the literature explosion and the importance of resource sharing and the need for developing an effective network of forestry libraries in India.

Plant resources of South-East Asia (PROSEA)

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Keywords: plant species; tropical plants, publications, PROSEA databank; handbook

South-East Asia houses one of the biggest remaining complexes of tropical plant diversity. Between 5000 and 10,000 plant species have been described in the course of time as being used by mankind. The information on these plants both old and new is scattered world wide that only scientists could consult a handful. Similarly, the vast amount of vernacular reports by emerging class of local scientists within the region hardly reaches an international audience and often - even colleagues in neighbouring countries.

Hence, an international programme was initiated with the objectives to document and make available the existing wealth of information on plant resources of South-East Asia; to make operational a computerised data bank on plant resources of South-East Asia and to publish the results in an illustrated multi-volume handbook. It is an interdisciplinary project covering the fields of agriculture, horticulture and forestry. A network of offices in six South-East Asian countries has been established to achieve these objectives. see also: http://www.bib.wau.nl/prosea/

The information gathered has been grouped into 20 commodity groups based on their primary uses. The data bank on plant resources has a total of 52,967 records as of 1998. Bibliographies of less accessible (often gray) form the records of this data bank. of these records, edible fruits and nuts and timber trees are the commodity groups with the highest records of more than 8000. More than 8000 species of plants both lower and higher have been covered in the data bank. Plants are also classified based on their conservation status and distribution. Retrieval of information has been made easier with the advent in computer software and CD-ROMs.

Between 1989 and February 1999, twelve commodity groups have been finished and published in 14 volumes; Pulses, Edible fruits and nut, Dye and tannin-producing plants, Forages, Timber trees, Major, Minor and Lesser known timbers, Rattans, Bamboos, Vegetables, non-seed carbohydrate-producing plants, cereals, Auxiliary plants and Essential-oil plants. in total 4602 species have been described, 3592 as major and 1023 as minor. The remaining volumes; medicinal and poisonous plants, spices, vegetable oils and fats, cryptogams, stimulants, fibre plants, plants yielding exudates and ornamental plants will be published between 1999 and 2001.

6.03.02 Forest Terminology: How to get society understand forest terminology

Forest Terminology in relation to Societal Change and Decision Making

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Keywords: Forest terminology, societal change, definitions, on-line dictionary

The last decade has seen dramatic, world-wide changes in the diversity of societal perceptions of the uses, needs, and values of forests. Many societal groups, particularly in the conservation area, are strongly influencing the management and conservation of forests on both publicly- and privately-owned forests.

Forest management is also becoming increasingly diverse. in the United States it encompasses a variety of objectives represented by owners that include private (industrial and non-industrial), public (federal and state), native tribes, and organizations interested in forests as long-term financial investments. One could argue that this diverse set of ownerships represents a broader cross-section of societal needs and values than do the conservation groups.

Given this diversity in needs, uses, and ownership of forests, it is not surprising to find that forest terminology is used inconsistently. Sometimes, as in the case of such terms as sustainability, forest health, and clearcutting, this is probably deliberate to further the objectives of the user. Until recently, existing terminologies were commonly dominated by traditional focus on timber management. To fill the need generated by more diverse objectives and values, current documents are typically accompanied by independently-developed glossaries. Consequently, in the development of public policy and regulation it is common to find that terms are defined differently.

A standard, accepted, on-line dictionary is needed that is used as a basis for all documents, debate, general communication, and policy development. Such a dictionary should probably be developed and maintained by a group of forest terminology specialists representing diverse elements of the broad field of forestry. These experts whould manage the peer review of definitions before incorporation. IUFRO should expand its leadership role in developing a standardized terminology, probably with regional variation of definitions, both nationally and internationally. The great advantage of an electronic dictionary is that it would be readily available and could be constantly updated and revised as terms are introduced or modified. Current issues needing to be resolved include the use of copyrighted definitions that are currently limited to use in the print medium, defining the extent of the field of forestry, and determining the extent of coverage of terms in each of the forest science disciplines.

Proposal of A Multilingual Forest Terminology Database Designed for Western and Non-Western Languages.

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Keywords: Forest terminology, multilingual terminology database, non-western languages, two-byte code, SilvaVoc-J

SilvaVoc, IUFRO's clearing house for multilingual forest terminology, is working to establish a forest terminology database to be published on the Internet. Non-Western languages such as Japanese, however, have some problems in multilingual databases, and current web browsers have a limited capacity to manage multilingual functions. For example, western computers cannot display Japanese characters correctly on the monitors, because they cannot manage two-byte code and have no Japanese font data.

SilvaVoc-J, which is a partner of SilvaVoc in Japan, developed an experimental system of a multilingual forest terminology database. This system was based on one of the solutions proposed by the author at the IUFRO international workshop "Multilingualism and Expert Cooperation in Forest Terminology" (MEXFT'98). It consists of three functions. The first function is a World Wide Web server, the second a database server, and the third one is a function to convert Japanese characters' fonts to raster images automatically.

The system works as follows. First, a user queries about a term to the Web server from a client computer. Then, the Web server requests to search the term to the database server via Common Gateway Interface (CGI). The database server carries out the search and sends the result to the Web server via CGI. If the result term contains Japanese two-byte characters, it is converted to a raster image on the way to the Web server from the database server. Finally, the Japanese term is displayed as an image in a Web browser on the client computer.

The system does not require Japanese font data and special browsers on client computers. in other words, Japanese characters can be displayed in popular Web browsers such as Netscape Navigator and Microsoft Internet Explorer on any countries' computers. Furthermore, the method is available not only for Japanese characters, but also for characters of other non-Western languages.

Therefore, the system also makes it possible to add other non-western languages to the multilingual forest terminology database.

The experimental system of a multilingual forest terminology database will be demonstrated in the presentation.

Terminology as a way to communicate values. Sustainable forest development: vision of the world in the 21st century

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Keywords: Forest terminology, Spanish language, English language, teaching programmes, terminology work, sustainable forest development

Language is a working instrument common to all subject specialists, a working tool and a means for communicating scientific findings.

The objective of the Programme of Foreign Language of the Technical Center of Higher Education is to elaborate versions and summaries of expert materials in Spanish with an adequate usage of the Spanish mother tongue. The educative project as main working document in the three dimensions, the instructive, sociopolitical and extension aspects, serves as a basis for integrating English as a foreign language programme with the other expert programmes.

Facing the challenge of the globalization, the correct usage of the language as a distinctive feature of the national identity and the valorization of linguistic variants are of major concern to the project leaders. The strategy was set to use Terminology as a way to integrate English into other teaching programmes in the University of Pinar del Rio. This strategy consists of several phases, resulting in the integration of the students in research work, sistematic terminology work and in the organization and elaboration of concept systems of the contents of the several subjects. With this strategy the transdisciplinary approach of the English technical language course leads, via sistematic terminology work, to the formation and strenghening of general and professional values which the students need to have as members of a society that has to face the challenges of a new century.

Sustainable forest development as a paradigm to reach sustainability is the perfect conceptual world. Terminology work takes into account the scientific perception of the world through knowledge-generating processes in the construction and permanent reconstruction of the student's "vision of the world". It aims at providing an education which allows to perceive semantic and conceptual features of sustainable forest development. These combined language and subject field teaching programmes are intended to prepare the students to the challenges that they will have to face as future subject specialists.

Sustainable forest development as a paradigm to reach sustainability is the perfect conceptual world. The scientific conception of the world through knowledge generating processes in the construction and permanent reconstruction of the students' "vision of the world" is taken into account in the terminology work to obtain an education which allows to perceive semantic and conceptual features of sustainable forest development and therefore provides a way of action in view of the challenges that the students have to face as future subject specialists.

Coming to Terms with Politicians and Definitions

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Keywords: Forest terminology, international processes, definitions

Recently there has been a large number of international agreements, conventions and protocols dealing with forest and forestry - especially since the United Nations Conference on Environment and Development (UNCED) in 1992. Politicians and high-level government officials, eager to do the right thing regarding the environment endorsed documents such as the Forestry Principles, the United Nations Framework Convention on Climate Change (UNFCCC), the Convention on Biodiversity (COB), and the recent Kyoto Protocol. Successful accomplishment of these agreements on a global basis requires common understanding and implementation at the national level. However, these agreements often contain terms that are not clearly defined or accepted on a national level. It could be that the endorsers either believed that they were commonly understood or they purposefully left the definitions and interpretations up to the implementing bodies.

To understand the magnitude of definitions in use at the national and international levels, IUFRO 6.03.02, in 1998, undertook studies of some terms associated with the Forestry Principles, Climate Change and Biodiversity Conventions, and the Kyoto Protocol. The studies included a world-wide literature review and internet survey for definitions of such terms as tree, forest, land cover land use, deforestation, afforestation, reforestation, old growth and ancient forest, protected areas, and low forest cover, that appeared to be ambiguous in many of the agreements. For example, the term "forest", key for the implementation of the Kyoto Protocol, may be defined as an administrative unit by one country, a type of land cover by another or a type of land use by yet another. With such diversity in definitions at the national level, it would be very difficult to develop any meaningful statistics at the global level.

How to do Terminology Work in Forestry. Services Offered by IUFRO

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Keywords: Forest terminology, co-operation, terminology services

Efficient communication among scientists and with decision makers needs a precise and clear technical language. The network of IUFRO experts in forest science is an immense pool of living expert knowledge. Experts create the terms we use to communicate and thus constitute an ideal partner for IUFRO's services in their attempt to define and make accessible the forest technical language to a wider public.

At a time when English has become the *lingua franca* of science, it is crucial that other languages - and IUFRO has four official languages - keep playing an active role. This broadens the horizon of scientific thinking and knowledge, but also makes unequivocal communication more difficult to achieve.

Vocabularies, glossaries and terminological databases present the technical vocabularies and, if relevant, interpret them for the interested public. The role of forestry experts is to help and assist in this process of explication and definition of their own specialised language, in order to guarantee the high quality and liability of these communication tools.

IUFRO offers services with regard to terminological problems through its Working Party 6.03.02 "Trends in Forest Terminology" and its terminology project SilvaVoc based in the IUFRO Secretariat, which are interrelated and pro-active. Additionally we will show how 6.03.02 and SilvaVoc incorporate IUFRO officeholders in terminology work and illustrate the most important services that are provided by 6.03.02:
- electronic discussion groups
- terminological hotline for telematic-based terminological assistance;

and by SilvaVoc:
- on-line Bibliography of terminological publications in forestry
- terminological database SilvaTerm.

Traditionally IUFRO's role in terminology has been to make people aware of terminological differences. Our approach is therefore based more on descriptive than prescriptive principles, e.g. instead of aiming primarily at recommending definitions, it is our concern to point out differences in the use of the terms. Guidelines for quality forestry terminology projects will be distributed at the IUFRO World Congress.

As globally co-ordinated forest research becomes a priority in the context of sustainable management and global change, the need for concerted action in terminology will increase. Partners from various geographical and institutional backgrounds will have to base their collaboration on common definitions. They will also need to avoid duplicating terminological efforts. Together, WP 6.03.02 and SilvaVoc can significantly contribute to this collective effort by consolidating the network, resources and expertise they have built since 1995.

6.06.00 Research driven by scientists' wish or society's demand?

Scientists and Forest Policy: Roles, Opportunities and Responsibilities

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Within the United States Forest Service, the role and responsibilities of research scientists is widely discussed in terms of decision making for policy and management. The issue is widespread within the national scientific community as scientists come face-to-face with the conflicting demands of unbiased research and moral and ethical considerations to make public their views and value judgments about trends and issues that their work has uncovered. The Forest Service has attempted to draw a clear line between science and value judgments in the policy and management of the Nation's public forested lands.

A successful example of an interaction between universities and forest companies to promote research and development in Brazil: SIF

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In 1974, the Department of Forestry - DEF of the Federal University of Vicosa - UFV in Minas Gerais, Brazil, along with five private forest companies founded the Society for Forest Research - SIF a non-profit organization with the objective of promoting research and development in the Brazilian forestry sector. At the same year, the Department of Forestry of that University was also starting its graduate program in Forestry. This fortunate coincidence led to one of the best examples in Brazil of an interaction between the scientific and private sector in the country. Most of the research thesis at Master and Doctorate level in the graduate program of Forestry of UFV were funded and developed at those associated companies. Since its foundation in 1974 SIF has promoted a series of short courses, workshops and international meetings and publishes today Revista µrvore which is considered the best scientific journal in the forestry area in the country. The objective of this paper is to show how an agreement between private forest companies and a federal university can lead to one of the best examples of interaction for forestry research and 6.06.00 Research driven by scientists' wish or society's demand?

Optimizing Societal and Corporate Needs While Delivering Quality Science to Support Forest Policy and Practices

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Aligning science activities to best address ecological sustainability, private sector business objectives, and/or societal demands is a major challenge in research and development (R&D). Forest resource policy makers must account for all three when developing legislation, standards and guidelines to reflect the wide array of multi-sector values. Policy is being increasingly scrutinized to ensure its integrity and relevance. Delivery of quality science to meet sector needs requires 4 major steps: a) identify sector needs (including the scientific community), b) translate those needs into research proposals, c) select of priority R&D projects, and d) ensure the service or product fits the need and is delivered on target.

Ontario is exploring the use of a process to effectively, efficiently and equitably address each of these steps. The procedure includes the use of a values and objectives driven survey of key stakeholders, a protocol for aligning science activities with stakeholder values and objectives, a delivery tracking system to help ensure a good product - need fit, and a performance-based system that guides and supports scientists and specialists to help them meet corporate priorities.

The process uses sophisticated information management and technology to involve senior management at key decision points, optimize the use of human and financial resources, minimize subjectivity and bias in decision-making, and reward scientists and for delivery of quality products and services.

Forestry and Forest Research in Brazil

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Brazil has an area of 8.5 million km^2 and a population of over 160 million inhabitants. Brazilian GNP was about 750 billion dollars in 1997. Natural forests still cover a large area of Brazil. Although one may list several different forest ecosystems, six of them deserve special mention: the Amazon forest; the Atlantic forest; the "Cerrados"; the "Pantanal"; the "Caatinga"; the "Paran Pine" forest. Brazil has about 6 million hectares of man-made forests, mainly with *Eucalypts* (many different species, the most common one being *E. grandis*) and pines (slash and loblolly pine). These forests were planted mainly from 1966 to 1987 by large companies with tax incentives from Brazilian Government. Today, nearly all wood used for pulp and paper, particleboard and fiberboard comes from these man-made forests. Besides, more than one third of all veneer and plywood comes from pines.

In the last decade, Brazilian government has changed legislation to diminish deforestation and created a large number of conservation units. None of these measures was fully effective as there are no effective law enforcement structures and conservation units need further investments on financial and human resources to work properly. Forest research had an important role in forestry development in the last century, but research institutes are facing problems due to a rather long economic crisis. The early and current story of forestry research in Brazil is presented, and current trends in organizational and tematic aspects are discussed. The weakness of information systems and the need for the strenghtening of networks are key factors to the success of forest research in the country, which is hindered by a steady diminution of funding and to the current process of privatization of public research institutes.

The perspectives of development of forest sector in Brazil are good provided some structural changes occur in the country, increasing competitivity of forest products.

Current Research at the Institute for World Forestry

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The mandate of the Institute for World Forestry/Chair of World Forestry is to conduct research on the structure and composition of forests, on their conservation, management, and potential for utilisation. The research is concentrated on the development of strategies to preserve forests and improve their multiple functions, on recultivation of degraded forest lands and on integration of forestry into overall regional development.

According to the research agenda, scientific activities and research projects focus on five key aspects covering tropical and boreal forest types:

Forest Ecosystem Dynamics

Regeneration and growth of trees essentially depend on their genetically programmed capability to adapt to changing site conditions. The knowledge of adaptability, of autecology and site preferences of important tree species is a significant precondition for the planning of environmentally compatible development of forests, and for the rehabilitation of degraded forests. Various projects investigate the autecology of tree species to gain knowledge about their suitability for integration in rehabilitation programmes. Furthermore, plant species diversity is studied to assess the effects of forest management in stands with different harvesting intensities and compared with pristine forest conditions.

Influence of Land Use on Biodiversity

Forests have a key function in determining the distribution and the abundance of many other plant and animal species. Biological diversity is becoming a central criterion for forest management and interdependencies are to be fully understood. Fundamental research topics deal with dispersal of plant diaspores, with browsing and predation and their consequences, with floral ecology and pollination success, as well as with competition. Sustainable management of forests mainly in an international framework also includes the careful utilisation of biological resources, other than timber, for the proper use and treatment of forests as a resource.

Forest Development and Monitoring

As part of the co-ordination and evaluation of the European Assessment on Forest Condition by UN/ECE and EU, a data bank is established. Data on site parameters, soil chemistry, elementary compounds in needles and leaves and the development of the canopy are included. All information is recorded in a time range of 15 to 20 years and is based on several thousands of monitoring points in Europe. The assessment methods of the different monitoring programmes of all participating countries need to be harmonised for interdisciplinary and synoptical analysis.

Silviculture as a Tool for Sustainable Management of Forests and Non-Timber Forest Products

Emphasis is put on research of structure and dynamics of tropical and boreal forest ecosystems as a fundamental prerequisite for the development of silvicultural systems. Concepts for silvicultural operations need to be elaborated and verified. They have to be oriented towards an economic feasibility, to ecological stability and socio-cultural compatibility.

Non-timber forest products play an important role in the sustainable management of tropical forests. Corresponding research concentrates on the production and utilisation of non-wood forest products.

Sustainable Forest Development

At the Conference on Environment and Development in Rio, the Federal Republic of Germany has agreed to implementing the Agenda 21, the environmental action programme for the 21st century. Chapter 11 of this Agenda ('Combating Deforestation') specifies research priorities of forestry research in the tropics. Moreover, Germany signed the Framework Convention on Climate Change in Rio. It obliges Germany to implementing the targets of the convention and to report to the Secretariat of the Conference of the Parties. This convention has meanwhile become national law. Considering Germanys international commitments, the Institute for World Forestry elaborates proposals in the context of harmonisation of diverging views for political decisions to be taken by the Federal Government.

6.06.02 How are innovations applied in sustainable forestry

The practice and prospect of participatory forestry in China

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Keywords: Participatory forestry, community forestry, implementation, impacts

In historical review of the philosophy of human development regarding interaction between forests and humans, a transition is occurring from the perception of forests as a resource to recognition of forests as an associate. Humans have stepped into this new stage with difficulty, and participatory forestry can be a brick for paving the way into this new stage of human development. Participatory forestry was introduced to China in the mid-1980s and then fostered by international aid projects. in the past decade, issues raised for study have included policy, indigenous knowledge, gender analysis, conflict resolution, technical improvement and innovation, and training with international technical aid. But studies were limited in the area that has been tested with focus on southwest China. Since the mid-1990s, community forestry projects have been implemented in areas of poverty in the middle and west part of China with international financial aid. The impacts of these projects were analyzed for behavior and attitude changes of various stakeholders related to forests, institutional support for developing participatory forestry, the orientation of objectives, technical improvement and innovation, and extension. The constraints in the development of participatory forestry were analyzed with regard to behaviors and attitudes of outside individuals and institutions, policy and regulation, role of existing institutions, promotion costs, financial agencies, participatory process, and techniques.The decision-making processes, processes for implementation, and impact of the participatory forestry projects were analyzed in comparison to those of the prevailing top-down forestry projects. in regards to the participatory forestry as an emerging philosophy and strategy, many issues related to forestry management were analyzed including land tenure reform, policy and regulation, and decentralization of decision-making. Because of the great variation in natural, economic, social, and cultural conditions and the imbalance of policy reform in different regions, many cases with great variation were provided. This resulted in the important conclusion that cultural, natural, economic, and social conditions should be considered and different nations and regions should find their own way in promoting participatory forestry. Recommendations for forestry policy reform and strategies for project implementation were put forward.

Survey, Assessment, and Analysis of Existing Extension Strategies and Transferred Technologies in the Cordillera Region of the Philippines

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Keywords: extension; technology transfer; information dissemination; technology adoption

The study identified technologies and information that were disseminated through a loan project by the Ecosystems Research and Development Service. Dissemination methods and extension strategies were also identified as basis for formulating an appropriate and effective extension strategy for end-users and the government. Respondents identified one to four types of information and technologies with soil and water conservation measures most widely known in three provinces and tree planting technologies better known in two provinces. Methods used for disseminating information include: lecture, lecture with brochure, training, training and actual demonstration, cross-farm visits, film showing, broadcast, brochure distribution, house-to-house interviews, and meetings. Cross-farm visits occur when a group of farmers in the same area will visit a group of farmers with model farms in another area to learn technologies being adopted in that farm and in turn share their experiences and technologies to this group of farmers.

The most common and preferred method was training with actual demonstration followed by cross-farm visits. These strategies showed high impact and are recommended for introducing technologies and information to this type of client (upland farmers, a majority of which belong to 30-39 age group and have either reached or graduated high school education). Farmer factors that influenced adoption in several provinces included age, sex, civil/marital status, education, household size, experience, farm size, tenure, and membership in organizations. Technology features (profitability, simplicity, practicality, compatibility with tradition,

and low cost inputs), characteristics of extensionists (interest, positive attitude toward their work, and communication skills) and credit facilities were perceived by respondents to have influenced the adoption of the technology and information.

Influencing the Adoption of Forestry Innovations: A Case Example from the United States

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Keywords: Forestry innovations; information dissemination; technology adoption; research organizations

People come to adopt innovations (new information, concepts, or technologies) through a process of becoming aware of the innovations, deciding to try it, and evaluating as to whether they will continue to use it. Forestry research organizations are in the business of producing innovations, but are increasingly challenged as how to best organize to promote the cycle of innovation adoption, implementation, and evaluation. This paper examines three ways that the Pacific Northwest Research Station, United States Department of Agriculture, Forest Service, promotes adoption of innovations that it has produced: (a) information and technology retrieval, (b) in-person interaction with scientists, and (c) organizational arrangements that emphasize learning. Traditional reliance on hardcopy scientific and technical publications is giving way to an increasing use of electronic information retrieval, including publication, software, and databases. Electronic access has broadened both the types and number of people aware of the station's research. Experiences with scientists include field trips, workshops, training, and some direct participation in research. Although such experiences can be effective in influencing people to try innovations, they are also time-consuming for scientists and involve an opportunity cost in time and resources that could be otherwise directed at research. Finally, the research station has experimented with several organizational arrangements that bring scientists, forest managers, and often citizens together. Such arrangements are innovative and complex, often requiring commitment from two or more organizations. Results have been mixed. Two examples of these arrangements are learning centers and adaptive management areas.

Rehabilitating Cold Deserts through Apropriate Transfer of a Technology Package

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Keywords: technology transfer; extension; participatory processes; cold deserts, sustainable development

The "cold deserts" in India, covering and area of 74,809 km^2, pose a challenge to development because of rugged terrains, isolation, inhospitable climate, and a lack of communication facilities. The development in the region has witnessed a sequence of changes of edaphic, abiotic, and social-economic environment over time and is unfortunately contributing to environmental degradation.

The traditional farming practices are being over shadowed by modern culture without a fresh look at these technological interferences and capital appraisal of their influences on economic prosperity and sustainable development of these hostile regions in perpetuity and commensurate with the cultural heritage. The cold deserts need to be conserved by adopting environment friendly and appropriate development packages. The suggested technology should depend least on internal inputs and aim at intensive farm research to maximize land productivity, resource conservation, and environmental protection, and catalysis of natural ecological development processes.

The transfer of technology package suggested in this paper caters to the needs of the poor and marginal farmers with recognition of innovation for and accountability to these users. It is based on participatory principles which are socially pro-people, that is, economically viable and culturally acceptable. This transfer of technology module will help solve complex problems by blending modern scientific innovation and the traditional expertise developed by the inhabitants for centuries. The suggested appropriate transfer of technology package intervenes into the physical, socio-cultural, agroclimatic, geographic, environmental and different components of soil, water, crops, livestock and resource endowments of the community. Appropriate technology needs to be considered for vegetables, fruits, peas, potato, kuth, saffron, hops, and traditional crops like minor millets, seed production of flowers, grasses, forest plantations, medicinal and aromatic plants, sheep and goat husbandry, fisheries, and management of nomadic grazing. These technologies need to be transferred through the participatory processes and extension education techniques for sustainable development of socio-economic conditions and ecological sustenance of cold deserts.

Adaptation and evaluation of innovative technologies by society: a step towards optimum utilization of forest resources for sustainability and socio-economic development

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Keywords: watershed management, technology, adaptation; evaluation; sustainable forest management

Sustainability in forest management is accepted as essential. Optimum utilization of available resources and adaptation of the latest management and innovative technologies are key factors in planning programs for forest management. India is striving to adjust and reorient teaching, training, and project implementation to address the changing focus of forest management. A technology policy statement was formulated to develop indigenous technology and ensure efficient diffusion and adaptation of imported technologies appropriate to national priorities and indigenous resources. The policy statement aims at attaining technical competence and self-reliance with maximum use of indigenous resources. It also aims at using traditional skills and capabilities toward commercial competitiveness.

Several other measures are envisaged to optimize demand on energy and ensure harmony within the environment. in view of the progressive pressure on the environment and natural resources, it was agreed on to give a new thrust toward conservation and sustainable development. To weave environmental considerations into the fabric of national life and the development process, the Government of India adopted the National Conservation Strategy in June 1992. This identified population control and conservation of natural resources including land, water, atmosphere, biodiversity, and biomass as the priority areas needing specific concerted action. These actions would integrate environmental consideration into policies and programs of development in various sectors.

The strategy also highlighted the role of International Cooperation and Systems for strengthening institutional mechanisms, research, and development, mobilization of financial resources, creation of public awareness, and training of professionals.

One of the significant steps in implementing the strategy was launching the National Watershed Development Project for restoration of the ecological balance in rain-fed areas and sustainable biomass production. It focuses on conserving rainwater and topsoil by (1) conservation, upgradation and optimum use of natural endowments in an integrated manner with low cost innovative technology and (2) generating employment for the poor rural communities, directly with farmers and watershed beneficiaries in planning and implementing all projects in the watershed by developing self-help groups.

The Doon Valley Integrated Watershed Management Project has implemented the National Watershed Development Project in Uttar Pradesh, India, with the help of the European Economic Commission since 1993. It includes agriculture, minor irrigation, horticulture, animal husbandry, community participation, soil conservation and forestry. The project now is being implemented in 255 villages covering an area of about 1,854 square kilometers. This paper discusses, reviews, and highlights issues of adaptation and evaluation of technologies, old and new, of the multidisciplinary project, with emphasis on environmental restoration, socio-economic development, and sustainable forest management.

6.06.03 Targeting the real forest managers

Impact of Societal Change On Extension Work in Bavaria

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Keywords: Societal change; Extension; Bavaria

So far the focus of state support and forestry extension activities for small scale forest owners in Bavaria has been put on farm forests. The whole system of education, further education and extension for private forestry was and still is adjusted to that type of forest owner. The structural changes in the agricultural sector causes an ongoing abandonment of farm enterprises which lowered the number of managed farms from 472.805 in 1960 to 252.972 in 1997 and extended the number of pure forest enterprises from 46.148 in 1980 to 73.275 in 1997. Therewith the number of forest owners no longer covered by the traditional forest education and further education system increased and will increase further on. Coincidentally the management objectives of these "new" non farm forest owner type changes, at least partially no longer focusing on wood production.

The traditional forestry extension approach in Bavaria to link extension with the financial support of private forestry within the framework of financial funding programs does not seem to be appropriate in the future: The catalog of supported activities generally aims at traditional forest management measures. in addition, due to budget restrictions, the available amount of funds for management activities decreased remarkably since 1990. Therewith the attractiveness to seek extension services will shorten too.

The classic extension clientele (farmers, wood production oriented forest owners) is also confronted with changes on the customers side: The ongoing concentration process in the wood industry sector in Germany creates new challenges to small scale private forest owners in terms of delivery conditions (just in time production, sufficient volume per harvest etc.) and grading of timber.

Simultaneously forest owners available time for individual forest management is decreasing due to the growing size of the agricultural part of the enterprise in the case of farm forests. Therefore private forest owner organizations or service enterprises will increasingly take over forest management competencies in small scale forests. These "new" forest managers are therewith of growing interest for extension professionals.

The described processes demand the modification of the existing extension praxis in Bavaria in terms of approaches and contents, from a reactive general outline to an extended active extension. A precondition is knowledge on the motivations and attitudes, as well as objectives of the "new" forest owners and managers. Most recent research shows, that the new clientele not necessarily spends less time in their forest but less time with forest work. Absentee owners dedicate up to 70%, farmers at least 90% of their time in the forest to active work. Lack of equipment and less skills also characterizes these new absentee forest owners. 2/3rd hire entrepreneurs for specific forest management activities, 1/5th exclusively. Income generation plays only a minor role, main management strategy becomes to "keep the forest", using concepts from "traditional" to more "close to nature" but also "do nothing".

Forestry Extension in Environment of Political Transition - example of Slovenia

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Keywords: transition, forestry, Slovenia

The article deals with the conditions raised from the political changes in Central and Eastern Europe. We focused on forestry which in many places went through radical transformation. We are dealing with Slovenia as an example.

The political changes which occurred in Eastern and Central Europe in the last years, seized strongly into every pore of social life. One of the essential matters that went through a radical change, is property. in nature, as well as in social relations, the system of pendulum is present. If in a system we hold one thing on one, extreme side for a long time, the reaction, in the moment of release, will be adverse and more impetuous than it is good for a system. If the rights, arising from private ownership were oppressed for decades, it is logical that the demands of the new, or better "renewed" owners would not always be profitable for the forest. Therefore it is urgent that the interests of singular components of the system (owners, profession, politics, public) are coordinated, because only such coordinated system will work successfully.

Even though the conditions in Slovenia were, and still are, different from the rest of the countries in transition, the basic relation and problems in a society are in its nature similar, if not the same, everywhere. That's why the description of the condition in Slovenia is enough to make an observer get a rough picture of the circumstances, governing in other countries in Central and Eastern Europe.

The main changes, performed in the field of forestry in Slovenia are:
- with the denationalisation process the share of private-owned forests has increased
- the rights and duties of forest owners towards their forests have been strengthened
- a united public forestry service has been set up for all the forests, regardless of ownership
- financing of forestry has been completely changed; because of public meaning of forests, the state finances the public forestry service and the major part of protection works in private forests and it also participates in financing of tending works and maintenance of forest communications.

The united public forestry service assures a more efficient professional guidance of forest development.

The system of forest-management planning has been completely renovated and supported by modern technology of space treating (ortophoto plans, geo-coding of all data about forest and forest space). We are paying a special attention to incorporation of forestry planning into general regional planning in the country, even bigger stress than so far is given to protection of nature and to the highest possible extent the wishes of forest owners, who also participate in forestry planning, are being considered. The public forestry service makes wild-life management plans, too. One of the most important tasks is education of forest owners and the public.

The Forest Bank: An Innovative Program To Manage Forests and Protect Biological Resources On Private Lands

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Conflicts between the need to harvest and extract timber products and to protect rare, threatened, and endangered biological resources are common throughout the world. in the US such issues have centered around a small number of high profile species such as the spotted owl in the Pacific Northwest and the Louisiana black bear in the South. Often, the critical habitat and species in question reside on large tracts of public land, and the controversy becomes one of public policy. However, across the US, about three fourths of the forest land is owned by private, nonindustrial land owners, and conflicts often become more personal between environmental organizations and private citizens. Recently an environmental organization, The Nature Conservancy, developed a program known as the Forest Bank, and is implementing it in Southwest Virginia as the first test site. The Forest Bank allows for a forest landowner to voluntarily place the value associated with his/her timber rights into the Bank, then withdraw an annuity equal to 3 to 5% of the value of the timber into perpetuity. For example, if a landowner has $100,000 worth of timber, he/she would receive from $3,000 to $5,000 each year. The Nature Conservancy would then take over management of the forest land, and harvest the timber in an environmentally responsible manner. in fact, the harvest of timber by The Nature Conservancy would be essential in order to provide a stream of income to keep the Bank funded at a level high enough to pay the annuities. This presentation focuses on a series of related research projects now being conducted by Virginia Tech in cooperation with The Nature Conservancy. Studies are underway to evaluate the willingness of forest landowners to participate in the program, to determine the impact on individual and community economics, and develop spatial data analysis techniques to relate demographic and economic data with land use patterns and critical habitats on the ground.

Household Livelihood and Labour-Time Use Patterns as Frameworks for Devising Community-based Agroforestry Extension Strategies

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Since the introduction of the concept of agroforestry and associated practices in the early 1980s, agroforestry projects have adopted conventional extension methods and approaches such as farm visits, group training, and the modified Training and Visit method. Typically, the planning of agroforestry extension activities by extension agencies has not taken into account the local conditions. Consequently, it has been observed that some categories of potential beneficiaries of agroforestry extension services have been sidelined. in addition, adoption of agroforestry technologies, especially in marginal subsistence agricultural areas, has been limited.

Participatory approaches have also been tried since the early 1990's. However, often these approaches continue to be based on operational frameworks of the intervening agencies.

Against the background of the need to devise extension methods that fit into the livelihood strategies of a target community, research was conducted for a period of 7 months in a semi-arid district of Lake Victoria basin in Western Kenya during 1996-97.

One of the objectives of the research was to determine patterns of labor-time use by peasant farmers in this semi-arid area in the context of livelihood strategies. The research identified the types of agroforestry practices that have been most popular with farmers and hence have diffused extensively.

A formal sample survey was conducted in five divisions of the Homa Bay District in Kenya. Three hundred households were interviewed during the months of August to October 1996. Through the interviews, data on the socio-economic background and agroforestry practicing households, and the types of practices that have been adopted were collected. Labor-time use data was collected using the personal recording method. Data sheets were provided to members of the households who reside in the farms for more than six months in a year. Respondents were requested to record all activities done in a day from the time of waking up to the time of retiring to bed. One hundred and ninety-seven members of the sampled households participated in the labor-time - activity component of the research. Records were kept for a 3-5 month time equivalent spread across 7 months. Over 100 different activities were recorded, then grouped into nine broad activity categories. The period of the day when the activities were undertaken and the duration were also summarized. Data was statistically analyzed to determine the proportioning of time between different non-farm and farming activities by members of the surveyed households. The analysis was done to identify differences according to gender and age, as well as the season.

The research has identified the complexity of livelihood strategies of rural peasants and how these complexities have defined households' decisions on allocation of the one scarce resource that is common to households: Labor-time. The diversity of activities and rural households' time constraints require that agroforestry extension agencies devise extension strategies that involve active participation of community members. Research to determine which agroforestry extension methods, which are already being used, can be adapted to circumstances of rural subsistence farmers to enhance dissemination of agroforestry technologies is necessary.

Socio-Economic Implications Affecting Farmers' Participation in Agroforestry Extension Activities in Garhwal Himalaya

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AA study was conducted during 1996 to analyse some of the socio-economic implications affecting farmers' participation in agroforestry extension activities in the villages of Chopariyal Gaon macro watershed of Garhwal Himalaya. Statistical tests revealed that farm size, household size and total number of animals in the household were significantly related to agroforestry participation at the 5% level. Distance travelled for fuelwood collection was negatively significant. Number of days used for fodder collection were not statistically significant. The study recommends that the well being of the poor and powerless can be improved by ecosystem rehabilitation through economically viable and ecologically sound methods, using a ?do it yourself? approach. It has been postulated that application of technologies based on isolated biological, physical and social science research cannot resolve this issue and that a proper understanding of the socio-economic conditions affecting the population is essential. in the model developed using this approach, the village organisations assume responsibility to meet the needs of the community. in addition to policies of consolidating the land use, land tenure and related issues are also addressed to ensure sustainability of both the technology and people's participation The use of conventional methods of policy and management practices, which result in the alienation of local populations from the forest and consequential forest degradation, is abandoned in this approach. The study also recommends that detailed analysis of clientele should be the prerequisite in any agroforestry activity to be undertaken.

The Forestry and Agroforestry Technology Transfer Through Agricultural Technical Assistance Units - A New Approach To Rural Extension

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In the context of community forestry projects participation, planning can be clearly defined as the union between activities realized by the local people and the project staff. The objective is to formulate plans and to choose the best alternative available for implementation. in Colombia, the Forestry Research and Promotion National Corporation (CONIF) and the Ministry of Agriculture and Rural Development (MAG) have implemented an alternative extension methodology entitled "Forestry and Agroforestry Technology Transfer Through Agricultural Technical Assistance Units (TAU's)." With the drug problems in Colombia, the project has also been implemented as an alternative to substitute or replace illegal crops in some Colombian regions. The aim of this project is to achieve high extension agent performance influence in rural households. The main function of the TAU is to give assistance to small farmers. TAU's have the widest cover of the country, because they are associated with the national extension service. This is the first continuous and systematic effort in Colombia to use such units. Through this training proposal, CONIF seeks to provide conceptual information and practical experience on forestry and agroforestry, methodologies to identify and to validate agroforestry practices, and information for the extension agents to design, advise, and support farmers to adopt technology. To ensure that the process is successful and practical, the training proposal has the following characteristics continuous with three phases: 1) theoretical/practical training; 2) learning application; and 3) advising, monitoring, and evaluation systematic with respect to the contents of the training materials, the lecturers, and field trips.

- Responsive to local needs. The project aims to resolve the ecological, economic and social problems related to watersheds, deforestation, erosion, and environmental education.

- Based on human development, the project requires that extension agents be qualified to make decisions, respond to the rural development issues, and to provide alternatives for resolving issues.

- Community participation: Extension agents and farmers work together to identify and prioritize problems, and devise solutions. This allows maximum use of farmer indigenous knowledge.

- Based on research and established technology: The project is supported by the latest research results from ICRAF, CATIE, as well as CONIF in Colombia. Additionally, extension agents can draw information from the Monitoring and Evaluation System and the Forestry and Agroforestry Technical Information System, which operates nationwide.

6.07.00 Tropical Forest History

Searching for a New Paradigm in Sustainable Forest Management: Participatory Forest Management as a Strategy for Forest Conservation and Development in the Tropics

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Participatory forest management (PFM) is a new field in the arena of forest resources management. It evolves as an innovative approach for forest management and conservation with active involvement of the people for the development of forest and raising socio-economic condition of the community. PFM can be considered as a development program for the poor in the tropical developing countries with mitigating forest resource conservation problems. It has been realized that forest protection is difficult without active involvement and cooperation of local community. PFM can replenish the degraded forests in the tropics and protect existing forest resources from further deterioration through partnership with public agency and community groups. Promotion of people's participation in tropical forest management needs much stimulation and encouragement among the public, trust on forestry administration, and a rigorous overhauling of forestry policy and legislation. It needs community resources mobilization and organization into a successful PFM. PFM can enhance the involvement of local community in forestry activities through which local people change their attitude from destructors to keepers of the forests.

This article will deal with a development of a model for PFM of the tropical forests. Modeling of PFM will include reformulating the policy and legislation; strategy for effective community participation (resources mobilization, community organizing, care and share (stewardship), partnership among public forestry agency, community people/ neighborhood groups, and PVOs/NGOs; incentives and rewards; appropriate technology development and adoption (ATDA); multiple-product forestry practices (honey, wax, deer farming, woodlot, orchard, silvipasture, cash cropping, protected area development, ecotourism, etc.); implementation and evaluation, and research and extension. This article is about how to mobilize resources, organize and involve community people into a body of strong support and action for PFM. Upland people and people around the forests realize the importance of forest in their lives from subsistence to life saving drugs, and they are careful about not to destroying the forest resources base.

Government forest policy should welcome and make provisions for popular participation in forestry planning and management. Reformulating of policies and laws that are necessary for people's active participation, support and recognition of community-based tenurial systems, and strengthening local institutions. The tenurial rights over the land and usufructory rights over the produce should be clearly spelled out in the form of an agreement. This is important to gain confidence of the participants by the government forestry agency in the PFM. Administrative restructuring, foresters' orientation toward community interaction, democratic participation of local community in decision making and implementation in forest management, are some of the important steps that should be taken into consideration. Some of the strategies for PFM in tropical forest management can be (i) establishment of community forest/forest village development, and agroforestry model, (ii) development of protected area, nature reserve, etc. through active participation of the community negotiated on limited access/uses by the community, (iii) ensure use rights of non-timber forest products (NTFP), and marketing development, (iv) tribal/shifting cultivators' rehabilitation/settlement, (v) formation of forest farmers groups/Forest user group, and (vi) encourage equal gender participation, (vii) conflict management, and (viii) community empowerment and control. in this connection, we can cite the examples from India where joint forest management (JFM) was practiced that benefited both the community and the forests; and Nepal where forest user groups (FUG) were organized and involved in participatory forest management and rehabilitation/reforestation of degraded lands.

Conflict Cultures: A Comparative View of Environmental Forest Conflicts in Selected European Countries and Regions of the USA

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Keywords: Environmental conflict, culture, conflict management, Europe, USA.

Cultural clash is often perceived as an important background to environmental forestry conflicts. Indeed, conflicts usually involve a struggle between sub-cultures of society (*e.g.* those related to rural communities, industrialism, environmentalism). However, cultural aspects of conflicts are in this paper viewed from a significantly broader angle.

Environmental forest conflicts can be viewed as cultural products of the societies in which they occur. Owing to its unique social, political, economic and resource structure, each society has its own cultural way of producing certain types of conflicts and managing them in a certain way. Each country has its own "conflict culture". Only by understanding the conflict culture of a society, may we consciously aim at realising the positive potential of conflicts for social development.

This paper presents the findings of a comparative study of environmental forest conflicts during 1984-95 in seven cases: Finland, France, Germany, Minnesota, Norway, the Pacific Northwest region of USA, and Sweden. The data comprises a total of 210 focused interviews, which are analysed by using Qualitative Comparative Analysis. The analysis provides an understanding of conflict patterns in each of the seven cases, focusing particularly on patterns related to the types of conflict and conflict management, and to the value, policy, market and resource aspects of the conflicts. in comparing whole societies and in examining long time spans, this research fills in a gap in research on forestry conflicts, which has typically focused on the examination of case-specific or country-specific conflicts.

As a result of the analysis, models of conflict cultures and conflict management strategies are presented, and the cases are understood in the light of these models. The model of conflict cultures is based on three dimensional setting where mild vs. intense conflicts, social stability vs. rapid change, and co-operative vs. separative relations are examined in relation to each other.

The models help understand that conflict culture is a dynamic phenomenon. The appearance of conflicts and responses to them change in time within any society. Within this frame, conflict management may be regarded as a conscious effort to constructively influence conflict culture. This view becomes apparent when using the cases to construct a model of conflict management strategies.

Forestry and Stewardship in South-East Asia, with Special Reference to Peninsular Malaysia

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Key-words: deforestation, biodiversity, tropical forest history

Climate and geography have rendered the task of forestry difficult and complex in the tropics. Early realization of the impact of deforestation on climate and environment made colonial foresters aware that forests afforded services other than the provision of wood and fuel. The rapid expansion of population in Southeast Asia as of the nineteenth century obliged foresters to put in place appropriate legislation to curb indigenous practices of shifting cultivation. The forestry service was much less successful in arresting the loss of forests to plantation agriculture.

After World War II, the challenge to forestry was intensified by Southeast Asia's emergence as a major timber export region. Where previously natural regeneration, long cutting cycles and manual extraction allowed the return of biodiversity, post-War extensification and intensification of logging has threatened the fundamentals of forest stewardship in the tropics. Ironically, it is where the environmental and biological value of forests are highest, such as in the moist tropics of Southeast Asia, that the forester's role has been most challenged by politics and economics. The paper will argue that it is within the context of these processes that global discourse on the ethics of forest conservation and stewardship has evolved.

Human impacts of South American forests. Historical development

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Before the discovery by european navigators, South America had a native population well integrated in its environment, using the forests as a natural resource without depletion. The spanish and portuguese colonization during the 300 years after discovery changed little in this situation, as the main human impact was concentrated on the coastal regions, were of course the forests were cleared to provide space for some agricultural activities.

After 1800, as consequence of political changes in Europe, more attention was given to South America. The establishment of local governments brought more economical activities. Also the improvement of colonization of new lands by european settlers caused in the first moment heavy forest destruction. The forest was the enemy, plenty of dangers, wild animals and diseases. and the region had no open grasslands for agriculture. But yet at this time the role of forests as watershed protection was recognized. in the surroundings of the city of Rio de Janeiro the first reforestation action started on coffee plantations, nowadays called "Floresta da Tijuca". Later in this century, the development of steam engines increased the use of wood for energy as well as material for the construction of railroads. But still in most of South America, the forest was a source for special products, like rubber or some special woods. Fortunatelly this extractivism didn't caused much damage to the ecosystem.

At the beginning of the XXth century it was clear for many people that forests should be replanted. The first attempts to plant *Eucalypts* and pines were made in Argentina, Brazil, Chile and other countries. Later, even plantations for rubber tappering (by Henry Ford) were tryed, without success.

Real impact on forests started after World War II. Due to the development of international markets, evolution of better equipment for logging operations and industrial investments (paper mills, iron industry), the pressure on natural forests raised, as well as reforestation for industrial purposes increased. in the 60ties, land clearing for agricultural activities, like soybean plantations or cattle raising promoted a new wave of deforestation, after extraction of the best logs of the forest.

Actually, plantation forestry has high technical and scientific standards in South America. But the management of natural forests remains more or less extractivistic. and after all valuable woods or other products are depleted, land occupation for agricultural purposes is the consequence. International pressure and local interest achieve some results in preserving special tree species (like *Araucaria araucana* in Chile) or even landscapes, like the forests in the coastal mountain range in southeastern Brazil.

6.07.00 Social changes and forests

A Historical Chronology and Impact of Urban Forestry: A Case Study of Kuala Lumpur, Malaysia

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Beginning with its founding at the confluence of two rivers, the city of Kuala Lumpur has seen the introduction of several exotic and local forest species planted within the built up areas. Initially some of the existing forest species were left intact as development was very minimal during the early years. When Kuala Lumpur was placed under the British administration several exotic forest species were introduced for their shade and beauty amidst the humidity of the tropical climate. These trees were often planted side by side with the local species especially within the town centre, residential areas, government buildings, club house, parks and greenbelts. Combined with the introduction of flowering shrubs Kuala Lumpur was slowly developed into a conceptual garden city. The wet and humid tropical climate quickened the growth of these urban trees. As Kuala Lumpur developed into a modern city the policy of tree plantings of the colonial era was slowly revised. Unlike architectural buildings of old, these trees could not and did not last long due to neglect and changes in the land use. As more buildings were built some of these trees were cut down, pruned or replaced with tree species that are occupy less growing spaces. This is more apparent after Kuala Lumpur was declared a territory of the Federal Government in 1974. Fortunately Kuala Lumpur City Hall or Dewan Bandaraya Kuala Lumpur (DBKL) undertook a majestic task of transforming the city into a tropical garden city by preserving some of the trees and at the same time introducing new species of trees to suit the needs of the urban environment. Rows and row of trees were planted alongside low and medium sized shrubs for functional and aesthetic purposes. Millions of dollars were allocated for this purpose. Such immense effort has transformed Kual Lumpur into a city of a balanced and healthy environmet for its population. A lot of the city population has benefited from the presence of these trees in so many ways. The economic, social, political, and environmental benefits are discussed. However, such transformation is not without problems but nevertheless Kuala Lumpur has managed to provide a pleasant image to visitors and citizens alike. These problems and solutions are in so many ways similar to other cities throughout the world. The lessons learnt in Kuala Lumpur may be applied to other cities throughout the world.

Learning from Self-Initiated Community Forest Management in Orissa, India

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There is growing recognition in tropical countries that safeguarding forests requires the active involvement of local communities, but knowledge of how best to do this is limited. Orissa's extensive experience of community forest management (CFM) provides some valuable lessons and insights regarding: (a) how and why communities manage their forests; and (b) the sustainability of CFM initiatives. The paper discusses the following aspects of CFM in Orissa: (a) the conditions that give rise to the initiation of CFM; (b) the size and nature of the benefits, and how they are distributed among the various sub-groups of a community; (c) the factors affecting its sustainability, including conflicts and their management; and (d) communities' support needs. The principal research activity was a survey, primarily socio-economic, of 43 forest-dependent communities. CFM was examined in the context of people's livelihood systems as a whole, since these can affect the size and nature of any benefits they derive from forest protection, and also their main reasons for deciding to protect. The authors conclude that CFM has made an important contribution to the regeneration and sustainable management of Orissa's forests, and argue that the formal balance of control of forests be shifted further towards communities. They highlight the plurality of institutional and management arrangements that communities have developed, and caution against forest departments imposing a standardised, blueprint approach, as has tended to happen in government Joint Forest Management (JFM) programmes. Several weaknesses are

identified in India's JFM programmes and reforms recommended.

Keywords Community, management, indigenous, sustainability, conflict

The relationship between forest and community in Turkey (after the first general assembly of forest villages)

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The year of 1998 was the seventy-fifth anniversary of the Republic of Turkey. in this connection, a lot of institutions evaluated their own past activities with the aim of producing more successful policies and conducting more successful activities in the future. So the Ministry of Forestry held "The First General Assembly of Forest Villages". There were those considerations behind the organisation:

Almost all of the forests belong to the government in Turkey. There are 19000 villages in or near forest land and they are called as "forest villages". Almost nine million people live in the forest villages and they are called as "forest villagers". Forest villagers have a hard life and they are also in the lowest income group of the country. As a result of this they frequently commit a crime such as illegal cutting or clearance of forest land. Furthermore, they feel that they are stranger in their own land because of the forests belong to the government and for this reason they do not hesitate to damage forests. It is the proof that there are 130000 forest lawsuit in the courts now. So the Ministry of Forestry is in dispute with forest villagers because of all of these negative conditions. So the first general assembly of forest villagers was held with the aim of improving the dialogue between the Ministry of Forestry and forest villagers and discussing all problems with a great participation. Before the general assembly each regional forestry directorate held meetings with forest villagers. Problems were discussed on the regional basic and delegates that would participate in the assembly were elected in these meetings. Two hundred fifty-five delegates were determined in this manner among forest villagers. Later elected delegates, members of universities, NGO's, experts and high level bureaucrats of the Ministry of Forestry, representatives of the political parties constituted the general assembly. All of the members of the general assembly discussed the problems and general forestry issues during two days in the capital Ankara. in the light of these discussions a declaration was written and declared to people.

More detailed knowledge on the general assembly will be given and its success will be discussed in the paper. Also the paper will have discussion on thought in the declaration.

Lessons learnt from international assistance to forestry?

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1.6 billion US$ is now reported to be used for "aid (assistance) to forestry". in international fora there is always a request for more assistance. But the assistance given to forestry development so far has not always been successful (instead a lot of failures). How can the resources available for "forestry aid" be used in a more efficient way? If we don't find ways of improving the use of funds we may soon see that the "aid-money" going to forestry will decrease. Recent studies from *e.g.* the World Bank show that there is little relation between assistance and growth. The reason is that assistance has often been given on political grounds. It is also shown that it is difficult to direct funds to a special area (fungibility). If an area is popular among donors the countries can reduce their own funding of this area. If the Government is committed to *e.g.* forestry many economists argue that one can as well give budgetary support. Is it possible and meaningful to try to direct support to forestry? When is it meaningful? What can be done at the sector-level? Problems in the developing countries are often discussed in connection with assistance. The report will take up some of the most important points. There are, however, a lot of problems within the aid-administration itself. What can be done to rectify this? What can be done to change donor behaviour? What can be done to improve delivery mechanisms? One point to analyse is "prerequsites for failure" and "prerequisites for success". Old-timers know a number of things that *e.g.* do not work. But the lessons learnt are not used. Why do we not learn from experience? Decisions taken about "aid" is as said very political. What can be done to better use the knowledge we after all have? Influence politicians? Other points to discuss are objectives of forestry and assistance to forestry. Is it it conservation, alleviation of poverty, "development" or what? It is also necessary to discuss where there are disagreements between different donor-groups. The report will also analyse situations where assistance to forestry seems too difficult to succeed.

One conclusion is most likely that assistance must go from quantity to quality. What can be done to improve quality? Is more support needed to build capacity? Should more resources be invested in planning (e.g.National Forestry Programmes)? Is research one field where more assistance ought to be given? The report aims to summarize the lessons learnt so far and if possible identify measures to improve the present situation in different types of countries. PS. During the last 15 years I have written a number of articles in Swedish where I have summarized the experiences I (and Sida) have gained of assistance to forestry during the last 30 years. in 1998 Sida published an English summary ("From forestry to land husbandry"). This report has arouse a lot of interest. There is evidently a need to discuss these issues at a greater depth than done so far. CIFOR has therefore initiated a research project to learn more about these questions. in late 1999 CIFOR will arrange a meeting to discuss experiences of aid to forestry and ways to improve it. As a background to the meeting a report will be written discussing some of the main issues.

The report proposed to be written for the World Congress 2000 will give a state of the art of the knowledge gained at the time of final writing.

The interaction of change in environment and society: analyzed through some cases in Central America

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The approach of this proposed presentation will be one of environmental sociology: the interaction between (the changes in) society and its bio-physical environment. The first part of the presentation will contain some basic ideas about the societal and environmental changes which have occurred, in the last decades. Some issues are presented which need to be addressed. in the second part these ideas and issues will be illustrated with case studies in Central America. Some guidelines for environmental and social policy will be distilled from the social process and practices analyzed.

General ideas and developments:

Environmental issues are rather new in society and science. 'Environment' and 'Conservation' became global issues, when awareness grew that the natural environment puts its limits to the treadmill of accelerated economic development, and that the future of mankind depends on the proper treatment and maintenance of the natural environment and its resources.

Public awareness rises when a latent problem becomes manifest and its negative effects visible .When material and social problems become manifest and widespread, there, usually, occurs a gradual change of societal values and norms. Ideas of what is worthwhile to aspire at, and what is socially good and bad behavior, are being reshaped.

With changing conceptions, the means and ends of policies also change: What was, initially, stimulated by incentives, at the present is discouraged by fines. Two examples illustrate this rather radical change of ends and means:

Until recently, fiscal and legal incentives in Costa Rica stimulated the conversion of primary forests into pastures and crop land, as forests were seen as a hindrance to development. Currently, the end and trend are opposite: maintaining the woods and reconverting part of the pastures and agriculture land into secondary forests by abolishing former subsidies to live stock production and subsidizing the use of land for forestry.

In the Netherlands the strong promotion of agricultural and livestock intensification, after the second World War, gave way to a policy of enhancing a more ecological way of production, as the negative ecological side effects of the former policy became more manifest: pollution of soil, groundwater, air, acid rain and so on. Now farmers are obliged to take preventive measures (internalizing the externalities) and are sanctioned if they don't comply. On the other hand farmers receive a subsidy if they allow part of their land become fallow.

However, this is not at all a linear process. It implies tensions and insecurity, inherent to a situation of conceptual and social transition. It leads to different types of social reactions and the pace of readjustment to the new situation, is also differential.

In general terms it is crucial to build a strong social base for policies geared at sustainable paths of development, and to find ways and means to reconcile different interests and points of view in society. This has several dimensions:

One crucial aspect is how to bring the interests and behavior of individuals or individual groups in line with the interests of the society at large. This is partly, a matter of internalizing new ideas and values in the conscience through environmental education by parents, school. and others. Nevertheless, the effects of this approach are limited if they are not accompanied by measures directed at economic interests such as internalizing externalities by sanctioning bad environmental behavior and remunerating good one by paying for environmental services.

Another central dimension is how to combine the struggle against poverty with the struggle for conservation and gain the poor as allies for purposes of conservation. The poor will be indifferent, if not hostile, to conservation, if their actual and vital needs are not attended. On the contrary, when their welfare needs are met and they get a stake in conservation for their subsistence and progress, their attitudes and conduct change, and they may become strong supporters of environmental policy, as can be inferred from different concrete cases.

This all has to do with a third basic question: Equity. For measures to be widely accepted, their costs and benefits must be equitatively shared: between groups in society, countries, and generations. It is not equitative and ethical to burden the next generations with the costs of irresponsible, unsustainable economic behavior. But it is not just either to neglect actual social needs of poor groups for the sake of conservation and needs of future generations. It is not effective either. On the other hand, groups and countries which contribute most to national and global environmental problems, should contribute more to their solution and prevention, especially if they are in a better economic position to do so. This is a very weak spot in environmental policy. Their is a general awareness, that environmental problems are global issues which require measures of a global coverage, but their is much less unity about how to share the bill, as illustrated by the problems to put into practice Agenda 21. Some cases to work out and validate aforementioned ideas:

A first case will be the analysis of environmental and social process in the Biosfera Maya in Peten, Guatemala. The original situation can be typified as follows:

Peten has a reputation of a land of nobody. Forests used to be converted into pasture and agricultural land by large and small colonists. (Although Peten was the heart of the Maya civilization, at the present native communities hardly exist in the region any more). Through the so-called agarradas colonists grasp parcels of forests and convert them into agricultural land and pasture. To stop this ongoing process of deforestation, ten years ago the northern part of Peten, still abundant in forests, was declared Biosfera Maya and Area of Conservation. Part of this was for absolute protection, another part was designated for multiple and sustainable use.

The heart of the question is: how to put into practice a policy of conservation in a context characterized by the pressure for land, the illegal exploitation of wood, an individualistic, short term economic behavior and weak social and public institutions; how to build a social basis for the new policy to make it effective; and how to bring about a new relationship between people and environment, in this particular context.

CONAP, the agency in charge of the administration of the Biosfera Maya, initially applied a conservationist biased and control based policy. Families and communities of colonists, inhabiting the same area. try to get a living out of a socio-fisical environment. new to them. Coming from the highland or coastal lowlands, theyïve got an agricultural background and outlook, although adopting some gathering practices of the original inhabitants, as to forest products like chicle, pimiento, xate. Their vision of future.is usually rather short and their knowledge of their new environment limited. The new environmental policy was seen as repressive in state of supporting. The goals of two central actors were divergent. There was originally no common ground to (inter)act upon in a fruitful way. CONAP had a long term perspective, but lacked a social basis and a clear strategy to realize its objectives, while the population had no stake in measures of conservation. So the policy was not effective and even counterproductive.

Nevertheless situations are not static nor are social process linear. New actors and views enter into the social scene. Through its projects in I&D: OLAFO and CATIE-CONAP CATIE started to promote security of tenancy and usufruct of forestry resources as a necessary means to get communities interested in their proper use and management. The legal and institutional framework was readjusted. A new legal institution was created: Concession Forestal Comunitaria. It was adopted and promoted by CONAP, as the most effective way to protect forests, giving the people who live in them, a direct stake in its conservation. The growing interest by the local population reflects itself in the growing quantity of concessions recognized and requested (over 10 in 1998). On the other hand development agencies give orientation and assistance in legal, technical, organizational and economic aspects. It is an incipient process and not yet sufficient in scope and mass to overcome the phenomena (outlined in the foregoing) which traditionally, characterize the region. Nevertheless some first promising effects can already be noticed:

Poverty alleviation provides to be an excellent incentive to get poor people to become conservation minded. People can become excellent guardians of the forests, when they protect their own present and future well being with the maintenance of the forests. Their livelihood becomes more varied and secure. Outlook and behavior change, when given a stake in the conservation of the forests, by entitlement of their use. Their vision broadens and enlarges. People start exploiting their resources having in mind present and future needs. Protecting the forests against fire, illegal cutting and 'agarradas' becomes an intrinsic part of the value orientation and social organization of the communities. New human and social capital is built as well as local institutions for regulating the use and management of resources, with incentives and sanctions, socially accepted, internalized and controlled. A critical mass and social basis is being formed, slowly but surely, essential for implementing policy goals.

In a second case the attention will be focussed on the changes which have occurred in a community of colonists in a land reform program, and within a buffer zone of the Tortuguero National Park in the north east of Costa Rica. in order to earn a reasonable living from their new land, the peasants had to adjust themselves to the limitations and opportunities of their new biophysical environment. in the process a serie of cognitive and organizational changes have occurred as to the way people valorize and manage their resources. Through experimentation and with assistance of Neotropico, a local NGO, peasant families encountered an optimal way of combining their resources and agronomic practices. Forest resources have been integrated in the peasant economy. The people have become environmental minded because it suits their economic and social interests. The case illustrates and analyses how a social group may start interact in a new and fruitful way with its environment and, in the process, changes its vision of space and time.

Some guidelines for policy and action will be abstracted from those process of change and the cases of good practice. Those are highlighted, as there is a need to show ways and means to reach a renewed, fruitful and sustainable relation between society and environment. People being the cause of most environmental problems, must find also ways and means to tackle them in an effective way. Conscience of the scope and complexity of the problems and process of natural degradation, must be accompanied by efforts to find proper answers.

Knowing forest, knowing people, knowing change

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Historically, one of the challenges in forestry is to holistically integrate the disciplinary expectations, methodologies, and conclusions of the social and natural sciences. Where forestry sciences are directed towards policy-making, there is the added problem of satisfying the needs of the "consumers": governing bodies, conservation authorities, multilateral institutions, and the like. While we can say that genuine progress has been made, especially since UNCED '92, it is also true that the divide has been growing. This is evident in studies of local knowledge. in the drive to meet the demands of both academia and policy, research directions have become increasingly fragmented. On one end of the spectrum is a vast array of highly technical reports (many not even released for public scrutiny) that are grounded in empirical findings of locally specific conditions and problems, but impossible to draw comparative conclusions from. On the other are abstract critiques and analyses that may be illuminating and programmatic but lack practical recommendations for on-the-ground action. in my own research among Malaysian hunter-gatherers, the Batek, another problem comes up: the ideological divide between people who have to live with environmental destruction and those who control it. in the Malaysian popular imagination, there is a great deal of mystification about the "environmental wisdom" and mystical understanding that forest peoples supposedly have: the sort of environmental perception that anthropologists would classify as knowledge of a highly practical and scientific cast. For the broader world, however, this knowledge is merely primitive exotica that apparently can cure everything from marital discord and impotence to cancer and muscle fatigue. Given the power of such mystifications, policy recommendations that might seem logical and natural from the point of view of the forest peoples might be viewed as utopian and idealistic by those in charge. Further, local knowledge, in this instance, is not the objective, isolable body of technical practices that we can "learn from" and transport easily elsewhere. This last is, I suggest, premised strongly on the equally entrenched belief that local peoples and local knowledges do not change without outside intervention; after all, only static ideas can be placed in storage liquid and implanted into other static situations. If we take the contrasting view, that local ideas and local environments have been changing more rapidly than research and policy directions, then the question is: at what level do we find a basis for comparison and developing a multidisciplinary science of resource management? Drawing from the Malaysian context, this paper will review and examine some of these ideological and practical problems and suggest research directions.

6.11.01 Forest Resources and Human Welfare in Developing Countries

An investigation on the forest worker's health in Turkey

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Forest areas in Turkey are generally located on the mountainously region. Therefore, forest labour is affected by the shape and conditions of the field. Forest workers in Turkey generally work during the spring, summer and autumn. Most of the forest workers are tentative and seasonal forest workers and rest of them are permanent workers. Approximately, there are 30 thousand forest workers in Turkey. These workers have task on logging, cutting, skidding and transport the logs.

The demand to the forest labour has been getting decrease because of forest workers' health problem, unsatisfied payment, high risks of getting injured and their hard working conditions. These unwanted conditions are affected negatively forest workers productivity. The % 99 of the forest areas in Turkey are managed by government and the most of the workers are male. in this study, the general forest workmanship in Turkey, especially the production and fire workmen's positions are exhibited. Furthermore the health problems investigated that are seen in these works. This study have done over workers who work at Directorate of Yusufeli, Serik and Iskenderun Forest Enterprise.

The workers are chose randomly and the questionnaire forms which are prepared before filled by the conversation one to one with workers. First of all, the workers are classified into groups according to their ages; 15-30, 30-45 and older than 45. So that to obtain the integrity of questionnaire and asking the questions belong to same topic, the general topics are determined. This general topics are worker's social economic position, health position and the effects causing health problems. The result of questionnaire evaluated by statistical methods. For this the simple statistical methods are used. For evaluated at least 30 worker are referenced. When the findings evaluated generally the production and fire workers are consisted of males. When this two kind of group compared the blood pressure of fire workers are more normal then the production workers. The diseases having ache-pain can be seen at production workers more then fire workers but these diseases changes according to climate properties. Generally the production workers have more backaches according to fire workers but fire workers have more arm and leg aches than the production workers. When the worker's habits observed, it is seen that two group have a high percent of habit of smoke and alcohol. According to evaluation, the forestry workmanship that is done in Turkey is doing as a obligation of economic results, it is not an optimal branches. The work conditions have very negative conditions according to be uneconomic and sociologic way. From the standpoint of health evaluation results, in the forestry workmanship, the diseases having ache-pain diseases such as nervousness, fatigue and insomnia, the other diseases; bronchitis-flue, eczema, itching can be counted. in this point, heavy work, lack of feedings and clothing and other negative work conditions performs. According to this, the rules below must be applicated to improve the forest workmanship in Turkey; to organize periodically health services for workers and mobile health crew, work organization, work place discipline, worker psychology, and education of workers, these topics must be improved.

Keywords: Forest Workers, Health, Steep Terrain, Eastern Blacksea Region, Turkey

Land allocation programs in Vietnam: from a view point of the H'mong peoples in northwestern mountainous region

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1. Background

Under the "DoiMoi" policy or economical renovation policy, the Vietnamese government has been driving forward the land allocation programs since 1993. The rights to use the national land are granted to individuals, cooperatives, armies, national enterprises and private companies, etc. The forestland is further divided into three categories: "special use forests" such as national parks, "conservation forests" where watershed management, etc. are applied, and "production forests" for the purpose of produce timber and non-timber forest products (NTFPs).

2. Objectives

1) to clarify the gaps and conflicts between the land category of the governmental program and traditional land category perceived by the people.

2) to consider the impact of the program to the livelihood of the people

3. Method of field survey

Four hamlets were selected as research sites in SonLa province where the ratio of forest coverage is the lowest (9%) in Vietnam. Main ethnic Group in the hamlets is the H'mong. We interviewed some leaders of each hamlet and thirteen households. Furthermore we listed NTFPs which were utilized by the people.

4. Customary land and forest utilization by the H'mong

The people have been making their livelihood by practicing swidden agriculture with ox plows of which main crops were upland rice and maize. They classify the fallow land into three based on a succession stage: "Pa Lau" or the grass land 1-2 years after harvest, "Pa HayCau" or Bush 3-4 years after harvest, and "Pa Dong" or secondary forest more than 5years after harvest.

The forests were prohibited from cutting tree customary. The forests were categorized into three: "Rung Ma" or cemetery forest, "Rung Tuoi" or old forest, "Rung SuoiNuoc" or water catchment forest.

Our survey showed that they collected around 60 species of NFTPs not only on the natural forest but also on the fallow, etc.

5. Gaps between the governmental programs and actual condition of land/forest utilization

Under the governmental programs, the land for swidden agriculture is divided into agricultural land and unused land that is prohibited from cultivating. The problem is that most of the fallow lands are classified as unused land and the people are forbidden to cultivate the fallow land. The gap is generated from the difference in the perception of agricultural land between the government and the H'mong The H'mong regard the fallow land covered with grass, bush, and forest as swidden land or farm land: the government does not regard them as farmland.

6. Conclusion

It is obvious that the area of the arable land for the people is reduced, fallow period is shortened, food production decreases, and the welfare of the people is lowered. Even though the program will have an effect on increasing the forest coverage area, it seems to be necessary to revise it in terms of the livelihood of the local people.

Forest resources and human welfare in Himalaya: the contribution of commercial medicinal plants

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Keywords: Rural livelihoods; income generation; non-timber forest products; trade; Nepal

Recent studies indicate that the annual trade in medicinal plants from the Himalaya amounts to thousands of tonnes of roots, rhizomes, tubers, fruits, leaves, etc. The annual value of the trade is worth millions of USD. The medicinal plants are collected by rural households in forests and other vegetation types throughout the Himalaya; hundreds of species are harvested and sold to traders in order to increase household incomes. The paper briefly introduces forest resources in Nepal Himalaya and how they contribute to improved human welfare in rural communities. The main aim of the paper is to document the economic importance of commercial medicinal plants to rural households in Nepal. In each of Nepal's five development regions, three districts were chosen for data collection; in each region one district was chosen in each of the three main physiographic zones (Terai, Middle Hills, and High Mountains). Thus, field work was conducted in 15 districts; a total of 636 collectors were interviewed in 92 groups. Results detail the number of households involved in commercial collection; estimate contribution of collection to household economies; and analyses collector net margins compared to wholesale prices in the main markets in India. Discussion focuses on identification of realistic interventions that may increase rural collectors' income from medicinal plant collection.

Russian and Chinese Forest Economies in Transition: A Comparative Analysis

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Keywords: economic reforms, privatization, forestry, economic development, China, Russia

Transition of a great number of countries from central planning of economic development to a more reasonable combination of planning and market economy is no doubt the most prominent phenomena in the world economy at the edge of the third millennium. The success or fault of this movement will likely be crucial factor for the future performance and development of the world economy society and environment.

Russia and China are the most prominent instances of the countries in transition. They count altogether for 21% of the total land area, 24% of the population, 26% of the forest land and 25% of the forest inventory. Meanwhile the share of both countries in the world gross product does not exceed 4%.

Forest sector issues are not to be treated separately from the rest of the economy. During the 1950s with the technical help from the former Soviet Union took on the Soviet model of economic organization in the forest sector, which is proved to be inefficient since the 1970s. China started economic reforms in forest sector earlier and advanced further than Russia. Several reasons cause China chose gradual transition rather than a radical changes. Russia used the "shock therapy" despite the desperate attempts of the former authorities to take smother economic curse.

The average annual production growth of 10% in China during the recent decade made up a steady growth of roundwood output and forestation. Forestry development also has greatly helped the economic growth, particularly the rural areas where the economy greatly depends in forests. Non-timber production and ecotourism have become important parts of forestry sector. For the same time Russia lost 2/3 of the pre-reform level of roundwood yield. China started successful decentralization and privatization of the collective-owned and state-owned forests. Russia by so far has no experience in this respect. in general economic reforms in China were more successful, advanced and less painful than that in Russia. But major political change in China seem still to be ahead. Environmental regulations are as well lag behind the economic growth. That became evident in 1998 during the disastrous floods of Changjiang river caused suffering to 200 million population.

The experience of China and Russia cannot be entirely compatible due to the discrepancies in the socioeconomic and resource conditions of the two countries. One third of the Chinese forest area is represented by plantations, whereas natural forest absolutely dominate in Russian landscape. Nevertheless the comparison of the two countries clusters transformation yields few major conclusions.

1) It is argued that there is no sustainable forestry without adequate privatization. Fair competition between contractors is the crucial condition of fair pricing the forest resources. When private parcels are intermixed with public forest tracts as in Scandinavia the price references could be easily taken from the private sector.

2) Analysis of Russia and Chinese experiences may be not sufficient to tell whether the gradual transformation in more preferable than shock therapy. Straight parallels are barely reliable due to the difference in historic development and contemporary situation. But the experience learned is very deductive for the other countries in transition.

3) Political stabilization seems to be a crucial factor for the economic growth.

Russia and China are both facing similar problems of poor economic performance especially in the public sector, unfair revenue distribution, environmental pollution, poverty and widespread corruption. Impartial analysis of the reforms in the Russian and Chinese forest clusters is to help to cope with the problems which are still far behind the final resolution.

The Contribution of Cassiavera (*Cinnamomum burmanii*) in Improving the Environment Quality and Society Welfare in Indonesia

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Indonesia is the greatest country in contributing Cassiavera (*Cinnamomum burmanii*) in the world. The export of this commodity is about 40,000 ton/year.

In a district in West Sumatera, Cassiavera contributing 41.66 % of the total income, and decreasing the soil erosion from 26.46 ton/has/year in an open area to be 14.25 ton/ha/year under Cassiavera stands. Cultivation is mostly as community forest.

Alternated Rows Harvesting can improve the role of Cassiavera as a conservation plant in a critical land.

6.11.01 Poverty and management of forest resources

Pauvreté et gestion des ressources renouvelables dans les pays en developpement: les liaisons dangereuses?

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La pauvreté est un phénomène social total, à la fois économique social et culturel. Pour un individu, ou un groupe social il se traduit par la dépossession de son présent, de son futur, de son identité, voire de soi-même, c'est à dire par une exclusion. La pauvreté frappe sous des formes diverses le plus grand nombre des pays en développement et est considérée comme la cause majeure de dégradation de l'ensemble des ressources renouvelables de la planète au premier rang desquelles figurent les ressources forestières.

La pauvreté qui se combine généralement à diverses formes d'insécurité, conduit à une mobilité des hommes et à l'accès libre de fait aux ressources renouvelables. Dans les pays en développement les ressources renouvelables et en particulier les forêts sont un des principaux moyens de survie des pauvres. Ceux-ci sont contraints à une pluriactivité continue: tout ce qui peut se vendre se collecte. Le lien entre pauvreté, insécurité alimentaire et exploitation des ressources renouvelables apparaît tellement fort que les organisations internationales considèrent la commercialisation des produits de cueillette comme un indicateur fiable des situations de disette alimentaire voire de famine. L'exploitation des ressources renouvelables échoit le plus souvent aux femmes et aux enfants et constituent pour ces catégories de la population une tâche harassante et très mal rémunérée.

La mondialisation de l'économie et le développement rapide des droits de propriété sur la diversité biologique, seront-ils des facteurs supplémentaires d'extension et d'approfondissement de la pauvreté, ou au contraire, seront-ils mis en place au niveau international de façon à constituer un moyen efficace d'éradiquer la pauvreté rurale dans les pays en développement? La même question se pose à propos des droits d'émission et de stockage du carbone définis après la conférence de Kyoto.

La transformation des modes de gestion des ressources naturelles et en particulier des forêts peut-elle être un moyen efficace d'aider les pauvres des pays en développement à sortir de leur misère ? Par le passé les politiques forestières d'exclusion des populations rurales de la gestion locale de leurs ressources forestières a constitué indéniablement un facteur d'extension de la pauvreté. Divers exemples montrent que la gestion locale contractuelle des ressources renouvelables constitue à la fois :

• une porte d'entrée efficace vers le développement local,

• un moyen de limiter, voire d'inverser, les dégradations des ressources renouvelables résultant de la pauvreté,

• un moyen de sécurisation et de sortie de l'exclusion pour les pauvres des pays en développement.

Fuelwood dependency

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In rural areas of Nepal most of the rural population have traditionally depended on forest resources to fulfil their basic energy needs for domestic purposes. As a case study the Shivapuri Watershed and Wildlife Reserve (SWWR) was selected to examine the nature of dependence on protected forest resources. People living in and around the SWWR were legally excluded from their traditional access to the forest after the area was declared a reserve in 1984. in spite of a two meter high stone boundary wall and active forest guards patrolling the reserve boundary the people living in the buffer zone surrounding SWWR continue to risk fines and imprisonment to enter the reserve to collect forest products to meet their basic needs.

This study was undertaken to determine the degree of dependency on forest resources inside the SWWR for fuelwood collection and consumption by the surrounding villagers and assess the factors affecting the dependency. The research was confined to two sample villages of the Baluwa and Nayapati Village Development Committees of the Kathmandu district in the southern buffer zone area of the SWWR (Fig. 1&2).

Systematic sampling was applied to select the sample households within the villages. Topographic maps, aerial photographs and knowledge of local people were used to pinpoint the selected households. An open questionnaire method followed by informal discussion was used to determine the number of energy consuming activities for domestic purposes. The amount of fuelwood consumed for each cooking activity was determined by user estimation and validated by direct measurement. Pieces of fuelwood from each household's woodpile were randomly selected to determine the origin of the fuelwood which was subsequently validated during field visits with local people and forestry staff.

The results show that about 40% of the fuelwood collected in the study area for domestic energy requirements comes from the SWWR with the rest coming from private woodlots (58%) and government forests (2%) (Fig. 3). There was no significant relationship between daily per capita fuelwood consumption and distance of households from the forest (Fig. 4). The socio-economic condition of the people and their ethnicity however, were found to be important factors determining the level of dependency on the reserve forest.

In the study area two main social classes were identified: the elite and the poor, divided along caste lines. The Brahmin and Chhetri castes comprise the elite group while the latter is comprised of Magar, Tamang and Newar castes. The more well off group has in general a higher social and economic status, more private land holdings, higher education and smaller family size. These socio-economic factors are reflected in the dependency level on the reserve forest with the elite collecting less than 30% of their fuelwood from the SWWR and the poor collecting over 70% of their fuelwood from the SWWR (Fig. 5). A further analysis of the proportion of fuelwood collected from the reserve forest for each social group revealed a distinct difference in the nature of the dependence between the two groups with the poor having a markedly higher level of dependence on the reserve forest than the elite group (Fig. 6). Although Figure 5 shows a decreasing trend in dependence for both groups as distance to the reserve increases neither trend was statistically significant. The most important factor determining dependency of households on reserve forest in the SWWR buffer zone is the socio-economic condition of the people, not horizontal distance to the forest.

The socio-economic values of sustainable mangrove forest management: the Matang Mangroves in Malaysia

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The socio-economic value generated from a forest is an important factor deciding its sustainable management. This is precisely the case of the Matang Mangrove Forest Reserve (MMFR), covering 40,151 ha in Malaysia. For about a hundred years, the commercial socio-economic activities (i.e. forestry and fishery) taking place within the MMFR ecosystem have sustained the utilisation of mangroves in its natural environment. The utilisation of the MMFR resources includes development of human settlements, timber harvesting, fishery activities, development of aquaculture and eco-tourism.

The sustainable management of Mangrove resources has resulted in the development of about 27 permanent coastal settlements. The MMFR ecosystem provides the resources, which meet the needs of local communities within the mangrove area as well as settlements on the landward side of the mainland. Mangrove ecosystem sustains two types of settlements, varying in size from a few hundred to a few thousand residents near MMFR. The sustainable management of the MMFR since 1902 has brought about local development, which supports local livelihood. Villagers in its vicinity are involved in fishing, forestry and other related activities. Local communities depend on the mangrove resources in meeting their daily subsistence needs. The mangrove resources also meet subsistence needs (food and medicine) and generate cash income for local population. It has been estimated that the MMFR meets the subsistence needs of 8,000 individuals comprising mangrove workers, their spouses and children.

The mangrove forest produces timber sustainably and is recognised as important spawning, nursery and habitat areas for many economically important species of finfish and prawns. The mangrove water ways and mud banks are suitable for aquaculture development. in monetary terms, the timber products (charcoal, poles, firewood) are expected to generate an annual income of about RM22 million for the 1990-1999 period. The values of non-timber products were RM84 million (marine fish, prawn and shellfish in 1994), RM17 million (cockle culture in 1995) and RM1.3 million (finfish cage culture in 1992). in terms of employment, the timber harvesting/processing industry creates employment for between 1,008 and 1,680 local people. There were about 2,039 fishermen living near mangrove areas in 1994. Mangrove harvesting/processing generated an average monthly income of between RM776 and RM964 per worker in 1997. On the other hand, a fisherman earned between RM934 and RM2,700 a month in 1997.

The role of research and development (R & D) has contributed much to the successful sustainable management of the MMFR. The R & D activities began in Matang since its preservation as early as 1906 and it plays an important role in the drawing up of working plans, which are revised until the present day. These working plans lay the strong foundation in outlining the various management aspects of sustainable management: management objectives, classification of forest type by function, best management option, the rotation, allocation of coupes, silviculture system, silviculture operations, silviculture improvement, reforestation efforts, control of operations, monitoring and supervision. To further enhance R & D activities, research and sample plots were set up to test and develop best practices in the management and silviculture of the MMFR.

The implication from the successful sustainable utilisation of the MMFR is that it is essential to highlight the socio-economic benefits of a mangrove ecosystem. Enhancing R & D efforts in these aspects would contribute much to the sustainable development of the mangroves. It is seeing beyond the timber value that the overall mangrove ecosystem could be sustainably utilised and managed.

Sustainable Management of Community Based Forests through Credit in India

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Collaboration between villagers and Government in community based resource management specially forests, started in India in the beginning of twentieth century, but the present type of Joint Forest Management (JFM) grew out of experiences at Arabari in West Bengal and Sukhomajri in Haryana in the 1970s. The National Forest Policy of 1988, the Government of India guidelines of June 1990 and the State Government's orders on JFM are all positive steps to benefit the forest communities in particular and rural people in general. It has been estimated by Forest Survey of India, that there are 34 million ha degraded forest lands. At present, there are 35,000 Forest Protection Committees (FPCs) in India who are protecting and managing seven million ha. forests under JFM. If we assume that only one million ha land is protected under JFM the annual fund requirement would be Rs.15,000 million based on a cost estimate of Rs.15,000/- per ha (1 US $ = Rs.43/- - February, 1999). Budgetary allocation for Forestry Sector is less than 1% and there is no likelihood of increase in future. It is, therefore, necessary to involve institutional credit to sustain JFM movement for sustainable management of India's forests. It may be mentioned that NABARD/Banks are funding forestry projects implemented by Forest Development Corporations. However, so far, no JFM project has been funded by any financial institution in India.

A study undertaken by NABARD in andhra Pradesh indicated that it might not be difficult to channelise bank credit to FPCs. Certain institutional arrangements are necessary including Government guarantee and legislation. Studies further indicated that there are three types of JFM activities that may be bankable, viz. Sal (*Shorea robusta*), Teak (*Tectona grandis*) and Bamboo species. It has been estimated that with an investment of Rs.15,000/- per ha, a return of Rs. 1,20,000/- is possible by sale of poles and other Non Timber Forest Products (NTFPs) in 8-10 years. The major expenditure for protection and management of forests under JFM is for payment of wages to the watchers. Bank loan with interest can be repaid within 8-10 years leaving a surplus that can be reinvested and or shared by FPCs. The intermediate yield of grass within 6 months of protection will also be available for sharing among FPC members.

JFM is a complex system involving ecological, economic, social institutional and political aspects. Hence, financial package for JFM projects is different than traditional Forestry projects. Thus, the working out of modalities of financing JFM projects is essential. For this, research on the incentives, cost and benefits for local communities, collecting data from several sites under a variety of ecological and social conditions and the biological relationships and production function of timber, NTFPs and other products are necessary. The economic sustainability and institutional implication of JFM approach need also to be studied. The effort by NABARD might be able to formulate few models for financing JFM projects in near future. The aspirations of the rural people have been raised too high by adopting JFM in all the states. Failure to channelise fund to the system would not only degrade the forests further but would also create social unrest, hence, require serious attention both from Government and the financing institutions. We are sure that in near future, banks would be in a position to fund JFM projects for their Sustainable Management through Credit.

Dependence of Local People on Protected Forests

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The Government of Tanzania is intensifying efforts to conserve the biodiversity-rich and ecologically-sensitive East Usambara forests in Muheza District in Tanga Region. The government's current strategy is to apply regulatory forest policy instruments that do not recognise the dependence of the adjacent local communities on the protected forests as their major source of non-timber forest products (NTFPs).

This research assessed the use of NTFPs by local people living in four villages - Bamba, Churwa, Mhinduro and Segoma - that surround a block of three protected forests in the East Usambaras - the Bamba, Segoma and Kwamgumi Forest Reserves.

A participatory data collection approach using mainly rapid rural appraisal techniques, such as semi-structured interviews, was applied to elicit information on NTFP utilisation and other socio-economic factors. A global positioning system was used to locate NTFP collection sites in the protected forests. Subsequently these spatial data were processed using a GIS to produce maps showing the NTFP collection sites.

The results of this study indicate that, despite government efforts to protect and conserve natural forests in East Usambara through regulatory instruments, local people still enter the forest illegally and extract forest products; the primary reason being to extract NTFPs for their livelihood needs and for cultural services. Evidence of local people's use of NTFPs and their dependence on the protected forests as sources, is clear from the fact that they can identify a total of 378 species or types of NTFPs classifiable into seven purposes -: as medicines, foods, construction materials, fuelwood, water, seasonal agricultural indicators, and worshipping sites. More than 54% of the identified species are obtained only from the protected forests, which implies a high level of people's dependence on them. The relationships between villagers and the protected forests are found to be dependent on whether there are alternative sources of NTFPs, and/or whether there are substitute products which are accessible to and affordable by the villagers.

Local people respond to the current restrictive management approach by opting for secretive access and NTFP collection measures, and one result is an over-utilised 'ring' on the periphery of the protected forests.

The attitudes of local people towards the protected forests as sources of NTFPs are generally positive, indicating the importance of the forests to them. However, their attitudes towards the forest guards as managers of the protected forests are generally strongly negative, and accompanied by conflict indicators, such as 24 court cases (1993-1997) concerning NTFP use.

The findings lead this study to recommend to the government to revise the Forest Ordinance, especially Part V Section 15, that gives directives on the protection of forests and forest produce. For the government's forest management approach to be effective at an operational level, a collaborative management approach is recommended that would involve local people in planning implementation, control and monitoring activities in forests adjacent to them, which would bring benefits to both local stakeholders and the government. It is the dependence by forest-adjacent communities on protected forests as sources of NTFPs which gives the opportunities for collaborative management strategies that should lead towards more successful conservation.

Further studies are recommended on the assessment of forest capacity to supply various NTFPs at a sustained level and on the need to determine and set NTFP extraction levels. Future studies should monitor the sustainability of any utilisation levels set for the villages and forests.

The Impact of Industrial Plantation Forest Establishment on Socio-Economic Condition of Local People

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The demand for industrial wood in Indonesia in the year 2000 is projected to be 80 million m^3 per year. As the current annual increment of production forest is estimated to be only 30 million m^3, Government of Indonesia is trying to develop a major expansion of industrial plantation forest. The target is to establish 6.2 million Ha of plantation forest.

The establishment of plantation forest in a particular area would directly or indirectly involve and influence local people living in and around it. It is expected that positive impacts would be accepted by those people, hence some benefits from the establishment of the plantations would be gainned by the people. The reality however is not always so, since benefits received by the people depend on how far they are allowed to involve in plantations forest establishment. Whereas the degree of involvement of those people in the plantation depends on the awareness of the company of the importance of involving local people in the activities and how much the company is willing to devote some of their benefits and transfer it to local people surrounding it.

In Indonesia, there are two different forms of industrial plantation forest which is expected would possibly increase the opportunity of the people to participate in forest plantation forest activities i.e inter cropping-Industrial Plantation Forest model and Transmigration-Industrial Plantation Forest model. By participating in the plantation, local people get a chance not only working as labour but also an opportunity to grow food crops in between trees. A study in two forest concession (HPH PT. Yayang and HPH PT. Hutan Kintap) in South Kalimantan province found that the establishment of plantation forest increased people's income by 17,5 % and 19 % respectively. Those activities also give a chance to the people to get some other incentives such as extension, provision of infrastructure and social facilities in their village. Subsequently in PT. Inhutani V (State Forest Enterprise) allowing farmers to grow rice, corn and other food coops under rubber plantation for three years could increase their income by almost double. The production of rice in the area is even relatively high, on the average could reach 3.5 tones of unhulled dry rice.

The objective of this paper is to give an overview about the impacts of plantation forest establishment on socio-economic condition of local people surrounding it in some areas of Indonesia. The information presented here has been gathered from several research studies and literature.

Extraction of Non-timber Forest Products and the Tribal Economy - A study in south India

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Man and forest have been having a close relationship from time immemorial. With the growth of civilization and with the develop0ment of agriculture and industry, man's dependence on forest has decreased. Yet, there are certain societies who have been living in forests for ages and who invariably continue to depend on forests. The non-timber forest products (NTFP) have been the main stay of forest tribals, sustaining their livelihood. in the recent past, medicinal and industrial demand for NTFP have created the value-in-exchange for NTFP, which were hitherto had only value-in use to the tribals. With increasing restrictions on timber harvest, NTFP constitute a large share of the value of forest products extracted. Lately, the NTFP have been contributing a great deal to the productive employment and household income of tribals. This is more so the case in respect of tribals residing in the interior forests. The special feature of NTFP collection by the tribals is that it facilitates the participation of all the members of the household irrespective of sex and age unlike other economic avocations available to them. in fact, NTFP collection is the only source of employment to the aged and children. This paper is based on a study conducted in the bio-diversity rich western ghat forest area of southern India. Apart from being a major contributor to the non-cash income of tribal households, the NTFP collection accounts for nearly half the cash income of the household. While some non-timber forest products are collected exclusively for home consumption, some other products as for the market only. The rest of the products are, however, collected both domestic use and for the market. This gives a clear indication that inspite of commercialisation of NTFP, they continue to dominate the household consumption basket of the tribal households. The men members of the tribal household collect a large share of a majority of NTFP than women. However, the employment contribution of women to the NTFP collection and processing is more than that of the men in a household. Being the forest dwellers for ages, the tribals are supposed to have property rights (though not explicit) over the NTFP. However, the State assigns the monopoly rights of NTFP extraction for major NTFP to registered forest contractors on tender basis. Thus, in reality, the tribals extract

NTFP for which the contractor offers a price, in lieu of wage. The NTFP collectors are to `sell' the notified NTFP to the authorized contractor alone. The monopoly rights assigned to the forest contractor thus come ion the way of the tribals getting a reasonable price for the NTFP extracted by them. Many a times, the daily earnings from NTFP extraction would be far lower than the wages the tribal receives from hiring out his labour to the Forest department.

6.11.04 Bridging the gap between monetary and non-monetary valuation of environmental amenities

Spatial analysis in economic evaluation of landscape management

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Keywords: GIS; forest management planning; spatial analysis; economic evaluation; multiple use

The roundwood sales decisions of non-industrial private forest (NIPF) owners produce more than 80% of the roundwood supply, as well as creating potential landscape and biodiversity losses in Finland. Sustainable forestry has been essential, and regeneration has been required by the forest law for nearly 100 years. However, the new legislation protecting biodiversity, and the quality and certification requirements have restricted the owner's freedom to manage his/her property. This has raised concerns among forest owners that their income will suffer through greater regulatory intervention under the new laws, silvicultural recommendations, and other restrictions.

Traditionally, Finnish forest management planning (FMP) and practices have sought to attain (i) sustainable wood production that would assure the availability of raw wood for industry. Where possible, (ii) increasing the volume of growing stock was a secondary goal. Nowadays, the emphasis in FMP is being placed not only on timber production but also on landscape, recreation, and biodiversity. The institutional framework includes the new forest and nature conservation laws, silvicultural recommendations, quality requirements and certification according to PEFC (Pan-European Forest Certification) or the FSC (Forest Stewardship Council). However, from the individual forest owner's point of view, maintaining biological diversity poses a dilemma. While it may add recreational value to the area, it may also mean a loss of income to the owner.

The purpose of this research is to describe an approach which incorporates the economic impact on the NIPF owner caused by these requirements of the FMP system, and to create a method and a program supported by a geographical information system (GIS) to implement this. The method is based on the combination of a GIS and an FMP system that generates several treatment schedules for compartments and selects optimal schedule combinations using linear programming.

The GIS is used to impose silvicultural treatment restrictions on the compartments and to create management zones (MZ) (= a group of compartments). The MZ is based on the production potential of the area, the preferences of the forest owner, the preferences of the local people and the requirements set by society. The GIS is also used to collect and formulate preferences so that the planning problem can be solved in the FMP system. Finally, the GIS program is used in the analysis of the alternative forest management plans.

Trade-Offs between Recreation Benefits in the Preferences for Managing Recreation Areas

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Keywords: recreation, biodiversity, public preferences, choice experiment method

Preferences of a group of visitors for recreation environment may be incompatible. Some visitors favor natural state of forests with low level of management intensity, while some prefer easily passable forest environment for recreation. Also a single visitor may have contradictory preferences, on one hand wishing for easily passable even-aged stands, on the other hand asking for conservation of biodiversity. The heterogeneity of the public's preferences for forest environment, and their confusion about the concepts and relations of different benefits complicate management planning. in order to evaluate public preferences for forest management of recreation areas, the benefits of recreation experience can be divided into attributes that reflect the public notion of what constitutes the recreation environment. The study area of Nuuksio lake plain with five municipal recreation areas and a national park can be viewed as a system of spatial units whose manager faces an option of choosing varying levels of intensity in their management.

This study examines the preferences of the general public for management of recreation areas. It approaches the problem by focusing on the interrelations and trade-offs between forest benefits, namely biodiversity, the cost of management and scenery, as stated by the preferences of visitors in municipal recreation forests. in this method, monetary values are given by the trade-offs between the cost of management and other attributes. For example, changes in scenery are being valued by the elasticity of foregone biodiversity richness.

The study applied the choice experiment method that is consistent with random utility theory as well as offers a wide range of information on benefit trade-offs. The multinomial logit model is used to analyse multi-attribute choices. A Hicksian welfare measure is estimated from discrete choice data following a theory developed for discrete choice models. Observing the choices made and connecting the different attribute levels to monetary changes enables derivation of welfare measures.

The survey is administered in a questionnaire format on-site at the study areas. The questionnaire contains the choice experiment, attitude and background questions. A special focus is on revealing the respondent's attitudes towards biodiversity conservation and forest management. Respondents are grouped according to their attitudes using factor analysis and those groups will be used as explanatory variables. Respondents are instructed to choose the best management regime from each choice set of three alternatives. Each alternative is presented using a map of the five recreation areas and the Nuuksio National Park. The alternatives present different combinations of management options in the five areas. The different sceneries are illustrated using pictures of forest featuring two age groups. Each alternative regime is also given a biodiversity level and the associated cost of management.

Methods and Defects of Value Assessment of Forest Environmental Resources in China

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Keywords: sustainable forestry, forest valuation

The common goal of society is to implement sustainable development so that both a sustainable economy and environment is achieved. Sustainable forestry is an important part of achieving this goal. This research points out that sustainable forestry will be the dominant theme in forestry development around the world. Research on the value of forest environmental resources is both necessary and important for forest environmental management in China. Forest ecology projects have important implications for public welfare, especially to the extent that such projects insure the sustainability of forest benefits.

There are evident theoretic defects or limitations in the existing methods of environmental economics, which are based on traditional economics. We applied these approaches in valuing forest resources in China. The paper describes the main methods of forest environmental resource valuation, including forest value classification and the main assessment methods. It then analyzes three conceptual and theoretic defects of those methods and two mis-uses in the application of those methods, including the mis-use of static and dynamic measures, and the mis-use of substitution of benefit measures for function measures. Finally, the paper discusses three questions: (1) what kind of research and and policy development would be useful in integrating forest environmental resources, which are never considered as scarce resources, into modern social and economic systems? (2) Should environmental resources accounting be complementary to SNA and MPS, or a principal part? (3) Have the the limitations of environmental economics research method retarded the development of environmental economics itself, as well as limited the application and extension of research achievements in social and economic development?

Based on the discussion of the questions mentioned above, the paper points out that research on the methods and defects of forest environmental economy will be helpful for developing an improved theoretical framework for valuation of forest environmental resources in China, and also provide useful information for developing policies to insure the sustainable management of these resources The purpose of research in this field is is to provide theory and methods that can be used to develop a modern Chinese forestry for the 21st century.

Non-Monetary Valuation of Non-Market Environmental Goods and Services

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Keywords: non-monetary valuation, environmental psychology, market research

The nature of many environmental goods and services is such that market prices fail to measure their value. The results of economic analyses of policy decisions that involve such goods will therefore be incomplete and biased without monetary valuation of the non-market components. The state-of-the-art of monetary valuation is imperfect and controversial, however, and effective application of available methods is often too expensive or infeasible. and, even if valid and complete, monetary economic analysis does not represent the full spectrum of human values associated with environmental goods and services. Complementary non-monetary valuation methods can contribute important and useful information to policy decision analyses, both to correct biases in economic analysis caused by incomplete monetary valuation and to represent those values that lie outside the domain of monetary economics. in this paper we identify the alternative methods available, discuss and compare their relative merits and applications, and explore the research frontiers of non-monetary valuation. The alternative approaches include (1) environmental psychology and psychometric measurement, (2) social survey research, (3) market research methods, (4) structured small-group decision procedures, (5) derived valuation based on scientific analysis of human dependence on things removed from direct human consumption, and (6) techniques for direct public involvement in the policy decision process. The paper integrates these various approaches into a comprehensive framework for non-monetary non-market valuation.

Measurement of attitudes and beliefs in contingent valuation as a preference construction tool in the case of forest quality

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Keywords: contingent valuation, forest regeneration cuttings, beliefs

In a contingent valuation (CV) study a sample of people is asked about their willingness-to-pay (WTP) for non-market goods or services in order to measure environmental benefits or costs in monetary terms. in a CV study respondents are expected to state their preferences concerning the good to be valued. The assumptions concerning the completeness of preferences and the rationality of decision makers have been criticized in the valuation literature. Several reasons for inconsistency and incompleteness of preferences have been discussed, such as respondents having conflicting values, uncertainty about his or her own values, or the complexity of the choice situation. For example, it has been suggested that protest responses and "don't know"-responses reflect respondents' frustration with a situation where a demanding choice must be made, but no tools are provided to help make the choice. in this study, attitude and belief measurement is offered to the survey respondent as a tool to form preferences about forest quality.

The attitude-behavior framework can be seen as a series of hypotheses, linking behavior to behavioral intentions, and secondly, linking behavioral intention to attitude, which is a function of salient beliefs about the attitude-object. Each salient belief links the object to an attribute or to an outcome of the behavior in question. The attitude is determined by the strength of these beliefs and evaluations associated with the attributes concerning behavior. in a WTP question, the behavior under consideration is whether to support a proposed policy that provides an environmental good, given a specified expense. in contingent valuation studies, the attitude-behavior framework has been used as a model that explains behavior. However, the multi-attribute structure of the model is very close to multi-attribute utility theoretical aids of decision making. By expressing their beliefs and attitudes concerning the attitude object, respondents also construct their preferences about the choice setting.

The valuation of non-market benefits of forests provides an excellent case to test the effect of attitude and belief measurement. The data come from a contingent valuation survey in a case of forest regeneration cuttings in Finland. A mail survey sample of about one thousand respondents chose between two forest regeneration practice alternatives: a) status quo management or b) environmentally oriented forest regeneration. Alternative (b) included an expense for the respondent's household. Half of the respondents went through belief and attitude questions regarding both alternatives, while the other half did not participate in the belief or attitude measurement. in this paper we test the effect of this preference construction tool on the item response rate of the WTP question and on the WTP itself. The WTP was estimated using a logit model of dichotomous choice. in addition, two different treatments of decision complexity were formed by varying the number of attributes in the alternatives. The perceived decision confidence of respondents was also measured and compared between the treatments.

Preference construction treatment decreased the number of responses. This was the case especially when the alternatives in choice setting had only some attributes. The treatment had some effect on dichotomous choice. When the choice setting was simple, the treatment increased the number of supporters of the environmentally oriented cutting. Also, in the logit model of dichotomous choice, belief questions increased the probability of choosing an environmental alternative. Including preference construction treatment in the model improved the performance of the model somewhat significantly. Belief and attitude questions decreased the perceived decision confidence, especially when the education level of the respondent was low. It seems evident that responding to belief questions about the good reminds respondents of the dimensions of the choice which they otherwise would not have considered. in this way the choice becomes more complicated and the respondent perceives uncertainty. On the other hand, this raises the question of the response quality in dichotomus choice in general. Should the CV-questionnaire guarantee that respondents deliberate all dimensions of the choice equally? Furthermore, how should we deal with the group of respondents who are more confused after screening dimensions?

Evaluating the Impact of Farm Woodlands on the Landscape: a Case of Blending Perspectives

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Several disciplines bring their own perspectives on valuation to aesthetics. Landscape architects enunciate descriptive principles for design and arrangement of landscape elements. Planners quantify the relative merit of landscapes seen holistically. Perceptual psychologists analyse individuals' responses to landscapes. Economists do not consider landscape as fundamentally different from other public goods, so incline to value it by their willingness to pay criterion. Using this, they may seek to displace the contributions of other disciplines: hedonic pricing attempts directly to place a cash value on landscape elements; contingent valuation of a given landscape change condenses citizen preferences with consumer purchasing decisions; but both methods suffer disabling weaknesses. It is more constructive to integrate the insights of other disciplines than to compete with them. By such a combined process a farm woodlands programme in Wales has been evaluated. Hypothetical planting schemes were designed for representative landscapes, using received design principles. A single assessor evaluated, subjectively, impact on landscape quality, judgements being calibrated by reference to a larger assessor group. Landscape change was given a monetary scale via recorded differential willingness to pay for travel to Welsh landscapes of different quality. The resulting value of aesthetic gain was similar to the expected cost of the programme.

6.11.07 Social Dimensions of Forest Protection (Africa, Europe, North America)

Collaborative Forest Fire Management Strategies in Ghana

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Fire is currently the most important cause of deforestation and forest degradation in Ghana. The severe drought and fires which occurred in 1983 and 1987 exacerbated by indiscriminate logging in some of the affected reserves have resulted in the conversion of forests from generally aggrading ecosystems to systems of progressive degradation. During the past 15 years, wildfires in Ghana have resulted in an annual loss of approximately 3% of Gross Domestic Product (GDP) during the past 15 years through destruction of forests, agricultural lands and property. in 1993, the total area of forest reserves in the high forest zone affected by fire was estimated at 0.917 million hectares, more than half the total area of reserved forest.

Wildfires in Ghana are mainly anthropogenic in origin. The major human activities that can lead to uncontrolled fires include, charcoal burning, palm-wine tapping, slash and burn system of farmland preparation and hunting. in order to prevent further environmental degradation resulting from wildfires, the Government of Ghana initiated a collaborative forest fire management (CFFM) programme aimed at mobilising local community support for wildfire prevention, detection communication and control.

The CFFM approach recognises that successful wildlife prevention and control programmes need to be developed and implemented in partnership with local communities. The CFFM system aims to improve management of natural resources and increase the flow of benefits from forest lands to the local land-owning community as an incentive for increased participation in forest and wildfire management.

The paper describes the key elements of the evolving CFFM strategy including the use of a learning process approach to guide the overall development of the programme and various field activities including consultation, needs assessment, investigation and consensus building. The progress made up to date in the implementation of CFFM strategies including the establishment of green fire breaks are outlined. The paper concludes with a comparative assessment of the classical wildfire management approach, involving the Forest and Fire Service Organisations, and the collaborative approach involving forest users including local communities.

An Economic Analysis of Residential Nonconsumptive Wildlife Recreation Expenditures in the United States

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This study utilized cross-sectional data obtained from the 1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation to analyze individual's annual expenditures of nonconsumptive wildlife recreation in the United States. Residential nonconsumptive wildlife recreation is defined as a person who participates in a recreation activity less than one mile from home with the specific intent of observing, photographing, and feeding wildlife.

In the process of selecting an appropriate model most consistent with consumer behavior associated with nonconsumptive wildlife recreation, the tobit model and the double hurdle model for the residential expenditure model were evaluated. Based on the likelihood ratio test result, the double hurdle model fit the data much better than the tobit model.

The empirical results from the residential expenditure model indicated that income, age, gender, education, wildlife category (such as birds, mammals, and insects), visiting public parks or natural areas, maintaining natural areas for fish or wildlife, and planting around home for fish or wildlife had a significant effect on residential nonconsumptive wildlife recreation expenditures.

An individual's annual expenditures were predicted to increase $0.00006938 for every $1.00 of income growth, increase $0.3029 when participants are middle-age individuals, increase $2.6054 when participants are male, increase $2.6649 with increases in educational status, increase $11.3563 when observing birds, increase $4.6485 when observing mammals, increase $4.0757 when observing insects, increase $7.8431 when participants visit public parks or natural areas, increase $5.8571 when participants maintain natural areas for fish or wildlife, and increase $6.6430 when participants plant around home for fish or wildlife.

The results in this study provide insight into determinants of residential nonconsumptive wildlife recreation expenditures which can be used for planning and decision making purposes for nonconsumptive wildlife management. This study also provides guidance in the choice of empirical model for use in this type of expenditure analysis. Together, these results provide a rigorous analysis

Improving Forest Management Practices in Quebec (Canada) Through a Social Learning Process

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To develop a truly sustainable approach to decision making in forest management, a model is needed to facilitate collaborative decision-making between different parties with widely varying objectives. The task is to transform the dialogue between stakeholders into a collective learning process that will permit the forest manager to find new solutions to current problems; solutions to which forest users hold the key. The goal of this research project was to create a social learning process 1) between stakeholders and forest managers in which the stakeholders informed the forest decision makers about ways to improve forest management and 2) between stakeholders and researchers in which the stakeholders expressed their needs to the researchers.

A mechanism of social learning was developed for the management of 400 000 hectares area held by the corporation Cartons Saint-Laurent, in Quebec, Canada. An initial round table involved representatives of the following organizations: Native people, regional counties, town council, wildlife management associations, hunting and fishing associations, Ministries of Natural Resources Wildlife, and Environment ministries, forest contractors, local business associations, country cottage owners, and snowmobile association. A second round table involved researchers from three universities conducting research projects in forestry, sociology, economics, geography, and biology. Two project managers serves as the link between these two round tables. The stakeholders and their areas of expertise were identified and these are being used to determine the issues for the Cartons Saint-Laurent forest management area. All stakeholders shared their knowledge in order to develop new alternatives that may improve forest management.

To date, this social learning experience has showed that new interactions between the stakeholders resulted in the development of new information networks. Moreover, the identification of areas of expertise and skills of stakeholders helped to develop a practical partnership where everyone had something to contribute to improve forest management practices. For example, involving the researchers helped to direct their projects towards stakeholders' needs and concerns, and involving the wildlife stakeholders helped to increase the forest manager's knowledge on this issue.

However, the success of our experience depended primarily on a preliminary stage in which the process was carefully planned and designed with the involvement of all stakeholders. This preliminary stage helped us to develop several mechanisms of social learning to suit the different parties involved. For example, Native people and snowmobilers did not have the same concerns and thus did not wish to be involved the same way.

The imputability of interested parties involved in the process, the proliferation of public participation initiatives in a same region, and property rights were issues raised during the process that still have to be addressed. Nevertheless, this approach of public participation could be used by forest managers wishing to initiate a certification process for a given territory.

Institutional Impediments to Conservation and Management of Forested Dispersal Zones Adjoining Protected Areas: Some East Africa Examples

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The multiple uses of forests means that forest management is often constrained by a variety of factors. The traditional timber-oriented forest management was relatively simple in that the goal was to maximize timber production by manipulating the forest system in favour of selected commercially important species. Recent shifts in forest resource conservation and management paradigms embracing participatory and whole-system approaches present rather complex and difficult forest management scenarios. Nowhere is this complexity more real than in Sub-Saharan Africa where a broad spectrum of colonial and post-colonial land and resource tenure regimes exist and where rapid social change threatens to destroy communal forest resource ownership systems.

Participatory natural resource management present challenges within the scientific and social domain: scientific in that technical solutions are needed to deal with the forest ecosystem based management, and social in that we need to define relevant management entities and formulate supporting policy and legislation. in East Africa as in other parts of the world, forest management problems seem to revolve around the increasing human-resource interactions in or close to protected area systems. Whilst the delimiting of protected areas (e.g., National Forest Reserves and Parks) in most African countries in 1940-50s, following European and North American models achieved some reasonable natural resource conservation goals, continual conservation of these resources is no longer possible without the support of surrounding local populations. This derives from an historical alienation of local populations from resources and perpetual inequitable distribution of benefits from these areas. Equally central, are weak institutional mechanisms in place to address management issues. The sectoral nature of regulatory government agencies (e.g., one agency responsible for forest and another for wildlife resources) means that different policies and laws often apply even when ecological requirements would demand otherwise.

Given the socio-economic conditions of communities adjacent to forest-protected areas, conservation solutions must seek to maximize the mix of economic benefits derived these sites. This will involve a landscape-level ecological characterization and site specific analyses of rural livelihoods towards land/resource-use zoning. Effective involvement of local communities entails a clear understanding of what constitutes 'a community' and existing local structures within the broader context of resource conservation and rural development partners. A pragmatic approach to creation of local community institutions is demonstrated using examples drawn from the Maasai Mara National Game Reserves and the Tsavo-Amboseli ecosystems in southwestern Kenya.

Keywords: Protected areas, dispersal zones, resource continuum, adjoining communities

Community based bioprospecting of *Mondia whytei* indigenous plant as income generating activity in Western region of Kenya

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Bioprospecting for non-timber-forest-products (NTFP) by involving the rural communities has been seen as alternative in salvaging deteriorating environment, alleviating poverty and enhancing economies of most countries (1) NTFPs are a source of phytomedicines, social and spiritual fulfilment to most rural communities and urban dwellers in the world (2) A study carried on ethnobotanical survey of medicinal plants and trade potentials of NTFPs established that they play an important role in Kenya's economy generating about US$ 40 million annually (3) About 70% NTFPs in Kenya's are from natural ecosystems and not on farms. Most of them are of plant origin, few derived from animals. These NTFPs are used as constituent of main products. The constrains of NTFPs bioprospecting in Kenya are: no date on status of NTFPs scarcity of scientific information like bioactive ingredients, forest clearing and unsuitable exploitation has reduced biodiversity, production and marketing not clearly established, no direct link to rural income. A community based research carried out by Kenya forestry research institute to alleviate poverty and conserve the environment through bioprospe3cting of a locally valued plant species *Mondia whytei* has been a success. (4). The communities are domesticating this species through agro-forestry systems and their income base has broadened. Bioprospecting of this plant species is a good example of how benefit can be return to communities, custodians of biodiversity and how it can be an incentive to environment conservation.

6.11.07 Social Dimensions of Forest Protection (Asia)

Indigenous Technologies for Sustainable Resource Management in Indian Cold Deserts

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The Indian Cold Deserts located in North Western Himalayan Region, covering 74,809 m^2 area, pose a greater development challenge due to rugged terrains, isolation, inhospitable climate and lack of communication facilities. These areas are ecologically varied and biologically diverse, unique systems. These are further characterised by subzero winter temperature (-40°C to 20 °C) annual precipitation less than 30 cm. Shrubs and perennial herbs form the dominant vegetation. A variety of biotic, abiotic, ecophysiologic and socio-poltical factors restrict the economic growth of the region. There are inadequate sources of livelihood with agro-pastoralisum forming the main source of the income. Farming is traditionally practised without any marketing facilities.

Institutions related to economic development are either missing ore are too weak. Nomadic grazing is practised for meeting the requirement of wool and milk. Poor communication network is further leading to isolation. Collection of medicinal herbs is also practised for meeting the cash requirements. There is over exploitation of certain herbaceous flora by the pharmaceutical agencies. Natural vegetation is mostly herbaceous *Thymus, Medicago, Trifolium, Anemone, Potentila, Epilobium, Verbena, Alluim, Aconitum, Delphenium, Aquilegia, Primula, Geranium, Polygonum* and *Cannabis* are the dominant herbal species. Common shrub species are *Hippophae, Myricaria, Ephedra, Artemesia, Rosa, Astragalus, Caraga* and *Salix*. in addition manmade forests are found along the river banks rivulets, and nallahas comprising mostly of poplars, willows, *Hippolhae spp.* and *Myricaria spp*. Excessive harvesting of natural and plantation trees for energy requirements during freezing winters is a common scenario. Inspite of harsh living conditions, inhabitants of Cold Deserts have sustained them over a period of time. They have rich knowledge concerning their environment and natural resources, including crops and livestock. This traditional knowledge is acquired through generational experience and is flexible to the needs of the natives. The sustainability of village ecosystems is ensured through indigenous resource management. The identification of these traditional technologies are packaged through intervention into physical, socio-cultural, environmental and different components of soil, water, crop, livestock and other resource endowments of the community. The documentation of indigenous techologies will help in conservation of rich traditional knowledge, hitherto practised, but now the most threatened due to cultural mixing and opening up of communication systems. It will also give an insight to know more critically the scientific bases for superstitions which are being followed by people for sustainable management of resources and improving crop and animal productivity. It also opens the scope for scientific explanations are not available till date. The paper includes the detailed account of indigenous technologies with particular reference to the age old knowledge on the use of herbs for the treatment of human and cattle ailments. The judicial use of local flora for pharmaceutical purposes can also form the basis for commercial enterprenurship.

The Development of Community Forest in Improving the Environmental Qualitay and Society Welfare in Indonesia

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In Indonesia, Community Forest Policy is described in the Basic Forestry Act No.5 of l967. in order to develop Community Forest, the government has carried out various ways.

In the Year 1995, the Community Forest in a district in Central Jawa contributed 29,76 % of the total income, and decreased soil erosion.

Some important aspects needed to encourage more farmers to involve in Community Forest activity are the establishment of forest farmer groups, Cooperation of forest farmer groups for wood marketing, and partnership between farmers and the owner of the wood industry.

Sociocultural and political aspects of biodiversity conservation: Implications for Sustainable Forest Management in a Tropical Timber Production Forests in the Philippines

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The study was conducted to provide relevant social data for the formulation of a socially relevant, equitable and acceptable Sustainable Forest Management and Biodiversity Conservation Plan of the Surigao Development Corporation (SUDECOR) area in Surigao del Sur, Philippines and to address the concerns with respect to the rights of indigenous peoples and tenured migrants in the area. The sociocultural part was specifically aimed at identifying the actors/stakeholders in forest resources management, and at determining how people and communities regarded and used forest resources, how they viewed forest biodiversity and biodiversity conservation and how they perceived SUDECOR. The political analysis on the other hand sought to assess the political environment of forest production and biodiversity conservation in the Project area. Specifically it was aimed at analyzing the effectiveness, influence and importance of various organizations from the communities viewpoint; gender division of labor and decision-making; the ethnic and class relations and the relation between SUDECOR and indigenous communities in the concession area. Data were gathered mainly through focus group discussions (FGD) and interviews with selected groups and key individual informants (KI) conducted in the SUDECOR timber concession area and surrounding communities. Based on the results of the study nine (9) socio-economic and political strategies for sustaininable forest management were proposed, namely: 1) mutual respect for their rights and recognition of corresponding responsibilities by both the SUDECOR and the affected indigenous cultural communities; 2) creation and establishment of a field level consultative body as a mechanism for participation among affected stakeholders; 3) provision of stable livelihood communities; 4) protection and conservation of floral and faunal species which are endangered and useful for the communities depending on the resource; 5) assessment of indigenous resource conservation practices and integration of relevant ones in the sustainable management plan; 6) institutionalization of benefit sharing scheme for community participation in sustainable forest management; 7) formulation and implementation of an information, education and communication (IEC) program supportive of the project; 8) provision of other extension services; and 9) creation of an IEC and/or community relations office within SUDECOR.

The Increase of Community Participation in Forest Management through Development of Social Forestry Program in Indonesia

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In the last few years there is a tendency of a change towards new forest management system in which people's participation becomes the focus of attention. This concept has several different names such as community forest based management, collaborative forest management, joint Forest Management and Social Forestry. Three main principles are applied in this new forest management system i.e 1) Local people need to be involved in forest management activities; 2) Local people have legal rights and obligations to participate in forest management activities; 3) There is a need to actively involve local people in deciding activities developed to guarantee forest management system which is economically feasible, socially adaptable and ecologically sound.

To anticipate those tendency, Government of Indonesia (GOI) c.q Ministry of Forestry and Estate (MOFE) has developed several programs with the main purpose to rationalize and empower the life of local people living near and around the forest area and to increase active participation of the people in forest management activities. There are various forms of Social Forestry program in Indonesia i.e. PMDH forest (Village Development Program), Community Forestry, Mixed Farming Timber Estate, Transmigration Timber Estate, Small scale Private Forest, etc.

The research on community participation in forest management through social forestry program establishment was conducted to learn how could the program increase and facilitate community participation and describe how far and in what activities local people could participate in forest management activities in some area of Indonesia. Some case studies presented in the paper focus on what the local people receive and how they react offer establishment of those programs. The information presented here has been gathered from several research studies and literature.

The results showed that from time to time there are dynamics in Social Forestry program development. Begin from the first time when the program was introduced, it showed there is a change of intention where professional foresters who mostly in the past think they know more and have the right more over forest resources start to change their mind. Now they realize that local people have also the right to be involved in forest management activities. Furthermore, active participation of the people in forest management activities has also an important role in determining the success of sustainable forest management. Top-down approach as the only method applied in program establishment now is gradually left. The new introduced method, PRA (Participatory Rural Appraisal) start to be used widely in designing alternative activities in Social Forestry program. The degree of community participation depend on the concessionaires (as executor); the GOI c.q MOFE (as supervisor and evaluator) and the local community themselves.

6.12.03 Sustainable land use as precondition for sustainable forestry

Sustainable Land Use and Sustainable Forestry

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The Rio Conference 1992 declared "sustainable development" as one of its central concepts and deemed it as a guideline for all future activities. The model of sustainable development represents a concept which seeks to reconcile people's social and economic needs with the long-term conservation of natural living conditions. This does not mean that protection of the environment should be subordinate to economic and social factors; instead, it should be an integral component of development. in fact, in chapter 9 of AGENDA 21, the signatory states pledged to manage natural and environmental commodities in a sustainable manner so that they could be utilized now and in the future. A comprehensive form of sustainable trade should also mean that, among other things, any types of ecologically damaging and resource-wasting land use are to be avoided. in order to reach the objective of sustainable land use, the "implementation of policies and programs that will discourage inappropriate and polluting land-use practices and promote sustainable utilization of terrestrial and marine resources" (AGENDA 21, section 9.21 b) should be initiated. From our point of view there seemed to be no doubt that at a long run sustainable forestry is feasable only in the frame of the sustainability of the overall land use. From the authors point of view there seemed to be no doubt that in the long run sustainable foresty is only feasable in the frame of sustainability of the overall land use. Orientated on the Driving Forces-State-Response Model of the OECD (Organization of Economic Co-Operation and Development) criteria and indicators for the assessment of sustainability of land use have been developed and are presented in the paper. Additionally, orientating on some of the criteria discussed and agreed to at the Third Ministerial Conference on the Protection of Forests in Europe in Lisbon (1998) indicators for the assessment of sustainablity of land use in forestry as a small step of the realisation of sustainable forest management has been developed. For verification of the selected criteria and indicators, the "Naturpark Südlicher Schwarzwald" (Nature Park Southern Black Forest), established in February 1999, has been chosen. The parc area of around 300.000 hectares represents all existing conflicts between the different land users as there are agriculture, forestry, tourism & recreation, trade, industrial & private housing settlements as well as nature conservation. C&I are supposed to enable and rationalise political decisions concerning land use in general and forestry in particular with regard to sustainability.

New Challenges for the Forest Sector to Contribute to Rural Development in Europe

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Rural areas across Europe are facing more rapid emigration than ever before. Due to the diminishing prospects for financially feasible agriculture, and the lack of supplementing sources of income, rural areas are characterised by high unemployment, narrow occupational base and poor job creation. The vicious circle of rural underdevelopment is feeding itself - low work opportunities result in increasing emigration, decreased tax revenues, which in turn, decrease investments to infrastructure. The result is a loss of attractiveness of rural regions for human resources.

The main challenge for the forest sector in supporting rural development is to find counter-measures to break the vicious circle. Rural areas of Europe are becoming more and more just sources of timber with no processing industries. Higher and especially more innovative utilisation of existing wood and non-wood forest resources would contribute to rural development by increasing employment opportunities, and raise the economic benefits obtained from the forests.

The challenges of the forest sector in contributing to the vitality of rural areas in Europe have been extensively examined by the authors. This paper presents the major findings of the potentials and practices in utilising local forest resources for high value added production, and discusses how forest-based income and employment could be increased.

Among the main findings regarding the prevailing situation is that the correlation between forest resources and employment is very weak. Employment per unit of processed wood is highest in those countries, which feature a higher concentration of population and closeness to markets, which attracts more refined stages of processing industries. The main consumers of forest products are situated in the large urban agglomerations, whereas the main producers and exporters are in regions and countries with an overall rural structure. It is therefore obvious, that strategies aimed at increasing the potential for the forest sector cannot concentrate on regional consumption alone, but that the main task lies in connecting rural producers and urban consumers. Today's development of communication infrastructure and transportation logistics provide useful tools also for the forest sector for linking up rural and urban areas. One such example is the on-line marketing of forest products and services.

Ownership fragmentation and absentee ownership are an increasing problem in mobilising forest resource for income and employment, since in many rural areas average forest plot areas are well below any economic significance for the owner. To tackle this problem, various forms of co-operative forest management activities have been developed, which provide labour for those who remain in the regions, as well as income for the forest owners who do not live at or near their land anymore.

At the processing side, much of the hope is put especially on small and medium-scale (SM) mechanical wood industries. The reasons for the optimism are obvious. The required investments are often rather modest, and the restrictions of economy of scale are not that substantial than in mass-scale pulp and paper industries. Businesses in SM industries may start up on mainly local and regional markets, which makes their business easy to manage. Exploration of export-opportunities has also been a successful factor for the development of many SM industries. in this respect, investments in staff qualifications have proven essential.

The development of services is also seen among the opportunities to create forest related income and employment. Tourism is usually named among the chief potentials, but other options exist as well. Examples are visible, where employment also has been created through conservation activities such as the carrying out of traditional management methods in the interest of landscape aesthetic. One of the chief problems here is the development of appropriate transactions mechanisms to direct income from these activities to rural regions rather than extra-regional actors.

Today, the forest sector employs 3.2 million people in Europe, and undoubtedly has increasing importance in rural development issues in the 3rd millennium.

Change of forest region seen from the land use

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In the last century, the total amount of forest area in Japan has remained fixed at a ratio of about 70%. However, there have been large changes in land. It is important to understand the characteristics of the forest area to have sustainable use of forest. It is also important to understand whether changes in forest areas have been caused by societal and economic developments. We attempt to explain geographical features of the forest area and changes in land use in Japan.

We obtained the data for land use and geographical information from the 2km mesh land use data provided by UNEP/GRID-Tsukuba and the 50m mesh altitude data provided by GSI (Geographical Survey Institute). The former are made from the topographical maps of three periods: circa 1900, circa 1950 and circa 1985. Land use types are classified into 31 categories, including urban agricultural, and forest uses. The 50m mesh altitude data consists of the altitude in spots of equal length and width based on 1/25000 topographical maps of GSI. First, inclination and slope azimuth were calculated at each grid location using the altitude data of the four neighboring grid locations. Thus, a database of landform information containing inclination, slope azimuth, and altitude value was constructed. Next, the average and dispersion statistics, the maximum, and the minimum altitudes and inclinations and the average and dispersion statistic of the slope azimuth of the 2-km meshes were calculated using the landform information of the 50 m meshes.

Forest area comprises 2/3 of all land in Japan in 1990, 1950, and 1985. The next largest category of land use is agriculture at about 17% of total land area. The key points of land use change between 1900 and 1985 are as follows. The total amount of forest area did not change. Land devoted to agricultural use hardly increased. Land devoted to urban use increased rapidly after World War II, whereas land devoted to other uses declined rapidly. Land use in 75% of the total area saw no change, whereas 13% was changed by 1950 and 16% by 1985. Most land use changes consist of 1) changes from forest use to other use, 2) changes from forest use to agricultural use, 3) changes from agricultural use to urban use, and 4) changes from agricultural use to forest use.

As altitude increases and inclination becomes steeper, land use tends not to change. For altitudes less than 200 m, much area is diverted from forest area, whereas from 200-400 m, much land is diverted to forest area. For inclinations less than 10%, much area is diverted from forest area, whereas for inclinations of 20-50%, much area is diverted to forest areas. The forest area has increased on land of higher altitudes and inclinations. The largest such increase is at altitudes of 300-699 m and inclinations of 30-49%. Land devoted to other use has diminished. The largest such drop is at altitudes of 100-499 m and inclinations of 20-49%. We conclude that changes of land use depend on characteristics of geography.

In forest areas, the broadleaf tree woods have decreased whereas the mixed woods have increased. in area devoted to broadleaf tree and conifer woods, the average altitude increased and the average inclination became steeper. However, for mixed woods, the average altitude decreased and the average inclination became gentler. The cause is artificial wood development since 1950. The artificial woods area became 10 millions ha.

Some Notes About Shifting Cultivation, Problem and its Alternative Solution in Indonesia. A case study in HPH PT. Hutan Kintap, South Kalimantan.

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Shifting cultivation is an example of a traditional land-use system, which is often in conflict with the management of the forest. in Indonesia, shifting cultivation has been practised in almost all of the island. in the areas where the native fertility of the soil has been high, or man/land ratio has become high due to population growth, this system has changed to more intensive land use ones.

Numerous interrelated factors like the increase of population growth, rising demand for land for commercial exploitation and immigration of landless poor and refuges from other regions are generating the deteriorated and migratory shifting cultivation spread in many regions. This often causes the degradation of natural vegetation and soil resources and other environmental problems.

These processes induce an extension of shifting cultivation to new areas and a gradual impoverishment of resources. This spiral process of land degradation and rural poverty does not only create much human suffering, but also results in the loss of natural resource, which otherwise would be used for generating development activities.

In the early 1970's, there were various attempts had been tried in Indonesia to diminish the expansion of shifting cultivation through the development of several resettlement and not resettlement programs. Two example of resettlement programs are HPH Bina Desa, now called PMDH program (Forest Village Community Development Program) and Tumpangsari program (inter cropping program). The target was 500,000 shifting cultivation hourseholds should be rationalized in every five years. in fact however, at the end of 1988, there were only 123,470 families that could be resettled, disregarding that a substantial amount of them has left.

The research on shifting cultivation and its control in South Kalimantan with a case study in HPH PT. Hutan Kintap was carried out to investigate what factors motivate the people to practise shifting cultivation and how far the programs developed in the area could improve the living condition of shifting cultivator household in terms of better socio-economic condition and the increase of self reliance of the people. The results show that there are several factors underlying the people to practise shifting cultivation, some of them are need of land for crop cultivation, limited job opportunities, lack of skill and knowledge, low wage, tradition, etc. The two programs established in the area have not satisfied its participants. As a result many participants still practise shifting cultivation and even leave the program. in order to overcome the problem some adaptation and modifications of the program should be done or otherwise a new program should be established to replace the less appropriate program developed before.

Crossing traditional boundaries: The role of social and psychological parameters in interdisciplinary landscape analysis projects

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The issues we face in contemporary natural resource planning and management are complex. The continued development and use of the resources stresses biological and social systems and raises problems that transcend traditional boundaries between disciplines. No single institution or discipline is equipped to manage or indeed is expected to have the full competence to solve the complex problems. Collaboration through integration of perspectives between the different disciplines may be the only way to successfully complete this task. It is crucial to our ability to cope with this challenge that we improve our understanding of the elements and processes involved in integration of perspectives across those boundaries. The results presented here come from two research project with similar objectives, to develop ways to integrate findings across disciplinary and organizational boundaries: The assessment phase of the North American Interior Columbia River Basin Ecosystem Management Project (primary data) and the Danish Boundaries in the Landscape (secondary data). Researchers have theorized about interdisciplinary collaboration processes but few studies look at concrete projects, such as the ones compared in this paper. Three levels of boundaries emerged from the data: Individual-based boundaries that precipitate barriers and appear to be bridged by facilitators between individuals; Group-based boundaries with related barriers and facilitators of collaboration between groups in the projects; and Organization-based boundaries that induce barriers and facilitators to collaboration between participating organizations. Comparison of the two research projects revealed a set of similar barriers to collaboration across different boundaries in the two western cultures.

6.13.00 The response of law to changing social demands on forests and the environment

Forest Legislation in Developing Countries: Emerging Trends and Persisting Dilemmas

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Recent years have witnessed a significant acceleration in the revision of forest-related laws in developing countries. Not surprisingly, the results of these law reform efforts have been extremely varied. They have taken place within the context of vastly different legal and political traditions, reflecting a wide range of economic, ecological and social variables. It is possible, nevertheless, to identify several trends that have achieved prominence in forestry laws over the last decade. Drawing upon the experience of FAO's Development Law Service, this paper will report on several inter-related clusters of issues in which a reorientation of national forest laws is evident:

- Local forest management. Increasing attention has been devoted to enhancing the legal capacity of local people to manage forests on which they depend, through the introduction of community-based management arrangements, decentralisation of forestry institutions and innovative tenurial instruments. - Private sector involvement. Efforts to stimulate private sector investment in sustainable forestry has resulted in a variety of legislative efforts to reduce the most common constraints, such as overly restrictive or cumbersome regulatory regimes and unsuitable land tenure arrangements. New approaches to contracting services and monitoring performance are finding their way into legislation.

- Environment and sustainable management. Laws increasingly focus explicitly on the environmental functions of forests, imposing new planning and inventory provisions closely tied to biodiversity and other environmental considerations, EIA and management planning.

- Accountability and law compliance. New legislative approaches have emerged to attempt to deal with several factors which have traditionally undermined the enforceability of forest laws, including corruption. Increasingly laws include a greater emphasis on transparency in government forest policy and management, better public access to information and public input into decision-making and improved penalty provisions.

- Institutional restructuring. There have been new experiments with the redesign of government forestry institutions, with the splitting of regulatory and management functions into separate bodies, and new approaches to the financing of operations.

In each of these areas, there have been important conceptual advances, and a variety of interesting legislative techniques have been crafted. At the same time, many of the recent laws show evidence of a profound ambivalence within governments about the appropriate direction and velocity of reform in the forestry sector. and indeed, efforts to create legal frameworks that reflect a balanced appreciation of the multiple dimensions of forestry have brought to the forefront legal and policy dilemmas that have vastly complicated the jobs of lawmakers.

Impacts of Environmental Legislation on Forest Management Practices in Chile

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Este país ubicado en el extremo sur de américa, reconoce durante el siglo XX que recién termina dos esfuerzos legislativos tendientes a conservar y a desarrollar nuestros recursos forestales: en 1925 con la ley de bosques, aún vigente y en 1974 con la ley de Fomento Forestal, ambas con diversas modificaciones.

La primera con un marcado carácter proteccionista y de preservación, entre otras medidas, reguló la corta de bosques nativos en áreas de protección y el uso del fuego en terrenos de aptitud preferentemente forestal y la segunda impulsó fuertemente el proceso de forestación y reguló la corta o aprovechamiento obligando a reforestar una superficie igual, a lo menos, a la cortada o explotada conforme a un plan de manejo previamente aprobado por la administración forestal.

A estos dos textos de jerarquía legal debe sumarse algunos instrumentos internacionales ratificados como "ley de la República" referidos a la protección y comercio de la flora y la fauna y sobre conservación de la diversidad biológica y una profusa regulación reglamentaria de protección de especies y áreas silvestres protegidas, legislación toda fuertemente patrimonialista, sectorial y sin una visión ecosistémica o ambiental propiamente tal.

Sólo en 1994, después de más de 20 años de la Conferencia de las Naciones Unidas sobre el Medio Ambiente Humano de 1972 y la Conferencia sobre Ambiente y Desarrollo de 1992, y la fuerte presión del comercio internacional, en Chile con el carácter de "ley marco", se aprobó la Ley sobre Bases Generales del Medio Ambiente que vino a legislar con sentido global y sistémico, incorporando la dimensión ambiental en todas las actividades del quehacer nacional, entre ellas, la actividad forestal. Esta ley recoge y desarrolla los principios de prevención, realismo y gradualidad con que el gobierno impulsó su política ambiental a partir de 1990, destinada a proteger el medio ambiente, preservar la naturaleza y a conservar el patrimonio ambiental.

La creación legal de diversos instrumentos de gestión ambiental, entre ellos, la obligación, para los proyectos de desarrollo o explotación forestales de gran magnitud, de someterse, antes de su ejecución, al Sistema de Evaluación de Impacto Ambiental, ya ha producido y producirá en el futuro como consecuencia la posibilidad de prever, predecir, identificar e interpretar anticipadamente el o los impactos ambientales que dichos proyectos o actividades forestales provocarán a los recursos ambientales asociados como comunidades humanas, suelos, aguas, aire, fauna y paisaje, permitiendo que en su etapa de diseño se identifique y se describa la o las acciones que el titular ejecutará para impedir o minimizar sus efectos significativamente adversos.

En consecuencia, el país entra al siglo XXI con la esperanza que aún es tiempo para revertir la etapa de destrucción y deterioro de nuestros recursos forestales, y ,a través de su manejo sostenible y sustentable, poder satisfacer las necesidades actuales pero asegurando al mismo tiempo la satisafacción de las necesidades de las generaciones del porvenir.

The Effect of the Federal Estate Tax on Non-industrial Forest Ecosystems in the United States.

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Anecdotal evidence indicates that the federal estate tax has a disproportionately large, adverse effect on transfers of forest land estates and contributes to the fragmentation and conversion of forest ecosystems. The Mississippi State University, College of Forest Resources, and the USDA Forest Service, Southern Research Station, are cooperating in a study to measure the magnitude of the effect of the federal estate tax on non industrial forestlands and other rural land holdings. Data for the study were collected using mailed questionnaires. Members of the American Tree Farm System, the National Woodland Owners Association, and a nationwide sample of rural landowners were surveyed. Study findings include: 1) Over one-half of nonindustrial forestland owners (53%) held assets valued above the threshold amount for the federal estate tax; 2) Over one-third of forestland estates (36%) incurred the federal estate tax (this is roughly 20 times the rate for the U.S. population in general); 3) Forestland and timber typically accounted for nearly one-half (45%) of the owner's estate; 4) Only about one in three forestland estates (32%) qualified for the "special use" valuation provisions, and only one in four (25%) elected to use them; and 5) About two-thirds of forestland owners (65%) sought the help of a financial or forestry professional to plan their estate. of the estates that owed a federal estate tax, about one-third (35%) needed to sell timber or land to pay part or all of the tax. in nearly every case where timber was sold, the sale was without regard for local market conditions or the forest management plan. in a large fraction of the cases where land was sold, the land was converted to another, more developed use. These last findings are based on small sample sizes and need to be confirmed by additional research. Nonetheless, their implications for forested ecosystems and for tax policy are clear.

Forest and Environmental Law Developments in European Countries with Economies in Transition

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Keywords: Forest Law, Environmental Law, Central Europe, Eastern Europe, European Countries with Economies in Transition

In 1998 and 1999, two International Meetings on "Experiences with new forest and environmental laws in European countries with economies in transition" were held in Ossiach, Austria, both organised by IUFRO 6.13.00, the forest law and environmental legislation subject group, and supported by the Austrian Ministry of Agriculture and Forestry. Eighteen different nations were represented in at least one of both meetings.

The most extensive part of both meetings comprised of sessions on the legal situation in European countries with economies in transition; the whole range of possible stages of development of forest law and environmental legislation as well as problems concerning implementation and administration were covered by oral presentations and discussions.

By means of the moderation method, impending problems and topics were collected, selected according to their relevance to the participants, and discussed.

Highest priority was given by the participants to
- Harmonisation of Forest and Environmental Legislation; ranging from basic conflicts between forestry and environment to necessary harmonisation processes and needs due to international commitments.
- Private Forests; rights and obligations of private owners, training and participatory management, the owners/authority relationship were discussed, in order to find suitable legal arrangements.
- Financing; comprising sources, problems and incentives.
- Protected Areas; national parks, management and financing.

Other topics of relevance were Governance and Participation (Forest Policy), Public Forest Administration and Management, Forests Functions as well as Privatization of Forests.

Papers presented during both meetings have been published as follows:

Schmithüsen, Franz; Herbst, Peter; Le Master, Dennis, Eds., 1999: Experiences with New Forest and Environmental Laws in European Countries with Economies in Transition. Proceedings of the International Symposium Jointly Organized by the IUFRO Research Group 61300 and the Austrian Federal Ministry of Agriculture and Forestry, Ossiach, June 1998. Forstwissenschaftliche Beiträge der Professur Forstpolitik und Forstökonomie der ETH Zürich, Vol. 21, 1999. 142 pp.

Schmithüsen, Franz; Iselin, Georg; Herbst, Peter, Eds, 2000: Challenges in Implementing Forest and Environmental Legislation in European Countries with Economies in Transition. Proceedings of the Second International Symposium Jointly Organized by the IUFRO Research Group 61300 and the Austrian Federal Ministry of Agriculture and Forestry, Ossiach, September 1999. Forstwissenschaftliche Beiträge der Professur Forstpolitik und Forstökonomie der ETH Zürich, Vol. 23, 2000. 111 pp.

Certification and nature conservation regulation

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Pluralism, neocorporalism, participation and integration are terms, which have significantly gained in popularity since the early Seventies. The forest industry is increasingly faced with societies demands for protection and recreation areas, demands which conflict with forest owners (commercial) interests respectivly forest owners property rights, their competence and legitimacy.

Thus the question arises, in what way is influence exerted on forestry. This will be presented using the situation in Germany as an example. When considering the legal situation, it can be observed that the legal framework regarding forestry can be considered to be quite well established. in the (immediate) future there will be no changes or no significant changes in this respect. This is also true for other parliamentary decisions in the field of forestry, since a sufficiently strong lobby of agriculture and forest interest groups is active in parliament itself as well as in parliamentary specialized committees. Thus, influence is exerted on forestry by structures outside parliament. Therefore, the following dynamic structures are being studied:
- developments regarding forests on an international level (*e.g.* conferences in Rio, Helsinki, regulations within the framework of the European Union, etc.)
- changes in the field of nature conservation law, particularly in the area of regulations
- processes on the private economic level *e.g.* with regard to certification

While most of the developments on an international level - at least in the forestry sector - do not involve any important changes for German forestry, interesting trends can be observed in the field of nature conservation regulations and on the private economic level. Nature Conservation Regulations

The example of protected areas shows that there are slow but significant shifts in competence, which effect forestry. The following reasons can be stated:

1) Legal frames are solidified by regulations which are not decided on by parliaments but rather by a forum of specialists such as ministries or other state offices, in other words they get directly submitted to

the state governments. For example in the case of a proposal made by a nature preservation authority, an intervention by agriculture or forest lobbies is less possible.

2) Specific regulations are required for each protected area. This means that only a few forest owners' rights are affected. Up to now foresters have often failed to act against these regulations collectively, resulting in there having been no real resistance against the individual regulations.

3) Forest management has a rather negative image among the population compared to people's associations with forest and wood. Accordingly, a large portion of the population is of the opinion that more forest areas should be protected. Environmental groups are considered more competent in this respect than foresters.

In this way nature preservation authorities are able to make regulations in accordance with their interests on the basis of laws decided by parliament. For example a higher degree of restrictions has already been achieved in landscape protection areas, i.e. forest management becomes more difficult in these areas.

"External determination" - a case study of certification

Environmental groups, trade unions and distributors demand a certification of forests according to the principles and criteria of Forest Stewardship Council (FSC). The impact of these groups on forestry as seen in Germany seems to be stronger than foresters have expected. The forestry, especially private forest owners fear "external determination", which would result in a public interference in their autonomy of forest management. Consequently the debate about certification was dominated by emotionally and ideologically plagued arguments and "false" information. Dated perceptions and pictures of antagonism, known from the discussion "environmental conservation versus forest management", re-emerged. in this study the interests, ideologies and opinions of key players, the differing contribution of their power, given regulations and in addition to this communication strategies of the players and their strategic behaviour within networks will be presented.

Strategies

Thus it poses the question, what possibilities exist, with which the forestry can steer or exert an influence on the momentary discussion processes - and to what extent. The interests and demands of social groups and the resulting consequences are not or only partially recognized by many representatives of the forest industry. The lack of recognition is due to foresters having been able to manage their forests with relative autonomy within the framework of the political administrative system. There has also been no recognition at which level and with which methods environmental groups are acting during a political process. Therefore in the last part of the study the question as to which strategies enable the forest industry to reach a consensus with social interest groups and the support of the public will be discussed.

Selection of Policy Tools in the Context of Multilevel Policy Networks

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Merlo and Paveri argued in a paper given during the XI World Forestry Congress that a "substantial lack of attention to, or ignorance of, forest policy tools, not to mention the policy tools mix.. ." is apparent. For example, many policy analysts seem unaware that constitutional, democratic, mixed-capitalist states are actually quite limited in what policy tools or mechanisms they can apply, even when government intervention in markets for forest goods and services is viewed as desirable. Forest policy tools can be divided into two general kinds: market facilitation tools, those that facilitate the functioning of markets, and market intervention tools, those that modify the functioning of markets. Market facilitation tools include (1) information gathering and dissemination, (2) public education, (3) technical information, and (4) research. Market intervention tools are (1) insurance programs, (2) resource protection programs (from disease epidemics, insect infestations, and fire), (3) land management planning, (4) regulation and prohibition, (5) taxation or subsidization programs, (6) land trusts for amenity, recreation, conservation, or other values, and (7) public ownership or production of goods and services. They differ substantially in their relative effectiveness, cost, social and ideological acceptance, and difficulty in administration. No single tool or combination of tools is uniquely effective in addressing public policy problems in forestry. Schmithuesen observes that "A substantial expansion of international law on the environment and (economic) development has taken place during the last twenty years," and today forest and environmental policy must "be seen within the context of multilevel policy networks." International treaties, conventions, and agreements are comparable to domestic laws regulating human behavior and activities. The agent for implementation-the nation state-is the same and will continue to be in the foreseeable future, for no supranational organization has any corresponding power. Similarly, forest policy tools are the same for implementation of international policies as for domestic policies. Hence, international treaties, conventions, and agreements will be as effective as the policy tool (or policy tools mix) selected by the signatory nation states, including its subsequent administration.

Legal Implications of Forest Certification Programs: An Overview

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Forest certification programs typically define the environmental standards that forest enterprises must meet and also establish organizational mechanisms for achieving and certifying compliance. They thus bear a striking resemblance to government regulatory programs. Yet, because of their apparently voluntary and autonomous nature, certification programs are often conceptualized as separate and distinct from law. in fact, however, that certification systems are deeply intertwined with law. First, they use legal mechanisms to organize themselves, and often cite the possibility of intensified legal regulation to attract participants. Second, they can have a significant influence on governmental policies, and on the content and implementation of legal rules.

This paper reviews the primary ways in which certification systems are likely to influence legal systems and vice versa, using North American legal systems as the primary basis of analysis. It finds, among other things, that:

1. Certification standards and implementation mechanisms have not been formally adopted by most North American legal systems.

2. Legal systems seem likely to incorporate certification standards in many informal ways, such as adoption of best management practices definitions in environmental regulatory law, tort law, and even information regulation and financial regulation.

3. Regulatory officials are likely to treat certification as an indicator of good practice in many cases, and may reduce scrutiny on certified firms. A few states have enacted statutes giving certified firms special treatment, and some judges have mandated certification as a remedy for regulatory noncompliance.

4. A number of state and local government agencies have subjected the forested lands they manage to non-governmental certification.

5. If certification programs continue to grow in importance they are likely to be subjected to regulation by national and international legal systems. Such regulation may include the substance and procedures of certification, as well the qualifications of certifiers.

6. International trade law will also have considerable influence on the development and effectiveness of certification systems.

7. Over time, certification systems may bring significant changes to the institutional mechanisms through which societies deliberate about and adopt governing policies. The debate about the legitimacy of such developments is only beginning.

Forest Related International Legal Instruments

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Keywords: International Legal Instruments; Environmental Protection; Sustainable Forest Management; Rural Development; Nature and Landscape Conservation.

The commitments of international forest-related legal instruments are initiated by national governments, which negotiate the framework of co-operation. An increasing range of world-wide, continental and regional processes involving multilateral and supranational entities form at present the international system. in part, they develop their own political and institutional dynamic; in part, they emanate from the work of UN agencies. International and supra-national treaties, conventions and agreements reflect primarily global or continental concerns. They have, however, immediate consequences for the development of rural areas, from which the problems originate and where the solutions and developments chances are to be looked for.

Empirical research on the evaluation of the impacts of existing multi-level legislative networks and on the successes and failures, which result from them, are of considerable interest. Major issues are the relevance, the implementation possibilities and the effective contributions of their various regulations to sustainable resource utilisation in a given area. Since international and supranational legal instruments rely to a large extent on implementation by national and sub-national public services, non-governmental organisations and a large number of land-users, the distribution of competencies, financial and administrative arrangements, and decision making procedures need particular attention. Acceptance and commitment of land owners, local entities, and public opinion are important research issues. The same refers to shifts of responsibilities to the private sector, to bargaining processes and to contractual arrangements.

Implications of the Federal Income Tax for Private Forest Ecosystems in the United States

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Keywords: Income Tax, Sustainable Forestry, Ecosystem Management.

Changing social demands in the United States in recent years have resulted in greater emphasis being placed on ecosystem management, environmental protection and enhanced stewardship with respect to private forest lands. These concerns are implicitly included in the move to sustainable forest management on private ownerships. The federal income tax is an important component of this changing scene. Set out in the Internal Revenue Code, this tax has been in place in the United States since 1913. Forest landowners are subject to the federal income tax as are all other citizens. Numerous sections of the Code apply specifically to forests and timber; other provisions apply in general terms. The major components of the federal income tax applicable to private forests were examined in terms of their potential and actual contributions to enhancement of sustainable management on private forest ecosystems. It was concluded that some provisions lend little to and actually discourage enhanced stewardship, but that others are making significant contributions. Recent failed attempts at legislative change are discussed. The paper concludes with further recommendations for change which would enable the federal income tax to become a more forceful policy instrument for encouraging sustainable forestry on private timberlands.

The Role of Forest Land Tax Programmes in Promoting Ecosystem Management in the United States

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In the paper we examine if and how existing U.S. preferential property tax programs for forestland are used as policy instruments to promote ecosystem management on private lands. A comprehensive summary of the objectives, structure, and effects of existing tax programs has been compiled with an examination of the manner in which these programs impede or facilitate ecosystem management. No existing program incorporates objectives of ecosystem management explicitly into their program statement, but numerous programs have incorporated, either explicitly and implicitly, program goals and management objectives that have commonly been identified as characteristics of ecosystem management. We conclude that preferential property tax programs can play a limited but important role in incorporating principles of ecosystem management on private forestlands. However, because of the inherent complexities of forestland ownerships, forest management and ecosystem management, no one policy instrument can be expected to address all of the relevant issues, objectives and conflicts. Rather, the solution is more likely to lie in an array of policy instruments that complement and interact with each other.

Research Issues Related to Environmental Restrictions and Financial Compensation Measures in Forestry

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Keywords: Environmental Legislation; Financial Compensation Measures; Comparative Laws

Forestry worldwide is confronted with a constantly rising number of laws and regulations, especially in the field or nature, land and water protection. As opposed to former times, these provisions no longer aim just for the preservation of a few particular areas, but also for comprehensive and large-scale environment protection as well as for the compensation of impacts. Consequently the possibilities to restrict the management and utilization of forests have increased as well. This development almost inevitably leads to conflicts with forestry interests, making financial compensation measures a bare necessity.

Within the framework of a research project, the questions and issues related to recent environment protection legislation and its impact on forestry in Germany will be subject to legal scrutiny and a comparative analysis of the legal situations in France, Poland and the U.S. Both, Germany and France, are subject to the jurisdiction and legislation of the European Union, yet the conditions for the conversion of European to national law differ greatly for instance with regard to the form of government and the stuctures of forest ownership. Environmental laws in the U.S. have been passed on the grounds of the Common Law System, finding trailblazing solutions for conflicts with agricultural and forest management, such as the purchase of land, the separation of priority cultivation concepts, and the strict territorial jurisdiction of state and federal authorities. Poland, as most East-European countries, is currently in a state of political, enonomic, and social transition on its way to integration into the EU. in the early 1990ies, these countries mostly adopted environmental laws modeled after the West-European fashion. Meanwhile, these laws are being revised and amended on the bases of the previous experiences.

The empirical part of the project will cover an examination of the range and performance of the laws by an analysis of precedences, literature and by expert interviews. of particular interest will be the question, whether the legal provisions on financial compensation measures serve their purpose as control mechanisms in the conflict between environment protection and forestry. For the main objective of the laws is to regulate conflicts and balance diverging social interests. Keeping this in mind, the following issues shall be discussed:

- Do the legal facts deviate from the framework of environment protection laws and why-

- Are deficits the consequence of indistinct legislation or of the wrong (or non-existent) application of the laws?

- in how far have solutions been found in general practice to reconcile environment protection and forestry that have not been provided by the law; especially financial compensation measures, such as financial incentives, compensation payments, contractual agreements?

The results of these two research phases will then lead to suggestions for the future execution of those environment protection laws which are of particular importance for forestry. They will constitute the basis of the discussion about the necessity and adequacy of the utilization of forests for national and international legal environment protection measures.

The International Discourses on Sustainable Development and Sustainable Forest Management - Their Relevance for Modernising Forest Laws

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Since the 1980's, forest management is discussed politically on a world-wide level and under the premises of "sustainability". This discourse on sustainable forest management is related to the international discourse on "sustainable development". Sustainable development is the dominating discourse on environmental politics since the report of the World Commission on Environment and Development, Our Common Future, was published in 1987. It incorporates the goals of ecological protection, economic growth, social justice, and intergenerational equity - locally and globally, immediately and in perpetuity.

One declared - but failed - aim of the UN Conference for Environment and Development in Rio de Janeiro in the year 1992 (UNCED) was to agree on a World Forest Convention. The negotiations resulted only in a vaguely formulated and non-binding Statement of Forest Principles. The principles of sustainable management, conservation and sustainable development of all types of forests was furthermore included in Chapter 11 "Combating Deforestation" of Agenda 21. Any interpretations of the overall goals and principles of sustainable development inevitably incorporates value decisions. The results of ongoing political processes are driven by the values, interests, knowledge and relative negotiation power of political actors. As no objective definition of "sustainability" can exist the task is rather to define the procedures how sustainable development is to be interpreted.

Various initiatives for elaborating criteria and indicators for sustainable forest management have been started after Rio, among others the Pan-European Process for the Protection of Forests in Europe. These criteria and indicators are biased towards quantitative economic and ecological aspects. Social and cultural aspects are mostly neglected. The same bias even can be observed in the criteria-and-indicators-list elaborated by the Amazon Co-operation Treaty. This bias of criteria-and-indicators-lists towards interests of established administrations and powerful lobbies of industries can be explained by the fact that the generating process takes place in established policy-making systems favouring already powerful groups. The instrument of criteria and indicators in itself is a technocratic tool. Besides of the production of criteria and indicators no efforts are made to change procedures or to address underlying causes of forest loss.

Traditional forest policy-making systems are usually dominated by industry-related interest groups. The challenge of ecological modernisation – which is valid for forest management just like for our society as a whole – is a restructuring of procedures and institutions. Within the discourse of sustainable forest management, for instance, participatory processes in policy-making are demanded. The modernisation of forest laws can only be called successful, if an institutional change is achieved, which balances the power of interest groups. Social and ecological goals will only be considered besides of economic goals if respective interest groups are included in the policy-making process.

Endangered Species Regulations and Timber Harvesting: The Case of Red Cockaded Woodpeckers

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This paper presents a theoretical framework and empirical evidence on the relationship between regulatory uncertainty induced by the possible invasion of an endangered species-the Red-Cockaded Woodpecker (RCW)-and timber harvesting. Timber harvesting probability and methods in a large number of mature private forests are assessed using a forest production model based on the conventional theory of capital. The empirical results indicate that landowners whose forests are close to a known RCW habitat have a high propensity to cut timber and use a clear-cut method. All these behaviors may be to achieve one apparent objective: destruction or foreclosure of potential RCW habitat quickly and before the Endangered Species Act (ESA) comes into force. This means that ESA and other regulations have given landowners perverse economic incentives and induced actions that they would otherwise not have and that are detrimental to the full recovery of endangered species. The results have implications for future reforms in environmental regulations.

6.14.00 Urban forestry

State of the art of research and knowledge on urban forestry in the USA

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Urban forestry research promises to continue to be an integral part of the growth and development of forestry in urban and urbanizing areas of the United States. The future is expected to bring increased emphasis on research in support of the care of trees and other plants, ecological restoration, and comprehensive and adaptive management across the landscape. Particular emphasis will be needed on research to guide new developments in the comprehensive health of urban vegetation; ecological restoration techniques; resource inventory and monitoring; dialogue among forest resource owners, managers, and uses; collaboration among agencies and groups; understanding of how forest configurations influence forest use and benefits; knowledge about urban forest health; and dissemination of information about urban forests and their management. It is the integration of the landscape, ecological, and tree/plant-care research that will provide for the comprehensive and adaptive management needed to sustain urban forest structure, health, and benefits over the long term.

Keywords: urban, forest, arboriculture, landscape, collaboration.

Effects of fragmentation and trampling on the vegetation of Forests in Finland

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In Finland, about 80% of urban green areas are forests with natural forest vegetation. Participation in outdoor recreation is active and urban forests are the main environment for these activities. According to the Finnish law, citizens can use forests freely for recreation.

The growth of the urban population has resulted in the fragmentation and increased recreational pressure, *e.g.* trampling in these urban forests. The small size and isolation of remaining forest patches result in decreased biodiversity. When trampling is intense and persistent, the most wear-sensitive species will die leading to the disappearance of the humus layer and risk of soil erosion.

Preliminary results about the effects of fragmentation and trampling on the understorey vegetation of urban forests are presented.

Urban forest stands of varying size (1-1600 ha) were chosen for the study in the greater Helsinki area. Within these areas, mesic spruce (*Picea abies*) dominated forest stands of the Vaccinium myrtillus type, and drier pine (*Pinus sylvestris*) dominated Vaccinium vitis-idaea type stands over 80-years-old were examined, and biotope mapped was undertaken regardless of the size or level of wear in 1999. The total number of inventoried biotopes was 52. Biotope mapping was based on the understorey vegetation. For measuring environmental variables and monitoring the effects of fragmentation and trampling, one or two circular sample plots (radius 5.64 m), were located in the biotopes, depending on the size of the biotope (0.01-3.14 ha). Sample plots were located so that the minimum distance to the edge of forest was 30 meters. Dominant height, stem volume and basal area of trees and number of stems per hectare were calculated. The percentage cover of field and ground layer vegetation was inventoried in four 1 m^2 sub-plots located in each sample plot. in addition path area per biotope area was measured and the number of residents within a 1 km and 2 km radius of each biotope were used as measures of recreation pressure.

Both site types were affected by trampling in a similar manner. With an increasing number of residents, the cover of ground vegetation decreased and the amount of unofficial paths increased. The cover of ground vegetation and dwarf shrubs was the highest when recreation pressure was the lowest. The mean total cover of ground vegetation in the areas studied was 65%. When the number of residents within 2 km radius is > 20 000, ground vegetation cover falls below the mean of 65% (R^2=0.25). Cover decreases about one percentage per 1000 persons. The size of the forest patch in relation to the number of recreationists is one of the main factors affecting species cover and composition.

Soil moisture variations and availability in tree-pits in urban Hong Kong

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Urban areas of Hong Kong are characterized by pervasively high-density and high-rise development with meagre niches left for amenity vegetation. Suitable sites for ground planting is particularly limited at roadsides where the narrow pavement and proliferation of underground utilities often preclude trees. The use of tree planters or containers provides possibilities to insert greenery in locations where above-ground space is adequate but soil volume is restricted. They can also be installed on building podiums, rooftops and indoor habitats such as building foyers and shopping malls. Hitherto few studies have been conducted on planter soils, and none has been attempted in the humid tropical cities. This research attempts to evaluate systematically the quality of planter soils in Hong Kong with special reference to their moisture status in relation to tree growth. A stratified random sampling procedure was adopted to select 12 planters in a dense built-up district, three each from four categories defined by planter geometry, for detailed assessment. With 300 cm width and 60 cm depth as division lines, they are classified as narrow shallow (NS), narrow deep (ND), wide shallow (WS) and wide deep (WD). Vertical holes were opened in each sampled planter with an auger and lined with a PVC pipe of 5.18 cm internal diameter with sealed bottom and an openable top lid. A Time Domain Reflectometry (TDR) miniature moisture probe was lowered into the access tube to monitor gravimetric soil moisture at depth intervals of 5 cm once every two weeks for one year (June 1998 to May 1999). Soil samples were collected in topsoil and subsoil layers to analyze selected physical and chemical properties. The soil mix is mainly composed of local decomposed granite amended with organic matter which is usually peat moss. Most soils have high stone contents of 30-40 per cent, high proportion of sand from 77-87 per cent, with all samples falling into the extremely coarse loamy sand textural class. Bulk density, which is closely related to porosity, has an average value of 1.72 Mg/m^3 which indicates poor structure and compaction down to an average of 33 per cent total porosity. Topsoil, despite the presence of more organic matter, tends to be more compacted and less porous than subsoil. The lack of organic matter and high sand content are unfavourable to soil structure formation and maintenance. The sand, however, could maintain a relatively high proportion of air capacity (AC) pores over 60 µm diameter which serve adequately infiltration, drainage and aeration. There is nevertheless a shortage of medium available water (AW) pore in the 0.2-60 µm diameter range.

Moisture content follows closely the rainfall regime with marked seasonal variations between the dry and the wet periods. Moisture content increases with depth in most planters. The occurrence of layering (lithologic discontinuity) in some planters retards the downward movement of moisture, resulting in water perched in the topsoil and hence less available in the subsoil. The less compacted subsoil of some planters manages to store more moisture, and this phenomenon is conspicuous in deep planters. Waterlogging sometimes occurs in the subsoil when rainfall supply is abundant in the wet season. Drain holes where present are often blocked and are ineffective in shedding excess water. The lower portion of the planters is beset by excessive water accumulation in the wet season. Shaded planters have more water and subdue temporal fluctuations, indicating the importance of moisture extraction through evapotranspiration. The implications on soil water management and planter design for urban tree planting are explored.

State-of-the-art of Research and Knowledge on Urban Forests and Trees in Europe

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More than two thirds of the total European population live in urban areas, and the number and share of urban dwellers is still growing. Thus the quality of the urban environment is becoming of increasing importance for larger groups of people. Trees and woodlands as main elements of the urban landscape play a major role in providing good urban living, working and leisure environments. As a result, the planning, design, establishment and management of urban trees and woodlands has asked for more attention. However, sustainable management and development of urban tree and forest resources have to be supported by specific research, sound expertise and education. Until now, European research and education related to urban trees and forests have been limited and fragmented, and a wide range of researchers and professionals from various disciplines have been involved, including forestry, landscape architecture, horticulture, biology, sociology, urban planning and other. This means that a better overview and more coordination of research and education at the European level may prove to be highly beneficial.

This paper is based upon a review of research and knowledge on urban forests and trees in Europe. The review has been carried out during 1999 and 2000 at the Danish Forest and Landscape Research Institute with the support of the European Cooperation in the field of Scientific and Technical Research (COST). The aim of the comparative study has been to make a general review of ongoing research and higher education on urban forests and trees in Europe. The concept of urban forestry, defined as the planning, design, establishment and management of trees and forest stands with amenity values, situated in or near urban areas, has served as a theoretical basis for the study.

For the purpose of the review, scientific and higher educational institutes in Europe dealing with urban forests and trees were identified. By means of country studies largely carried out by national urban forestry experts, the state-of-the-art of European urban forestry research has been described in a comparative way. Emphasis has been on identifying institutes and main research themes. in addition, insight in attention given to urban forests and trees within higher education was analysed via case-study reports and a survey. For this purpose, focus has been on higher education within the fields of forestry, horticulture and landscape architecture.

By comparatively analysing both urban forestry research and education at the European level, similarities and differences, as well as major developments and needs in European urban forestry have been identified. The results of the study, which will be widely distributed, may provide a useful base for the development and coordination of urban forestry related research and education in Europe. This paper focuses on more strategic-level aspects (in terms of urban forest and tree functions, policies, forms) that have emerged from the study.

An Analysis of Green Space Management Strategies in Metro Manila

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Management strategies focused on the street and park green spaces in cities and municipalities of Metro Manila, namely: Manila, Makati, Mandaluyong, Pasig and Quezon City were analysed.

Information on the biophysical, social and political conditions, management capabilities and practices for street and park green spaces on each site were gathered through survey and interview. The influence of these variables on the performance or success of the green space management as reflected in the conditions or status of trees in either street or park green spaces was determined.

Street and park green spaces of the cities and municipalities studied have varying biophysical conditions that are influencing growth and development of urban plants.

The public is higher aware of the importance of greening, activities and of the usefulness and disadvantages of having urban trees. Only few have actually participated in the greening activities but majority are willing to participate if given the opportunity.

Political atmosphere is only fairly supportive f the greening activities and other environmental issue and concerns, though some municipalities have already initiated greening activities. Legislation of greening ordinances is not given much attention.

Greening offices in the cities and municipalities are already installed. Some are permanent while others are still quasi in nature. Some are well equipped in terms of manpower, financial and technological resources while others still need to build up their capabilities. Each of the cities and municipalities has its own greening goal and objectives and has developed its own cultural management strategies. However, their practices need some improvements.

Monetary Valuation of Urban Forest Amenities: Possibilities and Constraints

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Most of the values attached to urban forests are non-priced environmental benefits. Urban development projects often decrease the amenity values of green spaces, which should be taken into consideration in planning. Today land-use planning procedures do not include systematic assessment of urban forest benefits and therefore, quantitative information on residents' valuations is needed.

This paper discusses the possibilities to value urban forest benefits in monetary terms and the application possibilities of such information in land-use planning. The paper sums up European research experience from two economic valuation methods, hedonic pricing and contingent valuation in the field of urban forestry. Furthermore, recent research results of empirical studies conducted in Finland in are presented.

The hedonic pricing method examines external benefits and costs associated with housing. Research results show that people pay for urban forest benefits through house prices. However, measuring and selecting proper variables to describe amenity benefits in house price models is problematic. in recent empirical applications a view to and proximity of urban forest are shown to increase apartment prices in hedonic models.

in contingent valuation method people are asked directly what they are willing to pay for provision of green spaces. Although the economic estimates are based on hypothetical valuations, the method enables valuation of larger range of urban forest benefits than the hedonic method. Recent survey results show that majority of the residents' are willing to pay for the use of urban recreation areas, but also for other amenity benefits of green areas.

The main use of valuation methods is economic evaluation of the impact of urban land-use plans and the evaluation of profitability of urban greening projects. The value of an urban forest capitalized in property prices can for example be calculated by using hedonic price models. The results of case studies show that management of urban forests for amenity benefits is profitable in economic terms. Furthermore, the results suggest that a limit can be found where condensing town structure, i.e. building on green areas, is not worth from the point of view of the society if the losses of green space benefits are taken into account.

6.15.00 Reconsidering study objectives and teaching methods

Information Technology in Forestry Education and its Role in Enhancing Flexible and Distance Education

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Computers and other Instructional or Information Technologies (IT) have been gaining importance in forestry education since the 1970's. The role of this IT has progressed from improving the efficiency of operations (eg automating common administrative procedures) through to changing the way things are taught and learnt and even what is taught and learnt.

Early examples of IT include word processor packages and databases that make it easier to update teaching materials and student records. IT that supports the reliable transfer of digital documents and other files - including file-servers and early examples of the Internet - allowed increased and more flexible access to traditional teaching resources during the 1980's. The 1990's saw the increasing use of presentation technology that allows academics and teachers to explore new ways of recording and showing information. This presentation IT includes digital slide shows, animations, digitised sound and movies, etc. In the 1990's another major emphasis was IT designed to enhance communication between individuals and within groups. This technology includes e-mail, bulletin boards and chat rooms and is being incorporated into many examples of flexible teaching to enhance the communication between students, teachers and other stakeholders. The world-wide-web (www) networks now allows the integration of many of these technologies by imposing a consistent protocol and standard of communication and digital information transfer. Currently there is an increasing interest in organisations who are integrating the administrative and teaching functions of these ITs into holistic packages.

The IT is being used to support teaching in different ways. These different ways may allow students to learn more effectively and in more flexible styles. This flexibility may also allow forest education and further learning to be available to stakeholders who are not able to attend traditional teaching campuses, ie distance education and open learning students. The IT is also used to increase the efficiency in teaching, where efficiency may be measured as increased output (more graduates) for less input (less time spent by academics, etc.)

This State of Knowledge Report will review some of the reasons that IT has been introduced into forestry education. The review will include examples of IT that have been introduced and how the curriculum and student learning changed as a consequence. Some examples of quantitative feedback from students to IT and its role in teaching and learning is included from case studies at the Australian National University. The Report will also cover examples and the reported strengths and weaknesses of flexible teaching and learning, including distance education, that utilises this IT.

Groping along in designing a new subject: participatory resource management

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Keywords: Participatory resource management, Forestry curriculum, Rural sociology, Conflict resolution

The introduction of this new subject, Participatory resource management (PRM), in the forestry curriculum is due to a greater emphasis on management in the forestry profession as well as increasing recognition of the value of interdisciplinarity. The recognition of PRM as a worthwhile academic subject also stems from its growing popularity amongst overseas Aid funding bodies as well as students and hence its capacity to attract viable student numbers at undergraduate and postgraduate levels.

Although there is a considerable body of literature concerned with theory and application of participatory concepts and principles in natural resource management (especially within the context of development and sustainable agriculture), the subject has only recently been taught as an academic subject as part of an university degree. The design of the course draws heavily on the practice and implementation of participatory processes within the professional practice rather than on a theory from which a professional practice is derived.

The subject itself borrows heavily from other fields: social sciences - including rural sociology, history, development and gender studies - and management - including conflict resolution, communication and group dynamics and education.

The challenges of the course are the effective introduction and integration of a social science type approach into a biophysical science curriculum, as well as to promote and foster an attitudinal change and a paradigm shift within the professional practice.

In this paper, based on personal experience in 2 academic institutions, student's feed back and the appropriate body of literature, I propose to relate and reflect on this experience.

Forests in Geographic Information Systems at the Graduate School, University of Helsinki, Department of Forest Resource Management

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Keywords: Educational program, Modular curriculum, GIS, Forest mapping

Geographic information systems (GIS) and remote sensing technology have revolutionized forest mapping in 1990's. Mapping has been changed from individual measurements to the combination of multisource GIS information. These new technologies, however, bring along several drawbacks and problems which should be solved or improved in the near future, *e.g.* effective combination of multiscale and multisource numerical data, effective acquisition of accurate GIS data, co-operation between various organizations, and a lack of GIS specialists in both forest research and practice.

In order to develop the use of GIS in Finnish forestry, the Forests in Geographic Information Systems Graduate School was established in the University of Helsinki, Department of Forest Resource Management in May 1998. in the first year, 15 researchers were chosen for admission to the school, which is financed by the Finnish Foresters Foundation, the Finnish Ministry of Agriculture and Forestry, and the Academy of Finland. Postgraduate studies can be pursued in the University of Helsinki, University of Joensuu, or in the Helsinki University of Technology.

The Graduate School will improve facilities for managing forests with the aid of rapidly developing computer technology and geographic information systems (GIS), developing methods for and training specialists in research, education and practice. The main objectives of the school are:

- To initiate an educational program in the fields of forestry, photogrammetry, remote sensing, and geoinformatics.

- To increase cooperation among those interested in GIS research and the use of GIS both in Finland and abroad.

- To develop GIS applications for use in forestry and the environmental sciences.

The Graduate School is linked with other GIS and remote-sensing research in Finland. in addition to the universities, numerous other organizations are participating in the program, *e.g.* the Finnish Forest Research Institute, the National Land Survey of Finland, Kehitt„miskeskus Tapio, the Finnish Forest and Park Service, VTT Automation, and Metsäteho Oy.

Professor Jeremy Fried from the University of Michigan was employed in 1998 for a year by the University of Helsinki as a GIS specialist and teacher. The establishment of a Graduate School and professor Fried's appointment provided an opportunity to create a new GIS curriculum within a department of Forest Resource Management. A defining objective of this curriculum was a flexible structure whereby students with different GIS backgrounds, disciplinary interests both related and unrelated to forestry, and varying amounts of available study time and learning objectives could all be accommodated. Towards this end, a highly modular curriculum was developed consisting of seven courses. Courses were presented using a variety of instructional approaches. Theoretical content was presented primarily via lectures and readings, with questions and discussion encouraged. Software expertise was developed through more than 80 hours of intensive, hands-on, instructor guided and self-guided laboratory exercises using various ESRI and other GIS related products. All courses shared a common web site for distribution of assignments and data, posting of links to GIS resources, and posting of lecture notes and seminar schedules. Although there have been previous efforts to provide GIS training in Finland before, this curriculum appears to have been one of the most comprehensive undertaking to date, and should form an excellent starting point for future efforts of this kind.

Reconsidering objectives and methods for education in forestry: the case of Kenya

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Keywords: Forestry curriculum, Forest policy, Communication, Teaching methods, Field orientation

People in the developing countries wholly depend on the forests for almost all their daily needs. This mainly includes shelter, food, medicine, fuelwood, fodder for livestock among other uses.

As the populations increase, the natural forests decrease, thus making it impossible for the people to meet their daily needs from the forests. Therefore new survival mechanisms have to be found in order to minimize the human pressure on existing forests. To halt the present demise of the forests and improve the society's well-being, a lot is required. This should mainly be through change of forest policy objectives and forestry curricula in their higher institutions of learning Sustainable conservation of forest has for a long time been the major objective of Kenyan forest policy. However, persistent outcry from the citizens, has forced the government to adopt new forest policies objectives published in 1994 in the Kenya Forestry Master plan (KFMP), 1995-2020, where not only the natural forests but also the individual farms are included in the aim of increasing the forest and tree cover of the country. Also arid and semi-arid afforestation is taken into consideration. This will ensure an increasing supply of forest products and services for meeting the basic needs of present and future generations and for enhancing the role of forestry in socio-economic development.

With the recent change in policy objectives, it also entails changes in the forest curriculum both at the technical and professional institutions, so as to have well trained staff to implement the said objectives. The forestry curriculum should change from production forestry to participatory forestry at all levels. Courses which are more land-user oriented should be given more weight, for example, agroforestry, social forestry, soil & water conservation, arid land afforestation. Other courses such as communication techniques should be continued into the 2nd, 3rd and 4th years at BSc. level.

The teaching methods used should change from class-room oriented to field oriented. The teaching institutions should set up demonstration plots in all ecological zones so as to convince the farmers that whatever they know is practical and can be done in the areas in question.

This paper will try to look into the present forest policy objective and the changes required in the forestry curriculum and the methods used in teaching forestry in the Kenyan institutions. It will also try to propose changes required in the teaching methods.

Scenario for Higher Forest Work Efficiency and Safety in Countries With Economies in Transition

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Forest work in countries with economies in transition is characterised by severe economic conditions, increasing gap between such countries and developed ones, low work efficiency and continuous fluctuation of workers. Low forest work efficiency is also affected by low training level of forest workers and numerous accidents at work. The analyses of the quality of work as well as a survey of causes of injuries showed serious deficiency of the traditional system of training. More then half of all injuries proved to have been caused by insufficient mastering of work techniques and due to not observing work safety regulations. At the same time it was also noticed that the mentors of practical training had been negligent.

This paper shows the scenario for the possible development of work techniques of forest workers in Croatia, one of middle-European countries with economies in transition. The new concept schedules periodical assessment (at six-month intervals) of forest workers by a FWT (Forest Work Techniques) questionnaire. The assessment would be carried out during regular work and it would consist of 20 elements including work preparation, performing work operations, handling and maintenance of equipment and tools and working dynamics.

In felling and wood working operations, the following elements would be assessed:

a) during felling: preparation for felling, establishment and checking of felling direction, supporting felling direction, preparing undercuts, determination of final cut height, the look of felling crest

b) during limbing and transverse cutting: body posture, chain saw movement, limbing quality, transverse cutting technique, use of measuring band, bucking accuracy

c) in handling tools: adjustment of chain saw engine, chain sharpening, use of other tools

d) time-table and duration of breaks, usage of personal protection kit.

In accordance with the results of the assessment, the workers would get the adequate QG (Quality Group) index and they would consequently be classified in the appropriate payment classes, which would apply until the next assessment. The difference between payment classes would range from 10 to 15 %.

For each quality group adequate training programs would continually be going on aimed at correcting and developing their work techniques starting with the analyses of most common irregularities and improprieties, including written and video information, field demonstrations and several-day training with a mentor. After passing their exam and being granted the certificate, training mentors are supposed to go through licence certification at two-year intervals.

Such approach would by all means improve the quality of work and lower the number of injuries as well as the frequency of professional diseases. It would also increase the efficiency and proficiency of forest work. On the other hand, the possibility of higher payment for better work quality would make workers more satisfied and this would bring to a more positive selection among forest workers.

It is expected that during the period of 2 to 3 years, more then 80% of workers could be classified into two high-quality groups.

Looking for Articulation in Professionals' Training: The case of the forestry occupational family

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Keywords: Occupational hierarchy, Educational development, Forestry curriculum, Competency, Chile

Economic development in many countries has been quite accelerated in recent decades. However, educational development sometimes does not run parallel to economic development, as has been the case in Chile. This presents a problem because the production sector does not have a readily available labor force required to support the economic growth, mainly because the skills, competencies and behaviors required by our advanced, technological, information-based society have outpaced our ability to provide training within our existing structures and systems. There are many production sectors, like the forestry one, whose development requires professionals from different levels working in teams. Because of their work characteristics, they can be thought of as an occupational family. in these cases, it is necessary that articulated training be planned, to allow these teams to work in an efficient and structured manner. in this paper, we propose a model that describes how to arrive to an occupational hierarchy based upon articulation of different professional levels in the forestry occupational family, which includes engineers, technologists and qualified forestry workers.

The model is a competency-based model, which is based upon the determination of the skills, knowledge, and attitudes that students should be able to demonstrate after completion of a program of study. Training of each individual group of professionals, who are located at different levels of an occupational hierarchy, should facilitate the development of required competencies, so that they can act with efficiency and effectiveness in their own field. Seen in such a perspective, the training process of a professional cannot be planned without considering globally all other professionals who belong to a same occupational family. Besides this, the process as a whole cannot overlook the relationships with other related occupational families. This means that articulation, both vertically and horizontally, is essential to professional training in an occupational family.

The model seeks to find an occupational hierarchy based on competencies required in the work place. A first phase of the model is the characterization of employers and the characterization of professionals. in our case, employers are forestry industries and forestry companies or organizations; professionals are forestry engineers and forestry technicians who have been trained at different educational levels. After this, an occupational inventory is developed. The model includes also a phase where forestry occupational positions are clustered according to responsibilities and tasks identified through a preliminary on site survey and a questionnaire.

Characterization of professionals considers the professional position or job and the tasks they fulfil. Through this it is possible to assign each professional to a certain level given by the responsibilities that are inherent to the position or job, and to a certain responsibility level, given by the complexity of the tasks he has to carry out due to his position. Once this characterization is done, tasks are grouped so as to conduct a preliminary tasks inventory, that is complemented through on site interviews Through content analysis of actions inherent to each position or job and of tasks fulfilled by the professionals, and through consideration of different types of companies together with the diversity level of their activities, it was possible to structure different groups of professionals, which later on could give rise to hierarchical levels of the occupation.

Ethnoforestry re-examined: Global status of indigenous knowledge on forestry management

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Keywords: Equity of Knowledge, Ethnoforestry, Indigenous knowledge on Forests, Tropical Forestry.

Ethnoforestry is defined as a continued practice of creation, conservation, management and use of forest resources, through customary ways, by local communities. This paper examines the world-wide status of ethnoforestry research based on a literature review. It also discusses examples from the field work carried out in India.

Ethnoforestry is classified into Protection Ethnoforestry, Plantation Ethnoforestry and Ethnoagroforestry. Protection provided by local communities to habitats are classified as protection ethnoforestry. Traditional methods of regeneration of livelihood species by people are classified as plantation ethnoforestry. These include direct sowing, bamboo rhizome planting, cutting, nursing of wildlings and closures. Traditional methods of growing trees and crops in farmlands are described here as Ethnoagroforestry.

Availability of vast research on ethnobotany notwithstanding, unfortunately, ethnoforestry has been, mostly, a missing knowledge in global forestry research, documentation and planning. Non-availability of written material in the subject is definitely the result of monumental neglect of local knowledge on forests by foresters in general and so-called scientific forestry scholarship in particular. Drawing on the primary research material from India, the related global research reviewed in this paper throws some light on the operational part of local knowledge on forests. Studies from India, Brazil, Nepal, Ecuador, China, Vietnam and African continent are examined.

Indigenous knowledge on forest management is crucial because of various reasons. Erosion and extinction of cultural diversity and indigenous knowledge is threatening the society. Inadequacy and unsuitability of classical forest management strategies require the help of indigenous knowledge to overcome the crisis of deforestation.

Philosophy of sustainability is ingrained in the traditional ecological knowledge. International ethics and legal obligations of the nations, and voices of the indigenous peoples themselves requires that foresters must take help of indigenous knowledge. The discipline is bound to deliver vital and incomparably significant results for the future of World Forestry. Ethnoforestry alone can ensure the equity of knowledge between village communities and the scientific forestry community. It will stop exploitation supported by the scientific community. Equity of knowledge alone can, ultimately, make the forestry sustainable. Community forestry requires local low cost options to regenerate degraded forests. Sharing of costs of high input regeneration could hamper people's initiative. Only ethnoforestry can provide location-specific solutions. Local knowledge is easily transmitted, used by a large section of the society, does not require costly consultancy, and thus, minimises possibility of corruption.

Data from the plantations carried out in Rajasthan, India, have demonstrated that indigenous knowledge on forests can reduce the cost of tropical afforestation up to 25 percent of the total expenditure. Economizing world's tropical forest plantations through Ethnoforestry is a distinct possibility.

Exploring alternatives for distance education in forestry

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Keywords: Lifelong learning, Internet, Forestry course, Continuing education, Extension

The boundary between formal higher education, and lifelong learning through a variety of alternative channels, is rapidly blurring. Learners demand instruction in a place and at a time convenient for them. Universities' response to this demand initially focused on live transmission of lectures and audio feedback from groups of students at remote sites. Opportunities for distant students to participate individually and asynchronously are rapidly increasing. Many courses can now be taken entirely over the Internet, while others can be viewed at home on videotape.

The College of Forestry at Oregon State University (OSU) has a reputation for high-quality forestry education. Notable characteristics include small class size, hands-on learning, extensive use of convenient field laboratories, and close personal interaction with instructors and peers. The College is actively exploring several initiatives in distance education (DE).

Administrators and instructors are presented with several challenges in developing DE. Technological hurdles must be overcome. Standards for communication networks are quickly evolving. Computer software for designing and implementing DE is still in its infancy, and most successful applications are purpose-built. in addition to content mastery, DE requires specialized expertise from computer programmers, network engineers, graphic artists, and audiovisual producers. Another concern is the cost of designing new instruction and providing new infrastructure. Some experienced practitioners estimate that developing a DE course requires five to ten times as much labor as a traditional course. A DE classroom can cost hundreds of thousands of US dollars, and students must be equipped with PCs, VCRs and other devices. Budgets are stretched, and because many new students are needed to justify these additional costs, competition between universities is rapidly intensifying.

Perhaps most importantly, educators are questioning how to maintain high-quality personalized instruction. Distant students expect to be provided with convenient access to learning resources, meaningful hands-on experience, peer interaction, and timely feedback on their efforts. They also expect to be able to guide and shape their own learning experience to a greater degree than do traditional students.

One direction for DE at OSU involves adaptation of existing curricula. For example, a forestry course which has been taught on campus for ten years was recently incorporated into a new DE degree program in natural resources. in order to make it accessible to students enrolled at remote locations, lectures were videotaped and the majority of course content was posted on the World Wide Web. Students communicated with one another, turned in assignments to the instructor, and went on "virtual field trips," using the Internet. Initial responses from students using the new technologies are mostly favorable.

Another direction at OSU involves creation of new infrastructure and curriculum to meet the needs of nontraditional students. For decades, working professionals have come to campus for continuing (further) education, but the focus is now shifting to bringing instruction to the workplace. in one example, a professor of silviculture on campus and an extension agent working 300km away collaborated on a course in uneven-age management. Students on campus, all forestry graduate students, attended lectures in a classroom television studio, and went on local field laboratories led by the professor. Students at the remote site, all professional foresters, watched lectures on videotape, questioned the professor via periodic teleconferences, and were led by the extension agent on field laboratories in their own region. A majority of the distant students indicated that they were satisfied with the experience and would be willing to take another DE class in the future.

Role of Forestry Education in India for Sustainable Management of Tropical Forests

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Keywords: Forestry curriculum, Social sciences, National forests management, Extension

Forestry education in India, ever since its inception remained as a package deal to train forestry practitioners required for the management of national forests. The aim has been to provide forest administrators to govern and manage the state owned forests which form 93 per cent of the total forested area. Forestry education, research and extension in India had been a preserve of the Federal and State Forest Services till 1985 when the Indian Council of Agricultural Research (ICAR) stepped in to introduce graduation programmes in forestry in six Agricultural Universities. The starting of forestry degree programmes in the universities was more or less a consequence of the general awareness to environment and forestry related problems. The media played a very active role in highlighting the problems of deforestation, wasteland formation, development activities to the detriment of forests, environment etc. During 1985, a high level committee in the Ministry of Environment and Forests, GOI, discussed the lack of trained manpower for executing various programmes in forestry and the projections clearly showed that this lack of manpower would continue well beyond the Eighth Five Year Plan.

To generate the desired manpower in forestry the training set-up in Indian Forest Colleges was found to be inadequate and hence the state Agricultural Universities were requested to start Bachelor programme in Forestry. To improve faculty resources about 80 senior teachers from the discipline of plant breeding, agronomy, horticulture etc. were trained in US Land Grant Universities for one year through a USAID funded program. Their main aim was to study a few related courses in forestry at BSc., MSc. and PhD. level and to see the functioning and integration of department of forestry in the College of Agriculture. This was a very useful programme and within a span of 2-3 years each new department of forestry had 2 to 4 trained teachers to teach basic courses in forestry. At this stage it would be worthwhile if the individual universities decided on building up faculty and research capabilities in all disciplines of forestry *e.g.* silviculture, management, agroforestry, tree breeding, social forestry, forest products and utilisation, forest protection.

In general, all the universities which started BSc. (Forestry) programmes in 1985 formulated their curricula on the basis of guidelines provided by the ICAR with only minor modifications. Some of the courses which lacked in the training package of State and Indian Forest Services trainees are biotechnology, microbiology, computer science, biochemistry, forest tribology and anthropology, meteorology and climatology, forestry extension, ergonomics, forest ecology and biodiversity, tree improvement and seed technology, etc. The forestry component slightly varies from university to university but social sciences find a prominent place in the curriculum, mainly because social forestry and agroforestry oriented personnel are in demand. It is very important that the universities specialise their teaching and research programmes in different areas related with afforestation, land use and wastelands managements, social and agroforestry , forest based industries, forest management, non-conventional energy resources, natural resources and biodiversity so that we have enough suitable manpower in the coming years for achieving sustainable management of the tropical and sub-tropical forest wealth of our country.

Improving forestry education through participatory curriculum development. A case study from Vietnam

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Keywords: Forestry curriculum, Participation, Social forestry, Extension

In many countries throughout the world, forestry practices are undergoing a major reorientation. A new and different type of forestry is emerging, creating a requirement for a different set of skills, knowledge and attitudes in those persons who must deal effectively with the demands from farmers and rural people, as well as from other interest groups such as environmentalists. Whereas much forestry training has until recently been strongly technology based, there is now a need to build an interdisciplinary capacity in many foresters and extensionists, encouraging an understanding of social principles and processes. The focus will no longer be on uniformity and technology; forestry training programmes need to become more relevant and flexible; diverse and yet well integrated. A wide range of stakeholders will emerge with different interests in what forestry education can achieve. The beliefs and values of some stakeholders may accelerate the change process, whilst others may deter innovations and new developments. The possibility for successful outcomes in the development of forestry education is enhanced, however, through approaches which increase participation of different stakeholders in meaningful ways. It is recognised that there are a number of constraints to stakeholder participation. Even so, a participatory approach to curriculum development should lead to increased opportunities for networking, negotiations and reflection by groups and individuals, including those who are normally marginalised, and a greater chance of successful, sustainable outcomes from the curriculum development process.

Participatory curriculum development (PCD) has been used in a number of contexts and regions of the world, particularly in the areas of agricultural and forestry education. This approach is not new, in that there are many instances of attempts to increase participation in the curriculum development process. During the 1990's however, greater effort has been made to articulate and advocate the basic principles and methods which can support PCD, and to share and disseminate experiences and outcomes more widely. PCD seems, on existing evidence, to have the potential to bring about improvements in both the quality and the effectiveness of university forestry education and training programmes in a context of dynamic change.

The paper explains the PCD approach, which begins with a detailed stakeholder analysis, followed by the identification of meaningful roles and responsibilities for different stakeholders. A series of interlinked steps for curriculum planning, implementation and evaluation is then outlined. The precise organisation and operationalisation of these steps is determined by the context and by the intervention of different stakeholders. This creates a continuous, dynamic, flexible process, with learning as the guiding principle for development.

A case study of the Social Forestry Support Programme with five university forestry faculties in Vietnam is then presented. The paper describes the PCD approach, the focus of which is primarily the development of social forestry education and training programmes, but also the review and revision of Vietnamese forestry degree programmes in general. It explains the process by which curriculum development is based upon systematic learning from the experiences and views of farmers at grassroots level, as well as from teachers, students, extensionists, project staff and other stakeholders at local and national level, and even from regional networks and organisations.

Some constraints affecting the PCD process are discussed, as well as a number of opportunities which have emerged during the programme in Vietnam. The current status of curriculum development activities in the programme are presented, along with plans for future collaboration and involvement of stakeholders. in conclusion the paper advocates the further dissemination of experiences with the PCD approach in order to achieve a wider support for its application in forestry education at local, national and regional level. Ultimately, this should contribute to an improvement of the quality, ownership and impact of forestry education and training for a wide range of target groups and institutions.

6.16.00 Modelling forest managers environmental decisions

Using forest sector models for environmental decision making in the United States

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Supplies of goods and services in the forestry and agricultural sectors are affected by land use changes, investment in land management, and policies. We examine environmental and socio-economic impacts in the United States of three different types of policies using model results from the Timber Assessment Market Model (TAMM) and the Forest and Agriculture Sector Model (FASOM). We look at policy scenarios pertaining to: 1) land-use pressures; 2) increased protection for wildlife habitat on public lands; and 3) climate change. With respect to analyzing policy scenarios, use of the TAMM and FASOM models can be complementary. As described in another paper at this Congress (Alig et al., Session 4.02.07), the TAMM system of models links product and stumpage markets and provides projections that are based largely on behaviorial tendencies as reflected by historical observations. The intertemporal optimization framework of FASOM allows ready examination of adjustments or responses to policies that may fall outside the historical range of observations. Investigating the sensitivity of FASOM projections to a range of different assumptions, as under additional scenarios, can be a useful form of policy analysis. This allows examination of different assumptions about supply conditions for land and capital, including the flexibility of the simulated market system to adapt to changes over time and across scenarios. Both models have been used to examine a number of different scenarios, including private responses to reduced public timber harvest, recycling of wastepaper, tree planting for carbon sequestration, and impacts from global climate change.

With regard to land-use pressures, model results indicate that access to additional land as potential afforestation investments provides additional private investment flexibility in market simulations. This may include non-traditional activities on agricultural land such as biomass and short rotation woody crop production and tree planting as part of adaptation activities in response to global change. Next, reductions in timber harvests on public lands for additional wildlife habitat protection may result in having some of the largest environmental and economic impacts occur in regions outside of which the public timberlands are concentrated. However, shifts in intertemporal patterns of private forest investment may act to reduce the price and harvest impacts of public harvest changes over time. Model results for mitigation strategies to address climate change concerns indicate the potential for leakage. Leakage may take place when policy-driven afforestation by the forest sector leads to some market-driven compensating conversion of forestland elsewhere to agricultural use. Another manifestation would be crowding out of investment within the forest sector. Forests created to sequester carbon would enhance future timber supply and decrease anticipated future timber prices. The lower prices may crowd out some forests that would have otherwise have been established in the absence of the policy. With an intertemporal model, lower timber prices may also cause some owners to harvest sooner and invest back in lower intensity management forests or convert to alternative land uses. The ownership tenure system in the United States makes private land use change a potential important determinant of the forest carbon budget, and projections of forest carbon sequestration are sensitive to assumptions about factor supply (e.g., inelastic supply of land within a sector). Costs of the mix of and land transfers and management inputs can vary notably with the type of forest carbon target, including timing and level.

A System of Short Term Forecasting for the Finnish Forest Sector (MESU)

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This paper presents a synthesis of the System of Short Term Forecasting for the Finnish Forest Sector (MESU). As its name indicates, the purpose of MESU is to make forecasts for and analysis of the Finnish forest sector. It has become increasingly important to be able to analyse changes in forest sector business cycles. This is, for example, due to the liberalization and globalisation of forest products markets. in addition, the forming of EMU and the launching of euro-currency will affect Finnish forest industry's main export markets. Part of the MESU-system has already been utilized in practice for helping the Finnish Forest Research Institute to make forecasts for the Finnish Forest Sector Economic Outlook (an annual publication).

The use of the MESU-system allows to make assessments in which the development of Finnish forest products export markets and the adjustments of Finnish roundwood markets are analyzed consistently. It is a hierarchical, demand-led system consisting of three parts (models). First, the demand for forest products in the major export countries is forecasted using a consumption function model. in the second stage, these forecasts are inserted as exogenous information in the next stage, the export market model, which determines the Finnish forest products exports. in the third stage, the forecasts from the export market model are, in turn, inserted in to the roundwood market model, which determines the forecasts for roundwood demand and prices. This paper will demonstrate the MESU-system by an example. Particularly, we analyse how the changes in the demand for sawnwood in Germany affect the demand for Finnish sawnwood exports and, in turn, the demand and prices for sawlogs in Finland. The theoretical framework of the system is based on economic theory and the empirical model is based on quarterly time series data from 1980-1997. As far as we are aware, MESU is a first attempt to build a short-term forecasting system, which links the demand for forest products to roundwood markets using econometric models and modern time-series methods. However, the theoretical and methodological framework of the MESU-system is general, and similar modelling approach could be applied to other countries as well.

The role of forest sector models to support environmental and forest sector decision making in the Nordic countries

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Keywords: forest sector analysis, modelling, experiences, Finland, Norway

The paper gives an overview of forest sector modelling in Finland and Norway and how it has been used in environmental and forest sector decision making. Strong and weak points with the application of these kind of models are discussed, and improvements of the present situation are analyzed. Till now rather few analyses have been performed related to environmental problems, as most of the modelling efforts have dealt primarily with supply and demand of roundwood and forest industry products. One major obstacle in both countries has been that decision makers have an uncomplete understanding of the basic mechanisms of the models, and thus have been sceptic in using them. However, there have also been positive experiences about collaboration with decision makers, in particular in Finland where various stakeholders have been involved, but also in Norway where the central government has been the main user.

6.16.00 Example of forest sector issues

Forest Sector Analysis for Macro Economic Development of Osun and Ayo States, Nigeria

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The study was carried out for a period of 24 months between July, 1996 and June, 1998. The exercise centred on an evaluation of critical elements of growth and economic development of teak plantation establishments *e.g.* volume production exploitation and regeneration ratios, optimum labour requirements and socio-economic impacts of activities dependent on the forests.The cumulative data were analysed using various tools,such as Smalian`s formula, Gross Margin Analyses, Discounted Cash Flow Analysis Net Present Value (NPV), Benefit -Cost Ratio (B/S) and Economic Rate of Return (ERR), Sensitivity Analysis, Production Efficiency Model, Optimum Labour Demand Model, Bar Charts and Simple percentages. Current forestry contributions of Osun and Oyo States were evaluated and feasible development strategies which would enhance sustained forestry sector of the two states to the gross domestic product (GDP) of the country were outlined. The results showed that the volumes per hectare of teak stand were insignificant (P>0.05) with 782.8 m^3 per hectare in a 21-year -old teak plantation in Ago-Owu forest reserve and 215.8 m^3 per hectare in an 18-year-old teak plantation in Gambari forest reserve. The NPV of N236,128.5, B/C of 12.9 and ERR of 33 percent (where NPV = 0) were signification higher (P<0.05) per hectare of taungya teak plantation in Ago-Owu forest reserve using a discount factor of 10 percent than the NPV of N233,214.0,B/C of 12.7 and Err of 31 percent (where NPV = 0) per hectare of direct teak plantation in Ago-Owu forest reserve.The NPV of N113,206.3, B/C of 6.2 and ERR of 30 percent (where NPV = 0) were significantly higher (P<0.05) per hectare of taungua teak stand at Gambari forest reserve than the NPV of N110,355.5, B/C of 6.0 and ERR of 28 percent (where NPV = 0) per hectare of direct teak plantation in Gambari forest reserve. The NPV and B/C were significantly sensitive (P<0.05) to increase in discount factor of 20, 25 and 30 percent in the two reserves.The production efficiency model per km^3 from 1992 tto 1997 showed that Marginal Products (MPs) of 1.6 for labour in exploitation activity were positive (P0.05) at Ago Owu and Shasha while MPs of -0.1 and -0.1 were negative (P>0.05) at Ago-Owu and Shasha forest reserve. in Gambari forest reserve, the MPs of 0.1 and 0.02 in exploitation and regeneration were both positive at decreasing rate (P<0,005) while the MPs of -0.04 and -0.1 were negative (P>0.05) in exploitation and regeneration at Ijaiye forest reserve. The optimum labour demand models indicated that Ago-Owu, Shasha, Gambari and Ijaiye forest reserves required 25 forestry staff, 17 forestry staff,6 forestry staff and 7 forestry staff respectively from 1992 to 1997. In Osun State, from 1992 to 1997, the forestry department generated N107,574,642.5 out of the total revenue of N271,348,554.8 realized by the Ministry of Agriculture. The percentage contribution of forestry department in six years was 39.6 percent. On the other hand, in Oyo State, from 1992 to 1997, forestry department generated N39,830,073,3 out of the total revenue of N112,320,149,8 realized by the Ministry of Agriculture. The forestry contribution in six years was 35.5 percent. in all these study locations, the respondents complained bitterly about the poor investment on rural infrastructural facilities.For instance, 90, 87.5, 80 and 75 percent respectively of the respondents in Ago-Owu, Shasha, Gambari and Ijaiye forest reserves affirmed that infrastructural facilities were grossly inadequate. The study therefore revealed economic efficiency of land use practices, positive labour efficiency in exploitation and negative labour efficiency in regeneration, under-employment of government employees in all forest stations, substantial and increasing annual revenue generation by forestry services and poor socio-economic impacts of forest operations on rural wellbeing. Forestry development strategies were developed. in particular, commmunal participations in plannning and management processes were identified as a critical strategy for significant improvement of forest sectoral contributions to the national economy.

Mandatory Biodiversity Conservation: Competitiveness versus Green Image Effects

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Mandatory biodiversity conservation in forestry is usually thought to decrease harvesting possibilities, raise timber price and weaken competitiveness of the domestic forest industry. If however biodiversity conservation leads consumers to view products as being higher quality, the resulting "green image" increases demand for domestic woods products. This paper studies the effects of mandatory biodiversity conservation by modeling the behavior of the domestic economy as a two-stage game. in the first stage the forest industry and the forest owners' association bargain about timber price, while in the second stage the domestic industry determines output in a Cournot rivalry with the foreign forest industry. in the absence of green image a binding biodiversity conservation requirement will increase the reservation price of timber for forest owners' association and thereby timber price. International competitiveness of the domestic forest industry weakens and its market share falls. If the green image is strong enough competitiveness effect may be more than compensated by increased demand in which case the profits of domestic forest industry may go up. Assuming the competitive timber market, where timber price is determined by equality of demand and supply, does not change these conclusions. A welfare analysis is carried out by assuming that the government maximizes the sum of producers' and consumers' surplus and accounts for the valuation of biodiversity.

Ways to sustainable forest management in the Mari El Republic of Russia

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Much has been said on sustainable development and sustainability lately. Governments in many countries try to introduce this concept into national policies and combine the economic growth with environmental issues. However, this is not performed in all regions equally, *e.g.* at the level of the Mari El Republic this idea has not found its realisation. This article is aimed at analysing the possibility of introduction of sustainability concept and sustainable forest management into the policy of the republic.

Describing the forest fund of Mari El republic in general terms, statistic states that the total area of the forest sector of the republic is equal to 1210 thousand hectare and the area covered with forests is 1095 thousand hectare. The total wood stock reaches 170 mill m^3, among them 40 mill. m^3 being for the stock of mature and decline forest ecosystems. The vegetation composition of the republic is determined by the natural conditions of the territory. The main resource of the republic is forest that covers about 52% of the territory.

In order to highlight the main sides and main drawbacks of the Mari El forestry it is possible to fulfil a comparison of the forestry policy analysis as well as the analysis of the current situation in the forest sector of Finland and the Mari El republic. It is possible to compare the two institutions because of their almost similar nature conditions and environment. However, Finland can be taken as an example of a country with significant experience of sustainable forest management. This is why a non-favourable comparison will be able to demonstrate the lack of sustainability in Mari El forestry. To find the way out of the current situation in the Mari El forest sector it is necessary to investigate how forest policy of the republic differs from the policy of the countries with the positive experience of sustainable forest management (*e.g.* Finland). This is why a short comparison of the main directions of forestry policies is presented here in the form of Table 2.

Table2. Comparison of Finnish and Mari El forestry policies.

Features	Finland	The Mari El republic
1. Aim at sustainability	Y	Y
2. Multi-functional approach to the use of forest resources	Y	N
3.Bias to economic forest function	N	Y
4.Forest protection:		
a) against fires	Y	Y
b) against pest and disease	Y	Y
c) against air pollution	Y	N
5. Afforestation	Y	Y/N[1]
6.Biodiversity conservation	Y	N
7.Main forest ownership pattern	private	State
8.Existence of a forest information system	Y	N
9.Exceeding felling (more than increment)	N	N[2]
10.Consideration of local peculiarities	Y	Y
11.Protection of landscape beauty	Y	Y/N[3]
12.Forest certification	Y	N
13.Different types of protected areas	Y	Y
14.Mono-culture plantations	N[4]	Y
15.Public participation in forestry activities and policymaking	Y	N
16.Best available methods and technologies	Y	N
17.Violations of forest legislation	N	Y

The differences between the policies can be explained by the contrast in economic situations in both Finland and Mari El, as well as by the difference in the source of funding (in case of the Mari El republic funding is influenced by federal donations). Though biologically the countries are mostly alike (the same plant species can be found in both) and forests consistute main natural resources in both regions, the difference in the economic development, as well as the former bias to military and heavy industry in the Mari El republic can explain the difference and negative sides of forestry policy and management.

Possible amendments to improve the situation in the Mari El republic can include the following measures:
- Introduction of multi-functional forest use and receiving benefits from different forest resources
- financing of activities by taking part in the international grant projects and valuation of all possible forest products
- further introduction of reforestation and afforestation
- investigation and introduction of the methods of forest sustainable use, criteria and indicators of sustainable forest management
- forestry education and professional training
- regulation on control and punitive measures against the violation of norms
- improvement in access to information, creation of policy information systems
- raising of local community awareness and stimulation of their participation in decision-making

To conclude, it is possible to point out that sustainable forest management has not been implemented into the forest sector of the Mari El republic and the current situation in forestry is far from being satisfactory. However, there is a way out of these conditions by introducing changes in the forest policy, and the changes should meet the latest international requirements and be sufficient for sustainable forest management.

Geographical price systems in the timber market

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Concentration of the forest industry and the spatial distribution of forests imply that transportation costs are important in the timber market. A spatial forest sector model based on partial equilibrium is developed in order to analyse regional implications of a change from uniform roadside prices to uniform non-discriminatory millgate prices for pulpwood in Norway. Uniform millgate prices implied regional differences in roadside pulpwood prices up to 25% compared to the uniform roadside prices. Factors influencing the geographical price system in the timber market are outlined. It is concluded that spatial price discrimination is likely in a pulpwood market with a limited number of buyers.

Ecological Economic Problems of Achieving Sustainable Forestry in Transitional Countries

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The main condition for achieving sustainable forestry is to overcome contradictions between ecological and economical systems. Such contradictions occur as the economical and ecological interests seem to be not compatible at first sight. But if one studies the issue more thoroughly, it will turn out that the co-ordination of current economic interests with long-term ecological imperatives is quite possible.

The achievement of long term summary ecological-economical effect should become the principal criteria for traditional economic criteria. The achievement of sustainable forestry is not possible both on the regional and global scales without such a principal and methodological change.

The achievement of sustainable forestry goals is much more complicated process in transitional countries in comparison with development and market oriented countries. This happens because the developed countries are facing one set of changes-the transition from the market to ecologically oriented market. Transitional countries have two sets of changes to accomplish-first one is the transition from centralised socialist economy to the market economy and second one the transition to the ecological market. This process requires more time. and if we want achieve global sustainable forestry the transitional countries would need assistance in speeding up this process. One should not forget that large proportions of the planet's forests are located within the territories of former USSR countries. These forests have significant global ecological functions, as do tropical forests.

In the paper on Economic Problems of Forest Management Development presented by Yuriy Tunytsya in 1986 at XVIII IUFRO WORLD CONGRESS we presented the methodological concept of transition to sustainable forestry in socialism. Since 1986 the former socialist countries have undergone radical changes in their political and economic systems. in the paper we propose for the XXI IUFRO WORLD CONGRESS these changes will be analysed by using the results of new research in the forest sector of Ukraine Russia and Belarussia. in particular, we will analyse the results of a joint project, sponsored by INTAS, on the strategy for achieving sustainable forestry in Ukraine, Russia and Belarussia. This project was implemented under the leadership of Prof.Max Krott and the young Ukrainian researcher Taras Tunytsya was one of its participants.

Ecological-economic conception of sustainable forestry includes a number of problems. These problems could be solved under the following conditions: The system of ecological-economical education in post-socialist countries needs to be improved. The transition from centralised economy to sustainable forestry in the conditions of a market-oriented economy is not possible without trained specialists. We consider it important for IUFRO, as an influential international organisation, to undertake the forestry education as an important part of its activity. Then, IUFRO can be renamed as International Union of Forestry Research and Education Organisations (IUFREO). We think that then the role of IUFREO can become even more influential in the society.

-Eastern European countries need more joint research projects with western partners.

IUFRO should be involving more young people in their activity on forming sustainable forestry.

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7.01.02 Mechanisms of tree resistance to phytophageous insects

Host tree - bark beetle interactions: effects of restoration of secondary Norway spruce (*Picea abies* [L.] Karst.) forests on food quality for *Ips typographus* L. (*Scolytidae*).

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The effects of thinning of pure spruce stands and converting pure spruce stands into mixed species stands (spruce, beech, fir) on the nutritional quality of the bark were studied. Chemical compounds in the phloem (*e.g.* nitrogen, carbohydrates, phenolic compounds) are undoubtedly relevant for nutrition and for breeding success of the phloem feeder and defence mechanisms of the tree. Changes of site and growth conditions resulting from restoration are expected to modify the chemistry of the host tree. Mass outbreaks of bark beetles like the eight spined spruce bark beetle, *Ips typographus*, frequently occur in secondary spruce stands (usually at altitudes below 1000m) after storm damages or snow breaks followed by warm and dry periods. The sites selected for this investigation repeatedly suffered from severe bark beetle epidemics. It is assumed that restoration of secondary spruce forests will reduce the risk of bark beetle attack.

We regard the following parameters as essential tree parameters determining the food quality for phloem feeders: the amount of nitrogen, protein, protein-bound and free amino acids, starch, soluble carbohydrates, organic acids, crude fat and fatty acids, mineral nutrients, polyphenolic compounds and tannins.

The results of our investigations on three different stands on seasonal changes in spruce bark chemistry during the breeding period are discussed with respect to breeding success of *Ips typographus*.

Characteristics of Douglas-fir trees resistant to damage from the western spruce budworm: Patterns from three populations

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Differences in biochemical or phenological characteristics between Douglas-fir trees that have experienced light versus heavy defoliation by the western spruce budworm may provide clues regarding mechanisms of resistance to budworm attack. I previously compared levels of foliar nutrients (nitrogen, sugars, minerals) and allelochemicals (mono- and sesquiterpenes) between "resistant" and "susceptible" Douglas-fir trees from two populations sampled in 1989 and 1990. I found a third population of Douglas-fir with individual trees that are phenotypically resistant to budworm defoliation in 1994. Here, I present data on budbreak phenology and radial growth rates for 16 pairs of resistant versus susceptible trees at this site for 1995, and data on foliar nutrients and terpenes for 1995 and 1996. I also compare and contrast the patterns seen across all three populations sampled regarding characteristics of individual trees associated with resistance to damage from the budworm.

Influence of mineral and water nutrition of Scots pine on resistance to the bark-beetle *Ips acuminatus* Gill and their associated blue-stain-fungus *Ophiostoma brunneo-ciliatum* L.

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Relations between modifications in C/N ratio in tree, tree resistance parameters and pest and disease performances are investigated. Because the C/N ratio can be influenced by modifications of C assimilation and N availability, 3 levels of nutrient conditions were applied, combined with 2 levels of water availability on young potted Scots pine. The impacts of these treatments on trees were followed with physiological parameters (photosynthesis and water status), chemical parameters (nitrogen, carbon, minerals and chlorophyll foliar contents, monoterpenes and phenols), and dendrological parameters (height and radial growth, budburst, phenology and biomass). Tree resistance and pest performances were studied after artificial introduction of *Ips acuminatus* and high-density inoculation (above the threshold of inoculation density) with *Ophiostoma brunneo-ciliatum* (an *Ips acuminatus* associated blue-stain-fungus). Effects of this artificial attacks and inoculations were appreciated through observations of pathogen performances (length of egg galleries, percentage of attacks succes) and tree resistance (resin soaked sapwood, reaction zone length monoterpene and phenol concentrations in the wounded and unwounded phloem, stem water conductivity). The results are presented and discussed with regards to the effects of water and nutrients on tree physiology in association with tree resistance to bark-beetles and with consequences for pest.

Defoliated Scots pines display high resistance to subsequent attack by *Tomicus piniperda*.

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In 1990-1991, *Diprion pini* caused extensive defoliation in Lauhanvuori national park and surrounding areas in south-westen Finland. Most trees lost all their foliage in 1990. in 1991, the outbreak area was sprayed with diflubenzuron (Dimilin), except in the national the park where the sawfly larvae consumed, most of the remaining needles. No further defoliation occurred in 1992.

In spring 1992, pine trees with 0, 10, 30 and 100 % foliage left (10 small and 10 large trees in each category) were baited with pine bolts in order to induce stem attacks by pine shoot beetles. All baited trees were attacked by *Tomicus piniperda* and some also by *T. minor*, but the attacks failed in all trees except in the totally defoliated ones (and some of the small trees with little foliage left). Most unbaited trees escaped attack entirely, but a few totally defoliated were successfully colonized. Attack densities of *T. piniperda* were optimal on the lower stem (ca 100 egg galleries x m-2), but the corresponding brood production was modest (ca 500 exit holes x m-2). None of the measures (resin flow, cambial electrical resistance, size of induced defense reaction phloem starch and sugars) used to describe tree vigour gave better information than the estimated remaining foliage. Thus, the risk for beetle-induced mortality following defoliation is a function of remaining needle biomass and beetle pressure.

Tree mortality, foliage recovery and stem- and shoot-attacks by *Tomicus piniperda* were further recorded in spring 1993, 1994, 1995 and 1997 on sample plots along 3 survey lines (10 plots per line) situated in a totally (line 1) and severely defoliated (line 2) part of the national part, and in the Dimilin-treated area outside the park.

Two years of total defoliation resulted in ca 75 and 50 % mortality in small and large trees, respectively, whereas only occasional Dimilin-sprayed trees (suffering one year of defoliation) died. Most mortality occurred in 1992 and 1993, and in spring 1997, the sprayed trees had recovered full foliage, whereas trees on line 1 and 2 held ca 50 and 60% of full foliage, respectively.

Altogether, more than half of the dead trees were colonized by *T. piniperda*, and the rate of attacked trees peaked in 1993. in all year, successfully attacked trees carried less than 10 % foliage, while attacks failed on trees having more than 20 % foliage. Unattacked trees had ca 50 % foliage. As the mean needle biomass for all groups of surviving trees was above 25% in 1992, we conclude that depletion of suitable hosts terminated the beetle outbreak in the area. The high resistance of severely defoliated trees, indicates that carbon availability may be less important for resistance than expected so far. (Although growth losses are no treated in this context, we also conclude that preventing a second year of defoliation was highly justified from a silvicultural point of view.)

This abstract is a based on the following two papers:

Annila, E., Langström, B., Varama, M., Huikka, R. & Niemelä, P. 1999. Susceptibility of defoliated Scots pine to spontaneous and induced attack by *Tomicus piniperda* and *T. minor*. (ms accepted for publication in Silva Fennica).

Langström, B., Annila, E., Varama, M. & Niemelä, P. 1999. Tree mortality, needle biomass recovery and growth losses in Scots pine following defoliation by *Diprion pini* and subsequent attack by *Tomicus piniperda*. (Ms intended for submission to Scand. J. For. Res.).

Pinus spp. Chemical Composition and Host Selection by the Winter Pine Processionary Moth

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Pine stands cover 1.3 million hectares in Portugal and are grown over extensive areas in the Mediterranean region. *Thaumetopoea pityocampa* (Den. and Schiff.) (*Lepidoptera, Thaumetopoeidae*), the winter pine processionary moth is a major defoliator causing economic damage, particularly to young plantations. Several authors have ranked *Pinus* species according to their relative susceptibility to *T. pityocampa* attack, but differences occur among geographical regions and altitudes. in the present study chemical analysis were made for 8 *Pinus* spp., some of which are native to Portugal and some introduced. Variations were detected among species, mainly in the terpene composition, which were related to the different levels of processionary moth attack recorded. Significant relationships were found between the relative percentages of b-pinene and limonene, present in the bouquets of the needles, and the percentage of pines having larval nests. in a separate experiment, the chemical composition of the needles of individual trees from a stand of *P. pinaster* originated by natural regeneration, were analysed. The variations detected, particularly in the relative amounts of some monoterpenes emitted by individual trees, were statistically related to the number of larval nests of *T. pityocampa* counted. in parallel, biotests were performed in an olfactometer, using extracts of needles of different pine species, to test host selection preferences by the adults. Results indicated a preference of the females for pine species which, under field conditions consistently suffer higher levels of attack in Portugal. Host selection and colonization by *T. pityocampa* thus appear to be influenced by monoterpene emissions of the pine trees.

7.02.07 Impacts od diseases on the sustainability of tropical forests

VA mycorrhizal *fungi* and their role in plant disease control

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Mycorrhizal association constitutes the most striking example of symbiosis in the plant kingdom. There are different types of *mycorrhizae*. The most common are ectomycorrhizae and vesicular *arbuscula*r *mycorrhizae* (VAM). Increased plant growth because of VAM colonization is well documented (Bagyaraj and Varma, 1995). The increased plant growth is attributed to enhanced uptake of diffusion limited nutrients, hormone production biological nitrogen fixation, drought resistance and suppression of root pathogens. Most reports in the literature indicate that VAM fungi decrease severity of diseases caused by root - pathogens. VAM fungi associated with different crop plants suppressing the fungal root pathogens like *Thielaviopsis basicola, Phytopthora parasitica Fusarium oxysporum, Gaeumannomyces graminis var. tritici, Sclerotium rolfsii, Pyrenochaeta terrestris* and *Pythium spp*. have been reported. Similarly, VAM fungi also alleviate the severity of diseases caused by plant pathogenic bacteria like *Pseudomonas syringae* and *P. solanacearum*. Reports on several hosts indicate that VAM fungi decrease the severity of pathogenic nematodes like *Meloidogyne avenaria, M. incognita, M. hapla, M. javanica, Tylenchulus semipenetrans, Pratylenchus brachyurus* and *Radophilus similis* (Sampangi and Bagyaraj, 1989). Mechanisms of suppression of root pathogens by VAM fungi: Studies conducted so far suggest that the mechanism of suppression may be due to morphological, physiological or biological alterations in the host. i. Morphological alterations: Thickening of the cell walls through lignification and production of other polysaccharides in mycorrhizal plants preventing the penetration and growth of pathogens have been demonstrated. A stronger vascular system observed in VAM plants increase the flow of nutrients, impart greater mechanical strength and diminish the effect of vascular pathogens. Smaller syncytia with fewer cells have been reported to impart resistance in the host against root - knot nematodes.

ii. Physiological and biochemical changes: Higher phosphorus concentration found in mycorrhizal plants can offset the severity of a disease caused by pathogens. Decreased root exudation in mycorrhizal plants possibly help in reducing the infection of roots by pathogens. High chitinase activity of the mycorrhizal tissue also may confine the growth of the pathogen in the host. Higher levels of certain chemicals like arginine, phenyl alanine, serine, orthodihydroxy phenols and sulphur containing amino acids reported in mycorrhizal roots were found to be inhibitory to root pathogens.

iii. Biological alterations: Mycorrhizal plants harbour higher population of microorganisms in the rhizosphere thus making it difficult for the pathogen to compete and gain access to the host root. It was also reported that roots colonised by VAM fungi harbour more actinomycetes antagonistic to root pathogens. Recently microorganisms producing siderophores, which are low molecular weight chelating agents that have high affinity for ferric iron and thus fungistatic to many pathogens, were observed in higher numbers in the rhizosphere of mycorrhizal plants. The biocontrol potential of VAM fungi can be exploited in field by further understanding the defence mechanisms and conditions favouring the experience of their protective ability. There is a need to strike an appropriate balance of pesticide - mycorrhiza - other biocontrol agent use in designing integrated plant disease management. The recent advances made in the biological control of rot pathogens of tree species will be discussed.

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Nursery Diseases of Tropical Forest Plantations

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Serious damage to forest nursery caused by seedling diseases often upsets planting programmes. Though seedlings of both exotics and indigenous tree species are affected by disease outbreak, exotics are more vulnerable to pathogen attack, especially after one or two rotations of growth in the host country. in the tropics, as more and more native species cross national boundaries and become accepted-exotics abroad, unknown pathogens also spring up suddenly in host countries causing disease outbreak in epidemic proportions. The warm humid climate prevailing in the tropics is most conducive for pathogen multiplication and host invasion.

Eucalypts, one of the most widely grown exotic species in the tropical countries are severely affected by leaf blight and stem infection caused by *Cylindrocladium spp*. in India, Vietnam, South Africa and South American countries. Wilt disease caused by *Burkholderia solanacearum* is the most damaging bacterial infection on *Eucalypts* seedlings in China and Australia, Brazil and quite recently in India. Among rust fungi, *Puccinia psidii* is the serious problem in Brazil, Taiwan and South Africa. *Cryptosporiopsis eucalyptii*, a recently described fungal pathogen causes leaf spot disease on several species of *Eucalypts* in Australia, Brazil, India, Japan, Thailand, Vietnam and Hawaii causing blight symptoms. *Kirramyces epicoccoides* affects growth and vigour of seedlings by causing leaf spot and subsequent defoliation in Africa, Australia, Brazil, India, Japan, Thailand and Vietnam.

In *Acacia*, though leaf spot diseases are reported from India, serious seedling diseases are rare except phyllode rust caused by *Atelocauda digitata* in Indonesia and powdery mildew in India and Vietnam. Pine needle blight caused by *Cercospora pinidensiflorae* is reported from Vietnam. Diseases like damping off caused by *Pythium* and *Verticillium* spp., collar rot caused by *Rhizoctonia solani* and seedling blight caused by *Sclerotium rolfsii* are the common seedling diseases occurring on indigenous as well as exotic tree species in several tropical countries. in teak, bacterial wilt caused by *Burkholderia solanacearum* and leaf spot caused by the fungus *Phomopsis* and *Colletotrichum* spp. are economically important diseases.

International movement of pathogens occur especially through exchange of infected seeds, and chaff and debris carried along with the seeds. Hence, effective disiffection and strict quarantine laws only can prevent international spread of diseases. Suitable silvicultural methods are adopted to prevent the occurrence of nursery diseases in all the countries. Judicious use of fungicides and bactericides are often recommended to control the economically serious diseases.

Ectomycorrhizas as a deterrent to seedling diseases of trees in the nursery

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Numerous investigators in the last several years have shown that ectomycorrhizas are essential to the establishment and growth of many tree species. Their beneficial effects are physiological in nature such as increased root absorption surface, selective in absorption and accumulation, ability to render unavailable substances in soil available to the plant host etc. A possible beneficial role of ectomycorrhizae in the tree growth and development is that the mycorrhizal fungus protects unsuberized roots from attack by parasitic fungi. It has been postulated that mycorrhizal fungi may conceivably afford protection to the root by i) utilizing root carbohydrates and other chemicals which would be attractive to pathogens, ii) providing a physical barrier to pathogens in the form of fungus mantle, iii) secreting antibiotics which inhibit or kill the pathogens and iv) supporting a protective rhizosphere population of the other micro-organisms. in common with many soil fungi, some mycorrhizal symbionts are capable of antibiotic action. The antibacterial and antifungal compounds produced by mycorrhizal fungi against root rot and damping off of nursery seedlings of tree species have been studied by several workers. They suggest that antibiotic production by the mycorrhizal fungi may be the factor in the survival of seedlings in nature by warding off attack by root pathogens. The production of antibacterial compounds by mycorrhizal fungi in pure culture has also been investigated.

Keywords: Mycorrhiza, Biocontrol, Root pathogens, Diseases of nursery seedlings.

Rust diseases of Indian Conifers

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Indian conifers include pines, deodar, fir and spruce. Pines constitute one of the most divergent and economically important group of species found in the Himalayas. The pine species occurring in India number four and are *Pinus roxburghii*, *P. wallichiana*, *P. girardiana* and *P. kesiya*. of these *P. roxburghii* and *P. wallichiana* are distributed widely extending over a long strip of 3200 km from the west to east occupying an area of 6728 sq. km. and 2270 sq.km. respectively. The occurrence of *P. gerardiana* and *P. kesiya* is restricted, the former distributed in the dry zone of inner western Himalaya and the later to eastern Himalayas and Khasi hills occupying an area over 400 sq.km. and 2000 sq.km respectively. The conifers help in restoring the fragile ecosystem of Himalayas. Apart from this they provide valuable natural resources like resin which contributes significantly to the local employment and national economy. Deodar (*Cedrus deodara*) fir (*Abies pindrow*) and spruce (*Picea smithiana*) occur at different altitudes in Himalayaa and provide timber for buildings and packing boxes. in *P. roxburghii* or Chir pine, stem rust caused by *Cronartium himalayense* is a major problem in the younger plantations, causing mortality to the tune of 5-40% in different localities. The rust completes its life history on a local weed Swertia spp. of all the eight districts surveyed the incidence was found in six districts in Garhwal and Kumaun regions. The pathogen produces pycnia and aecia on Chir pine, causes girdling and kills the affected portions. *P. wallichiana* or Kail is reported to be attacked by *Cronartium ribicola* a macrocyclic and heterocious rust. The incidence is observed in Bushahr and Kullu in Himachal Pradesh and Hazara, Kashmir and Kangan in Jammu and Kashmir. From Uttar Pradesh it is reported from Chakrata. The rust attacks young plants on stem and branches which become swollen, blistered and girdled. It develops pycnia and aecia on blue pine and urredenia and telia on *Ribes rubrum* and *R. orientale*. *Cronartium quarcuum* attacks *P. kesiya* in mature trees around Shillong (Meghalaya). The branches become swollen and aecia develop profusely. The damage is not very significant. The needles of Chir and Kail pines are attacked by *Coleosporium campanulae* and *C. barclayense* respectively. Small orange to yellow sacs of aecia are produced on the needles numbering 2-15. It gives an ugly appearance to the plantations. Mostly the younger plants are affected. No apparent damage is caused as the affected needles are shed at about the same time as healthy needles. in *Cedrus deodara* (deodar) needle rust is caused by *Peridermium cedri*. It is an autoceous rust and attacks the young needles of current year's shoot. The infected needles bearing pycnia and aecia remain shorter and curve backwords. Infected needles are shed earlier and therefore, the folaige becomes sparse. Witches broom is produced on the affected branches and in extreme cases it may cause mortality to the branch and young trees.

Other needle rusts reported are *Ploioderma cedri* on deodar, *Caeoma himalayensis* on fir and *Peridermium*

thomsoni on spruce. But all of them are endemic to small areas in Jammu & Kashmir, Himachal Pradesh and hills of Uttar Pradesh.

Epidemic Diseases - potenial threat to plantation forestry in India

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In India, plantation forestry commenced with the small-scale planting of teak, *Tectona grandis* in Nilambur valley, Kerala, the southernmost state in 1840s. Since then, teak has been growing on a large-scale in plantations as monoculture or mixed with broad-leaved softwood species through out the countries. Casuarinas were also introduced in the coastal belt of Peninsular India during the British colonial period for meeting the requirement of fuel wood for steam engines. At present casuarinas, especially *Casuarina Equisetifolia* have been growing on a large-scale under different afforestation programmes including agro-forestry in inland as well as coastal areas in Peninsular states of India. During 1960s large-scale planting of *Eucalypts* initiated in Kerala State by clear-felling the degraded semi-evergreen and moist deciduous forests in low and medium altitude areas and in grass lands in high altitude areas to meet the requirement of pulpwood industries. During the past 150 years of plantation history different timber and multipurpose tree species have been growing in different parts of the country. Though, the plantation forestry has experienced set-backs due to biotic factors like human interference and cattle grazing and abiotic factors like fire and erratic rainfall, epidemic outbreak of diseases posed threat recently. During 1970s epidemic outbreak of diseases occurred in *Eucalyptus tereticornis* plantations raised in humid areas in Kerala and Karnataka State devastating the crops entirely. Pink disease caused by *Corticium salmonicolor* affected the plants of >6 year-old and foliage blight caused by different species of *Cylindrocladium* affected the plants of <3 year-old severely. A second outbreak of pink disease in *E. tereticornis* plantations occurred in 1980s devastating the plantations in low and medium elevated areas through out the state. Recently, *E. grandis* raised in high altitude areas (950-1000 m above msl) which showed remarkable resistance to pink disease earlier, also become succumbed to severe attack by the disease. Pink disease and *Cylindrocladium* blight epidemics occurred in 1995 and 1996 and wiped out hectares of plantations to an extent alternative species like *Acacia auriculiformis* was sought for in *Eucalypts* failed areas. Teak, the hardy species with more than 150 years in plantation forestry in India, has also become severely damaged by the pink disease, recently, mainly due to the altered high input silvicultural practices. *Casuarina equisetifolia* plantations raised in inland and coastal areas in Peninsular states are found severely affected by stem wilt disease, caused by *Trichosporum vesiculosum*. Though the disease was noticed in 1905 in coastal plantations in Orissa State, epidemic outbreak of disease occurred recently, especially in Tamil Nadu, Karnataka and andhra Pradesh. The pathogen is indigenous and cause disease only in casuarinas. Whereas, Corticium salmonicolor has a wide host range of more than 420 tree species belonging to 104 genera both indigenous and exotic. Though biology of the fungus and etiology are well understood, disease management strategy heavily depends mostly on cultural measures due to economic constraints. At present, plantation forestry in the country is at the cross road and set backs from the epidemic outbreak of diseases have adversely affected the pulp, paper and rayon industries as well as the farmers. The paper highlights the possible influencing factors for the disease outbreak, and short-term as well as long-term disease management strategies to be adopted.

Status of forest Diseases in India and Future Research Needs

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With the increasing demand for wood in India, forestry has gained importance in recent years. To meet this challenge the productivity of forest plantations is being increased by intensive management. However, as the management intensifies with high inputs more and more disease problems are surfacing. Since, India's climate ranges from temperate in the northern region to tropical in the southern peninsula, types of diseases and incidence and severity show considerable variation chiefly due to the prevailing climatic conditions, edaphic factors and host species. This makes the management of forest diseases quite complex. The most widely planted species in India are *Acacia auriculiformis, Albizia falcataria, (Paraserianthes falcata), Azadiracta indica, Bambusa arundinacea, Bombax cieba, Cosuarina equisetifolia, Dalbergia, sissoo, Eucalyptus tereticornis, E. camaldulensis, Gmelina, arborea, Pinus, spp., Populus sp., Grevellia robusta, Tectona grandis, etc.*

Seedlings for raising plantations are grown either in conventional way in bareroot nurseries or more recently in root trainers with little management to high in-put management. This variation in nursery practices is reflected in the type and severity of diseases encountered. Generally, damping-off which occurs throughout India, is the most serious disease of young seedlings in forest nurseries. in temperate and drier regions, *Pythium, Fusarium* and *Macrophomina* are the dominant pathogens, whereas in tropical humid regions ubiquitous facultative parasites, *Rhizoctonia*, *Sclerotium* and *Cylindrocladium* are the major pathogens causing a wide variety of serious diseases. With the advent of root trainer nurseries problem of nematodes, otherwise unnoticed in conventional nurseries, has caused serious loss of teak seedlings in root trainers.

In plantations, various diseases affect the outplanted seedlings right from the beginning, till the time the crop is ready for harvest, the rotation period being from seven years in *Eucalyptus* to 60 years in teak. Since, some of the tree species are planted throughout the country under different agro climatic conditions in contrast to others limited to a particular climatic zone, two categories of diseases are identifiable: diseases of wide occurrence and diseases of restricted occurrence.

Among the serious diseases of wider occurrence, the prominent once are *Cylindrocladium* leaf blight (CLB) of *Eucalypts*, blister blight (BB) of *Casuarina (Trichosporium vesiculosum)* and phanerogamic parasite (mistletoe) of teak *(Dendroephthoe falcata)* which have been given some attention during the past two decades. However, bilster blight and teak mistletoe need more attention to work out strategies to control them. Since, CLB and BB are of international importance concerted efforts and networking of organizations in tackling them are warranted.

On the other hand there are certain diseases of restricted occurrence in a particular geographical area causing serious loss. Among them the important diseases are spike disease of *Santalum album* caused by phytoplasma, shoot blight of bamboos, heart rot of *Dalbergia sissoo*, *Cryphonectria* canker of *Eucalypts*, Hendersonula die-back of *Acacia mangium, Phomopsis* and *Macrophomina* die-back and *Melampsora* rust of *Populus*, and rust of native pines in Himalayas. Some of these diseases of restricted occurrence for example Hendersonula die-back are possibly manifested due to stress conditions under which the host is grown. Another category of diseases of rather recent origin is that appearing in high in-put plantations. The best example is that of pink disease of teak (*Corticium salmonicolor*) which came in prominence by causing more than 50 per cent incidence in high in-put plantations being grown by private companies as compared to 1-2 per cent in plantations raised by the State Forest Department. in the light of the above the paper evaluates the current status of some of the significant forest diseases in India and identifies priority areas of research for bridging the gaps in information for better management of diseases and increasing the much needed forest productivity.

Strategies linked to reduce the impact of *Cryphonectria* canker in South Africa

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Keywords: *Cryphonectria* canker; Population diversity; Double-stranded RNA

Cryphonectria canker caused by *Cryphonectria cubensis* is responsible for considerable damage to *Eucalyptus* plantations in tropical and sub-tropical areas of the world. It is, therefore, essential to have effective management strategies to limit the impact of this pathogen. Planting of disease tolerant clones is one approach, but the potential to reduce the virulence of the pathogen through double stranded (ds) RNA mediated-hypovirulence is also an attractive option. It is, however, necessary to possess knowledge regarding the population diversity of the fungus before biological control can be applied. in this study, a survey of diseased trees was undertaken to evaluate the occurrence of sexual reproductive structures, and thus to consider whether sexual reproduction is occurring in C. *cubensis* in South Africa. An experimental approach was undertaken to confirm these findings. The diversity of the South African C. *cubensis* population was assessed based on vegetative compatibility tests, and various measures of diversity were used to assess the data. A field inoculation was conducted to consider whether there was any correlation between VC groups and their virulence. Further the South African C. *cubensis* population was screened for the presence of dsRNA. Slow growing isolates were identified using growth studies and these were screened for dsRNA using column chromatography. Two dsRNA-containing isolates were obtained from a sample of 100 isolates. A greenhouse inoculation trial was conducted to determine whether the isolates containing dsRNA display hypovirulence. Results of this study showed

that only asexual reproduction occurs in C. *cubensis* in South Africa. Twenty-three VC groups were detected from a sample of 100 isolates each collected from single diseased trees in plantations in KwaZulu-Natal. Analysis showed that this represents a low degree of genetic diversity. Inoculation studies revealed that isolates belonging to different VC groups differ significantly in their ability to cause disease. Results of the inoculation to test for hypovirulence indicated that only one of the two isolates had a reduced capacity to cause disease. Studies are now being undertaken that will further promote the use of dsRNA for biological control of C. *cubensis* in the future.

7.02.10 Global spreading of pine wilt

Pine Wilt Disease: A Potential Threat to Coniferous Forests Around the World

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Throughout time, the distribution of the world's biota has not been static but has been gradually changing. This rate of change is much more rapid today because of biological invasions resulting from increased human activity, including international trade and travel and the disturbance of ecosystems. These invasions by exotic species include many unwanted forest pests, such as the pinewood nematode (PWN), *Bursaphelenchus xylophilus*, which has recently created havoc and concern around the world. This nematode is native to North America and is the causal agent of pine wilt disease (PWD) of *Pinus* spp., but other conifers may also serve as hosts. The PWN is vectored by *cerambycid* beetles (*Monochamus* spp.) which are normal inhabitants of coniferous forests worldwide. Different abiotic and biotic stress factors are reported to predispose trees to infection, however, variation in host specificity and pathogenicity has been noted for different PWN isolates. This nematode can also persist in living trees without inciting PWD.

As an exotic pest, the PWN is responsible for causing significant PWD in both native and exotic pines in Japan, South Korea, Taiwan, and The People's Republic of China. However, in North America, the PWN is not considered an important pathogen of native pines although it has caused PWD in some areas where exotic pines have been planted. The PWN is believed to have been introduced to Japan in logs from North America about 100 years ago, and today it is considered the most serious pest of pines by the Japanese. It is now also considered a very serious pathogen of pines in The People's Republic of China. The impact of this nematode and its vectors has resulted in enormous ecological, cultural, aesthetic, and economic impacts that will continue to create problems for generations to come. The PWN has a history of being transported in raw wood and wood products, and infested wood is believed responsible for spreading this nematode and its vectors both within and between Asian countries. Because of the perceived threat of PWD, some countries have established restrictions on importation or movement of coniferous wood from countries or regions of countries known to have the PWN. in Europe, a recent pest risk assessment concluded the PWN posed a potential threat to the continent's forests, so the nematode is now an A1 quarantine pest as described by the European Plant Protection Organization. As an exotic pest, the PWN should be considered a high-risk, disease-inciting agent for pine-growing regions worldwide. The threat of the PWN to coniferous forests is real and the only known way to reduce this threat is to be most restrictive in the importation and movement of potentially PWN-infested wood of all kinds.

Keywords: *Bursaphelenchus xylophilus*, pinewood nematode, *Pinus*, exotic pest, threat.

Unsuccessful experience in controlling the Pine Wilt in Japan

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After the discovery of the pinewood nematode, *Bursaphelechus xylophilus* as a causal agent of the dreadful wilting disease of pine trees in 1970, enormous efforts have been made to control this forest epidemic disease.

Aerial application of insecticide has been carried out to obstruct maturation feeding of vector beetles on the healthy pine trees, thereby to prevent the transmission of nematodes into pine tissues. This measure seemed to be effective to reduce the pine wilt death, but has to been performed with many limitations because of environmental concerns. The procedure of felling down dead pine trees, and de-barking and then burning them should be effective, if carried out thoroughly, but this control measure has become impossible because of the shortage of forest workers. Trunk-injection of nematicides was developed to protect such precious pine trees as planted in gardens, golf courses, parks, shrines and temples. But this effective method has been able to apply neither to pine forests nor to mountain pine stands due to its high cost.

Without any limitations such as financial cost, labor shortage, environmental problems, could we be successful to control pine wilt disease? Perhaps, not. Because humankind itself has made an important role in long-distance transportation of pine wilt. The transportation of the pine logs infested with pine wood nematodes and/or with vector beetles has been legally regulated, but such dead pine trees have been transported from place to place, and thus pine wilt has spread over wide area. Further factors such as air pollutants, acid precipitation, difference in host resistance between local varieties of pines, difference in nematode virulence between isolates, and so on had to be taken into consideration to facilitate the control measures.

Another important point is that there may remain some potential carriers of pathogenic nematodes even after thorough sanitation of pine stands. When the carrier trees become stressed due to high temperature and/or drought, the host resistance could be impaired and nematodes build up their population to kill host trees. Thus, a few years after thorough control procedures, however, pine wilt epidemic could revive in the same pine stands.

Possible adaptation and pathogenicity of pinewood nematode, *Bursaphelenchus mucronatus*, in central European Russia

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The pinewood nematode, *Bursaphelecnhus xylophilus*, causes a serious wilt disease of native pines in Japan and China and is a quarantine pest for Russia. Based on a pest risk analysis for *B.xylophilus* it was concluded that this nematode poses a threat to conifer forests in several areas and territories of Russia (Kulinich, & Kolossova 1995). A closely related nematode, *Bursaphelenchus mucronatus* is widespread in Asia and Europe and may mate with *B.xylophilus*. Various experiments have shown that *B. mucronatus* is weakly pathogenic or non-pathogenic to pines. A field experiment to determine the pathogenicity of the different isolates of *Bursaphelenchus mucronatus* was conducted in the Moscow region (Russia) in 1996-1997. Two-year old, Scots pine, *Pinus sylvestris*, seedlings were inoculated in July, 1996, with each of three *B.mucronatus* isolates: BmCh (from China), BmKOMY (from Komy Republic, Russia) and BmRFE (from the Russian Far East, Primorski Krai). Control seedlings were inoculated with a solution of the fungi *Botrytis cinerea* and *Fusarium gramminearum* in distilled water. Initial inoculation was 1500 nematodes per seedling. The nematodes were extracted 2 months after seedling inoculation and again 1 year post-inoculation in September, 1997. Seedling stems, roots and soil were assayed for presence of *B. mucronatus* nematodes. No nematodes were found in seedling roots or soil. No seedlings had died 14 months after inoculation and only BmRFE isolate nematodes were extracted from seedling stem samples (1 inividual./g of stem tissue). All other nematode isolates failed to survival in seedlings. According to the recent studies of Eroshenko and Kruglik (1996), *B.mucronatus* isolates from Russian Far East were strongly pathogenic to different pine species under field conditions in Primorski Krai. Kulinich, O.A. and Kolossova, N.V. (1995) The potential of the pinewood nematode *Bursaphelenchus xylophilus* to become established in countries of the former USSR. Russian Journal of Nematology 3, 35-48.

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Keywords: pinewood nematode, *Bursaphelenchus mucronatus*, pathogenicity, Russia

Strategy of protection of European forests from pinewood nematodes

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The widespread damage caused by the pinewood nematode (PWN) *Bursaphelenchus xylophilus* in Japan was well recognised by European scientists. There has been much controversy regarding the transmission biology of PWN, the danger of pine wilt disease and the risk management strategies. A pest risk assessment for the European Union (EU) has confirmed the quarantine status of PWN, justifying the phytosanitary measures taken to exclude this nematode from Europe. Furthermore, recent results from inoculation experiments indicate that PWN could pose a threat to pine forests of continental Europe. The total forested area of EU and Norway amounts to 146 million ha. The Nordic forests occupy almost 63 million ha, corresponding to 43% of this area. in the Nordic countries pine forests alone cover about 30 million ha. The annual softwood felling is in the order of 40 million m^3, which could represent a monetary value of about 3 000 million US$. The Nordic forests are of fundamental importance not only to the Nordic economies, but also as a major source of wood products for the entire EU. European coniferous forest ecosystems, regardless of locality, offer good opportunities for the establishment and spread of the PWN. The introduction of PWN into Europe could reduce forest productivity and enforce the erection of internal regulations of trade. There is also a risk of transfer of patogenicity from PWN to resident *B.mucronatus* by interbreeding. The most efficient strategy of protection is to prevent the introduction of the PWN. Preventive measures like forest selection and quality checks in processing would fail to detect latent PWN infections in asymptomatic trees. Thus, harvesting healthy-appearing trees for processing may not be adequate to prevent nematode infestation of wood products imported from areas infested by PWN. Heat treatments still remain the safest means of eradicating the PWN in wood. Methods should be developed to eradicate PWN also from forest products not suitable for kiln drying and pasteurisation. Treatments to eradicate PWN need also to apply for packaging and dunnage. in Europe efforts should be made to survey domestic wood products, and the forest areas for the presence of PWN and *B. mucronatus*, and to develop protocols suitable for monitoring nematode patogenicity on European conifers.

Nematode: characteristics and hazards of its global impact

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Pine forests, one of the great natural resources of our planet, are threatened worldwide by the pine wilt disease caused by the pinewood nematode, *Bursaphelenchus xylophilus*, and its *Monochamus spp.* vector. The direct negative impact of the biological interaction between the *B. xylophilus* and susceptible pine trees has been exacerbated indirectly by wood product trading practices and by some misunderstanding of the biological relationship. Consequently, the potential seriousness of pine wilt disease to the world's pine forests is not always fully recognized, and appropriate action is not taken in the geographic areas where it is necessary in order to prevent and/or slow spread of the disease.

Bursaphelenchus xylophilus belongs to the family Aphelenchoididae, which includes many other nematode species that feed on fungi for some or all of their life cycle and which are closely associated with insects. Many bark beetles pests of forest trees carry aphelenchids in their intestine and vector them from one fungal-feeding site to the next in the cryptic galleries of the forest trees. There are about fifty *Bursaphelenchus* species many of which are associated with forest trees and insects but none of these are lethal like *B. xylophilus*. *Bursaphelenchus xylophilus* is most commonly vectored by *Monochamus alternatus* in east and southeast Asia, but many other *Monochamus* species worldwide, some with overlapping distributions, vector this nematode. *Aphelenchiodes ritzemabosi* interacts with *Rhodococcus fasciens* to cause cauliflower disease of strawberries, but no other aphelenchid species except *B. cocophilus*, the cause of red ring disease of coconut, causes host death. Both *B. xylophilus* and *B. cocophilus* cause death of the host tree within a few months of infection and both these nematodes require a mobile, plant-feeding coleopteran as the vector.

Many other tree species are parasitized by nematodes but none of them die so fast and the disease does not spread so rapidly. Orchard trees, are significantly affected by plant parasitic nematodes such as the citrus nematode, *Tylenchulus semipenetran*s (causing spreading decline of citrus) and the lesion nematode, *Pratylenchus spp*. (several species of which attack a range of fruit and nut tree species). However, the pathological impact of these nematodes tends to be modest and relatively gradual through wilting during drought and through nutrient depletion. These nematodes often do not significantly affect the host tree except during periods of severe plant stress. By contrast, *B. xylophilus* infected pine trees characteristically die within a few months of infection, though the physiological processes leading to tree death also can be exacerbated by stress factors such as fire and mistletoe. A few nematode species, *e.g. Aphelenchus avenae* and *Aphelenchoides composticola* debilitate forest trees by feeding on the mycorrhiza but this limits tree growth rather than causing death.

It is not only the susceptible pine species of our indigenous forests that are vulnerable to pine wilt disease but also the extensive monoculture plantings of susceptible, exotic, pine species especially in the southern hemisphere. These large areas of pine plantations are vulnerable if the temperature is high enough (about 25?C) for long enough (continuously for 8 weeks) and providing that an insect vector is present. Concurrently, there is extensive international trade of pine wood chips and bark-covered pine logs that potentially carry *Monochamus spp.* and *B.*

xylophilus from countries that have natural populations of *B. xylophilus* and its vector to countries that have susceptible pine species and appropriate climates for the disease. The high temperatures not only increase the rate of nematode reproduction but increase also the number of generations per year of the insect vector thereby quickly raising their population threshold for the disease to epidemic proportions. As well, the higher temperature stresses the trees physiologically in that within a few hours of nematode infection they lose water faster from the leaves and the tracheids became blocked.

Control of this nematode disease is difficult because it affects very large area of trees, often in less accessible areas, and the nematode population maintains itself on fungus infected dead trees as well as on living trees. As well, the vector is a vigorous flyer and survives on dead or dying trees. The development and propagation of genetically resistant trees is a viable though very long term option. Modification of trading practices could provide faster results.

Distribution of pine wilt disease and its spreading manner in China

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Since the first discovery of PWN in Nanjing city, Jiangsu province in 1982,the nematode has distributed in 6 provinces Jiangsu, Anhui, Zhejiang, Shandong, Guangdong and Taiwan, as well as Hong Kong. There are 14 counties in Jiangsu, 16 counties in Anhui, 10 counties in Zhejiang, 3 counties in Guangdong, 1 county in Shandong. The total diseased area is about 70000 ha. The diseased pine species are *Pinus thunbergii* and *P. massoniana* mainly, as well as *P.densiflora*, *P.luchensis*, *P.elliottii* and *P. pinaster*. The vector of PWN is *Monochamus alternatus*. The phenomenon of the disease occurrence showes that the invasion of PWN into virgin areas is mainly caused by artificial transport of diseased lumber and packing box. The new diseased points are usually around new hotels,television transmission stations, factories, military units,public places and so on. Besides, it is supposed that wind, especially hurticane and typhoon, can bring the beetles (*Monochamus alternatus*), carrying PWN to virgin area far form the diseased area. Because the pines in small island can be attacked by PWN, the small island is above 7 miles from the diseased area and no body can go aboard the small island.

7.02.10 Epidemic factors of pine wilt

Ectomycorrhiza in pine forests infested with pine wilt disease

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In order to clarify the relationships between the pine wilt incidence and ectomycorrhizas which may affect or be affected by vigor of host pine trees, fruit body occurrence and species composition of mycorrhizal fungi were surveyed in Japanese red pine stands exhibiting varying degrees of disease incidence around Mt. Tsukuba, Ibaraki Prefecture, Eastern Japan. in healthy stands many species of mycorrhizal fungi occurred, in contrast to the infested stands where mycorrhizal fungi were rare. From two healthy and one infested stands, soil cores were taken around living pine trees and mycorrhizal root tips were classified into morphological "types". Composition of mycorrhizal types among the stands were different from each other. However, in every stand mycorrhizas were formed on more than 95% of the observed root tips. From this fact, decline in fruit body number in infested stands was not caused by decrease of mycorrhiza on pine roots, but the decline of fruiting activity of the mycorrhizal fungi. Mycorrhizal growth in 5-year-old pine seedlings inoculated with pinewood nematodes were markedly inhibited in both killed and survived seedlings. This indicates that infection of nematode reduce the allocation of carbohydrates to the mycorrhiza. From these results, fruiting activity of ectomycorrhizal fungi seemed to be greatly influenced by the pine wilt damage not only by the death of the host tree, but also by the latent infection.

Keywords: *Bursaphelenchus xylophilus*, ectomycorrhiza, forest floor, fungal flora, pine wilt

Wilt diseases- induced xylem embolism in trees

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Recently in the research field of tree water relations, the mechanisms and ecological meanings of the cavitation and the embolism in the tree xylem occurred during water stress and by freeze-thaw event have fairly been made clear. Three major wilt diseases are the Dutch elm diseases, oak wilt and pine wilt disease. Although it has been known that wilt disease induced water stress in their host by reducing the hydraulic conductivity of the cylem, embolism as a cause for this has received very little attention. in the case of Dutch Elm disease, embolism precedes any occlusion of vessel by other means. The exact causes of cavitation and embolism remain unclear. Pine wilt disease is characterized by rapid wilting during a short period of summer. The occurrence of cavitation and embolism during the disease development has been confirmed. This paper shows the general mechanism of cavitation and embolism occurred in trees suffered from three major wilt diseases.

Insect vector-nematode relationship and virulence of nematode against host plants.

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Infestation level of parasite and disease-causing organisms is associated closely with a relationship between their virulence and transmission ability. Rapid change in virulence sometimes occurs by the introduction of the parasite into new ecosystems. How much does the enhanced virulence change transmission ability and its components? Pine wilt caused by the pinewood nematode gives an interesting case to study the virulence-transmission relationship. The pinewood nematodes (*Bursaphelenchus xylophilus* and *B. mucronatus*) are transmitted to healthy trees by pine sawyer beetles (the genus Monochamus) and the beetles oviposit on trees killed recently by virulent nematodes. Interestingly, the nematodes are also transmitted to dying trees via the oviposition wounds made by the beetles. So, different nematode virulence against host trees must affect the vector-nematode relationship. I used 3 systems for analysis; the Japanese *B. xylophilus-M. alternatus* system including virulent nematode against host trees, the Japanese *B. mucronatus-M. saltuarius* system including avirulent nematode, and the American *B. xylophilus-M. carolinensis* system including avirulent nematode.

Field study shows that avirulent nematode has much higher transmission rate per tree per year (0.13-0.17) than virulent nematode (0.0050-0.0064) in Japan. Thus, a negative relation is found between virulence and transmission ability. A wide variation is observed in the initial nematode load on insect vector. Extremely heavy nematode load makes beetle longevity shorter. As the nematode load increases, such effect is much larger for virulent nematode than for avirulent nematode. This seems to have influence on the frequency distribution of initial nematode load. Actually, its peak is biased toward lower load for virulent nematode while toward higher load for avirulent nematodes. Longevity-shortening effect of nematode load causes beetle's reproductive capacity to decrease. Such deleterious effect on beetle's reproductive capacity is estimated to be highest for the American *B. xylophilus-M. carolinensis* system and lowest for the Japanese *B. mucronatus-M. saltuarius* system. Short life of beetles is also related with the probability of nematode's surviving till successful invasion of pine trees. The deleterious effect on survival rate of nematodes is estimated to be much larger for virulent nematode.

The study of the pinewood nematode showed that a negative relation between virulence and transmission rate. Some components of nematode transmission ability is considered to be associated closely with nematode virulence and other with a short length of time during which species interactions have been continuing in Japan. I will compare the virulence-transmission relation among biological systems including nematode, insect vector and host plants.

Recent advances in studies on chemical ecology and behavior of the Japanese pine sawyer adult

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Keywords: pine sawyer, chemical ecology, attractant, oviposition, feeding

Factors affecting oviposition, feeding, etc. of *Monochamus alternatus* (JPS) were reviewed. Mature adults of both sexes are attracted to the suitable oviposition site, freshly felled pine bold, diseased pine tree caused by *Bursaphelenchus xylophilus* (PWN), etc. Female shows a series of actions; oviposition behavior sensu lato and sensu stricto. The orientation to the site is mediated by odor, of which the major components are monoterpenes and ethanol. Besides the attractant, some new substances were found to stimulate or mask attractiveness of oviposition site. Differences in attraction behavior between sexes were also reported.

For control and monitor the pine bark and wood-boring beetles which had been considered to be causal agents being responsible to deteriorate and kill pines "Hodoron", an attractant formulation for those beetles including JPS, of which the main components are eugenol (9.0%), benzoic acid (23.0%), iso-propanol and other organic solvents, had been developed. Since the findings of PWN and JPS, another attractant "Madara-call" had been developed for JPS attraction, of which main components are pinene and ethanol.

Both volatile and contact sex pheromones concerning mating were reported, but most of their nature remains unknown. Presence of jelly-like oviposition marker on oviposition acar and inhibition of another additional oviposition nearby the laid egg were reported.

For oviposition adequate moisture on the host surface was essential. Some sugars, sterols, etc. stimulated feeding and/or biting. Some new chemicals stimulating oviposition were reported recently.

So many behaviors of JPS are known to be closely associated with certain chemicals. Some of their stimulus-response relation have been described and elucidated, but most of them remains unknown yet. Toward the integrated pest management of pine wilt disease, especially that of JPS, behavior-controlling method could contribute greatly to the system, and we anticipate development of researches in the science and technology along this line in the near future.

7.03.00 Review of recent developments in the management of major tropical forest insect pests. Theory and practice

Management of the Sal Heartwood Borer, *Hoplocerambyx spinicornis* in India

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Keywords: *Hoplocerambyx*, sal, borer outbreak, *Shorea robusta*, trap-tree operation)

The sal heartwood borer, *Hoplocerambyx spinicornis* Newman (*Coleoptera*, *Cerambycidae*) is considered the most destructive forest pest in India and is well known for its periodic outbreaks in high risk sites. An epidemic which began in 1994 in Madhya Pradesh provided an opportunity to study the behaviour of the pest and the response of the host, on the face of the existing outbreak management system, which relies on (1) removal of infested trees and (2) trapping beetles using trap trees and killing them. Observations over a two-year period from March 1998 to February 2000, revealed several interesting features of the rise and fall of infestations, which are reported here. There was a definite preference of the pest for trees of higher girth class, throughout the epidemic. Some of the infested trees recovered in course of time. Removal of sparsely infested trees may also mean removal of potential new infestation sites, thereby increasing the risk of infestation of un-infested trees. Tests showed that beetles were attracted to light traps. Incidence of the elaterid predator, Alaus sp. was recorded.

The findings of this study suggest rethinking and refinement of the existing recommendation for sal borer outbreak management, particularly, limiting the removal of trees to the more severely infested categories. Future research should focus on (1) isolation of the chemical attractant present in the tree sap and developing suitable mechanical trapping devices using the attractant chemical(s) to replace the traditional tree-trap, (2) standardizing the use of light trap for trapping beetles, and (3) exploring the scope of using the elaterid predator for biological control. International cooperation will be useful for isolation and synthesis of the attractant sap chemical(s).

Teak Beehole Borer, *Xyleutes ceramica*: Ecology and Management

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Keywords: Teak beehole borer, *Xyleutes ceramica*, control

The teak beehole borer, *Xyleutes ceramica* Walker (*Lepidoptera*, *Cossidae*) is the most important pest of teak in Thailand, in terms of its effect on reducing wood quality. It is also a serious pest in Myanmar, Thailand and Malaysia. This moth caterpillar bores in the wood of standing teak trees, making a big tunnel in the sapwood and heartwood, thereby causing serious depreciation of wood quality. Infestation takes place throughout the life of the tree and a 40-year old tree may have up to 165 tunnels. Infestation is localized; in some plantations, particularly in northern Thailand, up to 100 per cent of the trees may be infested.

Current control practices include removal of young larvae by scraping the infested bark using a knife, injection of insecticide into larval holes and trapping of newly eclosed moths. There is also indication of presence of beehole borer resistant provenances.

In Thailand, research has concentrated on life history and study of the sex pheromone. in collaboration with Japan International Cooperation Agency, the sex pheromone has been identified, purified and bioassayed and its use for monitoring and management of the beehole borer is being standardised.

Management of the Teak Defoliator, *Hyblaea Puera* - Current Status

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Keywords: teak defoliator, *Hyblaea puera*, baculovirus, population dynamics)

Currently, there is an unprecedented expansion of teak plantations across the tropics. They are managed intensively to get maximum yield in a short rotation period. in this context, this paper examines the current status and prospects for management of the major teak pest, *Hyblaea puera* Cramer (Lepidoptera, Hyblaeidae). Commonly known as the teak defoliator, *H. puera* has been recognized as a serious pest of teak plantations for over a century. Originally distributed in the natural teak belt of the Asian tropics, it has now spread, along with teak plantations, to other tropical countries, particularly in the Asia pacific and some central American and African regions. Severe outbreak has recently been reported from Costa Rica. in most teak growing countries in the Asia Pacific, extensive and repeated outbreak of this defoliator is a spectacular, annual feature during the early part of the growth season. It was estimated to cause an annual loss of up to 3 cm^3 of potential volume increment per hectare of plantation.

Past recommendations for management, which relied on augmentation of native insect parasitoids through promotion of the alternative hosts of the parasitoids by manipulation of the vegetation cover, proved inadequate because of the unique population dynamics of the pest. Aerial application of chemical insecticides, although tried in the past, cannot be practiced widely because of environmental considerations. Search for genetic resistance to the pest did not yield useful results. The present situation on teak defoliator management is as follows. (1) in the extensive teak plantations maintained by Government Forest Departments or Government sponsored agencies in India, Myanmar, Thailand and Indonesia, generally no control measures are practiced and the plantations continue to suffer loss of increment. (2) in high-value plantations over small areas in Thailand, as well as on an experimental scale in India, the microbial insecticide, Bacillus thuringiensis is applied aerially. (3) in plantations raised by individuals and private commercial companies in several countries, including India, Thailand, Malaysia, and Costa Rica, chemical insecticides are applied aerially, in some situations. This practice is now on the increase due to the rapid expansion of commercial teak cultivation across the tropics and poses a threat to environmental quality.

Current research on teak defoliator management, particularly in India, focuses on the one hand, on the potential of total population management by preventing large-scale outbreaks by controlling the population build-up in the early outbreak epicentres and, on the other hand, use of a baculovirus isolated from H. puera. Scientific understanding of the causation of the sudden outbreak of this pest that follows the early monsoon rains and spreads subsequently over extensive areas, is essential for developing appropriate management strategies. Recent research in India has suggested two hypotheses for outbreak initiation- (1) wind-aided concentration of dispersed local populations, (2) Long-distance displacement of pre-existing high-density populations between countries.

Status and Management of Small Coleopterous Borers in Living Timbers in Tropical Africa

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Keywords: Africa, Natural forests, Plantations, Bostrychidae, Platypodidae, Scolytidae

As natural forests in the tropics continue to shrink and plantation area increases, there is growing concern for the health of both. Managed forests and plantations in Africa often face difficult physical environments in combination with serious interference from pests, including insects. Among these, several borers are notorious for diminishing the quality of precious woods, either while a tree is still living or after its harvest. This paper synthesizes existing knowledge concerning three families of small, coleopterous borers (Bostrychidae, Platypodidae, Scolytidae), which are or may become, pests in living timbers in tropical Africa.

With a few exceptions, small coleopterous borers in Africa are polyphagous. They rarely attack healthy trees or seedlings, and direct mortality of hosts, other than heavily attacked seedlings, is exceptional. Their activity seems largely restricted to nurseries and plantations and their impact is mostly felt in conjunction with dry seasons, fire or other injuries.

Given global warming trends, increasing international commerce and future expansion of plantation culture, this group of insects could become a more serious factor in timber production and trade. Potential methods of dealing with them are discussed. It is suggested that in addition to cooperative quarantine efforts and innovative pest control methods, wherever feasible, the emphasis should be cultural i.e., a shift from plantations to more natural forest management, emphasizing more complex stand composition and structure.

7.03.03 Insect Pest Problems in Replanted Forests

Screening spruce for genetic resistance to white pine weevil in British Columbia, Canada

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The white pine weevil, *Pissodes strobi* Peck (Coleoptera: Curculionidae) is the most serious native pest of spruce regeneration in British Columbia, attacking primarily Sitka (*Picea sitchensis* (Bong.) Carr), white (*P. glauca* (Moench) Voss), and Engelmann spruce (*P. engelmanni* Parry). The weevil has one generation a year. The eggs are laid from late April to June in punctures made by the female in the bark below the buds of the terminal (year-old) shoot. The larvae burrow downward in the bark, feeding on the phloem, which eventually kills the terminal. Destruction of the apical shoot reduces growth and causes deformities.

With respect to white spruce, a large family trial near Clearwater, British Columbia, has been surveyed annually for weevil resistance between 1993 and 1998. The latest results confirm a preliminary resistance raking of each family developed in 1994 using an index which measured intensity of attack (number of attacks per tree), severity of each attack (how many internodes were destroyed) and tree tolerance to attack (i.e., if tree develops good form after an attack). The study demonstrated significant genetic variation in the attack resistance. Variation in resistance was related to ecoclimatic conditions of the parental tree source. Analysis showed that those parents from locations with high weevil hazard yielded higher proportion of resistant trees. These sites are primarily low elevation, low latitude sites, especially on Moist-Warm habitats of the Sub-Boreal-Spruce (SBS) biogeoclimatic zone.

On Vancouver Island Sitka spruce, screening has been conducted in seven test sites. Recent results obtained from measurements of weevil attack in new trials established by the BC Ministry of Forests, confirm the Big Qualicum area of Vancouver Island as a good source of resistant genotypes. To accelerate the screening process, and create a uniform weevil pressure, insect populations have been augmented at several trials. Spruce families with resistance have been able to withstand very high weevil populations. At Port Renfrew, BC, weevil attack was increased from less than 1%/year to 51% in one year, yielding new selections.

We hope that these new selections, along with earlier results, will form the basis for successful establishment of Sitka spruce plantations in B.C. These trials are also yielding important information on the population dynamics of the white pine weevil, the importance of its parasitoids in population control, the role of fungi in the weevil/host system as well as information on possible resistance mechanisms. We expect to integrate resistance as a component of an Integrated Pest Management System. An important consideration when utilizing resistant genotypes in reforestation programs is its deployment in mixtures with susceptible stock. Deployment of these genotypes should, at all times, take into consideration the need for avoiding the risk of insect selection

Insect pest problems in plantations in the high forests of Africa

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Plantation forestry is a relatively recent phenomenon in the humid Tropical Africa probably because of the rich natural forests. However the high rate of deforestation (1.2%) coupled with the ever increasing population have necessitated the establishment of forest plantations to meet growing demand and variety of needs. Whilst pest problems are largely unknown in the natural forests serious problems have been reported in the replanted forests. Pests such as *Phytolyma lata Hypsipyla robusta*, *Lamprosima lateritialis*, *Apate monachus*, *Angophe venuta*, *Godasa sidae* and many others have hampered the establishment of native species plantations. The Cypress aphid *Cinara cupress* and *Leucenia psyllid. Heteropsylla cubana* have also had devastating effect on introduced plantation species.

The ecological implications to the broader issues of why pests are more devastating in planted forests and not natural forests and why exotic species are more prone to attack than native tree species are discussed.

The effect of biocontrol agents on populations of the large pine weevil (*Hylobius abietis*) in Ireland.

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The large pine weevil (*Hylobius abietis*) continues to be a significant economic pest in Irish plantation forests where it inhibits re-establishment of transplanted conifers on clear-felled sites. Two broad approaches are considered when attempting to reduce the level of the damage caused by weevils. The first is to prevent or at least reduce the access of adult weevils to transplants while they are still small enough to sustain lethal damage. This is currently achieved using topical pesticides applied prior to transplantation, but in future this practice may be replaced by reliance on a combination of greater plant resistance and other silvicultural measures. The second approach is to reduce the productivity of weevils on the mosaic of clear-felled patches within forests where the problem is most acute.

Weevils breed in stumps of conifers left in the ground after felling. Stumps can be made less productive for larval development, or the adults, pupae and larvae could become more likely to suffer disease, predation or parasitism. A well-orchestrated and forest-wide strategy to suppress the weevil challenge to transplants, could add significantly to the first approach and lead to sustainable pest management (Leather et al. 1999). Ideally this would involve zero pesticide use, be at minimal cost and not affect forest biodiversity.

The parasitoid *Bracon hylobii* Ratz. selectively attacks the larvae of *Hylobius abietis* while they are below bark in the subterranean parts of tree stumps. The parasitoid is widespread on forest sites in the UK and in Ireland. On plantation clearfell sites studied over several years, it was found that a mean of 47% of larvae were killed by parasitism and a maximum rate of parasitism of 67% was observed. Only a small proportion of weevil larvae seem to occupy habitats inaccessible to parasitoids, and the hosts are available for parasitism for a long period during development. Research is being carried out to ascertain which forest conditions most clearly favour high levels of parasitism, and what relationship parasitism has to other biological controls such as the use of entomopathogenic nematodes.

Reference: Leather, S.R., Day, K.R. and Salisbury, A.N. (1999) The biology and ecology of the large pine weevil, *Hylobius abietis* L.: a problem of dispersal? Bulletin of Entomological Research, 89: 3-16.

Approach for an efficient control of defoliating insect damage: case of *Godasa sidae* (Lep. Noctuidae) attacks on *Mansonia altissima*

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It is a well-known fact, the impact of insect defoliation of forest tree species. *Godasa sidae* is a major pest of *Mansonia altissima*, one of the most important timber tree species in West and Central Africa regions. It has a high reproductive potential and a short life cycle, leading to many overlapping generations per year. However 2 outbreaks occur in the course of the year leading to a complete defoliation (100%) of the trees in plantations. Fourth and fifth instar larvae are those involved in the high intensity defoliation of the trees (more than 50% of defoliation is observed at these stages).

It was observed that the outbreaks are closely linked to the tree phenology for they occur when the leaves are suitable for eggs lying and young larvae feeding/survival.

The present paper addresses the what and how of the application of any control measure, with special attention to potential biological control.

Possible ways for an effective control of pest damage are discussed here. It is concluded that any efforts to undertake the control damage on trees as a result of defoliation must take place before the outbreak occurs, that is at an early stage of the pest life cycle.

Impact studies for a non-lethal pest (aphids, *Elatobium abietinum*) on spruce seedlings and mature plantations

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Sitka spruce is the most important commercial tree species in the west and north of Britain. Over 530 000 ha of Sitka spruce have been planted since the 1920s and about 5000-6000 ha of new plantings and restocking of Sitka spruce currently takes place annually. However, spruce plantations throughout the UK are susceptible to attack by green spruce aphid, *Elatobium abietinum* (Walker) (Aphidadae), which can cause severe defoliation of older needles. Young spruce trees in plantations are also often infested with root aphids (*Pachypappa* and *Pachypappella* spp., *Pemphigidae*), especially up to and during the thicket stage. The impact of these aphids on the growth of young Sitka spruce has been investigated by means of a long-term, manipulative field experiment in Hafren Forest, Wales, involving insecticide exclusion of aphids and artificial infestation of trees, and a series of nursery trials on pot-grown plants carried out at Forestry Commission research stations. Results from these studies indicate that whereas root aphids at typical field densities have no detectable effect on the increment of established plants, *E. abietinum* has an immediate and lasting effect on tree height growth and a delayed effect on stem diameter and volume.

Height increment is typically reduced by 20-30% by the end of the season following moderate-severe infestation in the spring, and is further reduced in the following two years, although by a smaller amount. Stem diameter and volume increments are not reduced in the year of infestation, but show typical reductions of 10-15% and 20-25% respectively, in the second year. Diameter and volume increments generally return to normal in the third year. The almost exponential growth of young spruce trees after establishment and rapid replacement of lost foliage means that effects on increment from single defoliation events are short-lived, but the corresponding losses in total height and total stem volume persist and are still evident up to 5 years later.

7.03.07 Biological Invasion of Forest Insect Pests - Agents of global change

Butternut Canker: An Exotic Threat to Juglans cinerea

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Butternut (*Juglans cinerea* L.) is considered a minor component of the hardwood forests of eastern North America, yet it is highly valued as a commercial wood with a diversity of uses. This species also provides mast for wildlife and adds significantly to the biodiversity of our forests. However, the butternut canker fungus (*Sirococcus clavigignenti*-juglandacearum Nair Kostichka, and Kuntz) has decimated butternut throughout its range in eastern North America during the past 30 years. This fungus kills trees of all ages and also has been found to infest nuts. The fungus kills trees by causing multiple branch and stem cankers that will eventually girdle the tree, but multiple infections may also predispose the tree to attack by other opportunistic organisms which tend to hasten tree mortality. However, small branches and young trees are usually killed by a single canker.

Recent forest inventory data indicate that butternut canker has had a major impact on butternut survival during the last several decades. For example, in North Carolina and Virginia, 77% of the butternut trees were lost between 1966 and 1986, and Michigan has reported an 84% reduction in the species during the same period of time. A 1993 survey in Wisconsin found that 91% of live butternut trees were diseased and 27% of the total population surveyed were dead. in 1995-96, butternut canker was found on 94% of trees in the Lake Champlain Basin of Vermont and approximately 25% of the trees surveyed at that time were dead. Due to crown dieback, nut production appears limited and regeneration in the Vermont surveyed stands is lacking. Because of concern for butternut, several states have placed a moratorium on cutting healthy trees growing on state lands, and the USDA Forest Service has introduced butternut harvesting guidelines for National Forest lands. Also, the Forest Service, in cooperation with several state and academic institutions, has initiated a tree selection program based on phenotypic disease resistance. Some selections have been made and they are now being propagated by grafting.

The origin of *S. clavigignenti-juglandacearum* remains unknown, but it is believed to be a recently introduced exotic pathogen because of the rapid way the fungus has spread throughout the range of butternut, the aggressive nature of the fungus, the scarcity of disease resistance in the host, and the apparent lack of genetic diversity in the fungus population. Because of the serious impact of this canker disease, butternut is currently listed as a category 2 species and it soon may be placed on the federal government's threatened and endangered species list. Butternut already has been eliminated from the standpoint of sustainable wood production, and the future of butternut as a viable species now remains in serious question throughout the hardwood forest of eastern North America.

Occurrence of *Bursaphelenchus* species (Nematoda, Aphelenchoididae) worldwide and their international spread by coniferous timber trade

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Keywords: *Bursaphelenchus* spp., distribution, conifers, wood, timber trade, spread

About 50 *Bursaphelenchus* species are known to occure worldwide. Due to new descriptions during recent years, their known number is increasing. These nematodes are, preferably, inhabitants of wood. Approximately two thirds of them live in conifer trees. They are distributed throughout the forests of the northern hemisphere and spread by insect vectors. Most of them are associated with Scolytidae, several species with Cerambycidae, Curculionidae or even Nitidulidae. Human activity is known to be the pricipal route for dispersal of *Bursaphelenchus* species over greater distances. *Bursaphelenchus* species have been intercepted on a number of occasions during international trade in wood and wood products. They easily survive adverse conditions. The likelihood of *Bursaphelenchus* species to be transferred to susceptible trees in new regions increases with the simultaneous presence of vector insects in the commodities.

South Africa is the only place in the southern hemisphere, where a determined *Bursaphelenchus* species (*B. leoni*) is known to occur. It has most probably been imported from the Mediterranean region. The most important species of the genera is B. *xylophilus*, the pinewood nematode, which has been imported with wood from North America to Japan. This nematode has been spreading by way of timber trade in East Asia and causes huge damage to pine forests in Japan, China and Korea. in 1999, the pinewood nematode was introduced into Europe and is now established in a restricted area in Portugal. Its introduction pathway is unknown. Some other *Bursaphelenchus* species, chiefly B. *mucronatus* and B. sexdentati have been found to exhibit a phytopathogenic potential in inoculation experiments. B. *mucronatus* is the most abundant species in timber imports from Russia.

The distribution of *Bursaphelenchus* species depends on geographic regions as well as on the availability of breeding places and vectors. *Bursaphelenchus* fauna differs from region to region and is basically divided into American and Eurasian species. Within Europe, preferences of species can be seen for southern and northern Europe. Some species and their vectors occur in Europe, Siberia and East Asia, others seem to be restricted to Asian far eastern regions. Several new records are presented. Temperature is important for the incidence of damage caused by relevant species on suitable hosts. Increasing international timber trade offers the possibility of their world-wide spread. Risks and limits of this process are discussed.

Studies on insect invasions in California's urban forests

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California has a long history of invasions of exotic insects dating back to cottony cushion scale on oranges in the late 1800's. Since then there have been a number of successful invaders facilitated by major ports of entry and international airports. Urban forest invaders such as the elm leaf beetle have become major pests not only in California but in the United States. There are two major tactics that are used in dealing with these pests - eradication and biological control. Eradication programs have been very controversial due to their reliance on chemical pesticides. More recently biological control programs have come under scrutiny due to potential threats to native species and biodiversity. We have chosen to pursue what we believe to be the least disruptive approach - biological control.

We have studied three invading urban forest species in our laboratory - the elm leaf beetle, Xanthogaleruca luteola, the blue gum psyllid, *Ctenarytaina eucalypti*, and the eugenia psyllid, *Trioza eugeniae*. Our studies have resulted in an IPM program for one insect, complete biological control for another, and a partially successful biological control program for the other.

More recently an extensively planted exotic tree, *Eucalyptus camaldulensis*, river red gum, has been colonized by the red gum lerp psyllid, *Glycaspis brimblecombei*. Populations of this leaf sucking, honeydew producing insect have reached such high densities that trees have been defoliated in many parts of California. To date the insect has been found in 30 counties. It was found initially in Los Angeles in June of 1998 and spread rapidly throughout the state shortly after. in addition, the red gum lerp psyllid has been collected from 20 other *Eucalyptus* species planted throughout the state. We have confined our studies initially to river red gum, as this is the tree that is most seriously affected by the feeding of the psyllid.

With each of the invading species that we have studied we have used a similar approach. To begin with we sampled to determine the distribution and abundance of the life stages of the invading insect. We followed this with the development of a monitoring program. With the elm leaf beetle we use a presence-absence technique with the egg stage in the lower crown of the elms. With the psyllids we use yellow sticky traps for adults. Interestingly, the parasitoids of both the blue gum psyllid and the eugenia psyllid are attracted to the yellow traps which facilitates our evaluation of the efficacy of the natural enemy. Once the monitoring technique is in place we initiate foreign exploration and the importation of the natural enemies. We follow the parasitoids in quarantine to be sure that they are primary on the insect being studied and once we feel that they are specific to the host and relatively safe we release and evaluate the natural enemy's role in the dynamics of the pest population.

Without more rigid regulations, insects will continue to be introduced into California's urban forests, and some will become pests. We feel that our approach is the best long term solution to dealing with invasions of exotic forest insects.

Evaluating the risk of invasion by potential forest pests

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The rapid increase in volume, frequency and variety of global trade, together with the high speed at which it is conducted has resulted in many examples of pest establishment in exotic locations. This is certainly the case for forest pests where wood as a product in its own right and, especially, as packaging material for other products, is being moved around the world in very large volumes.

The risks associated with wood as a pathway for pests are recognised by national plant health services and Regional Plant Protection Organisations (RPPOs) and there is an increasing need for relevant and robust risk assessment methods that can be used consistently worldwide. in this paper we show how a pest risk assessment (PRA) scheme developed by the European and Mediterranean Plant Protection Organisation (EPPO) has been employed in the UK to carry out assessments of a number of potentially serious forest pests. We highlight the strengths and weaknesses of the scheme. The determination of environmental suitability in PRA is of key importance and we show how assessments can be improved by the use of predictive models, such as CLIMEX. Thus, based on pest status in their country of origin, some pests, such as the southern pine beetle (*Dendroctonus frontalis*) in the USA, appear to pose a high potential hazard but we show that local environmental conditions in the UK are unlikely to support successful pest development, even if initial establishment is possible. By contrast, the establishment of an Asian longhorn beetle, *Anoplophora glabripennis*, in the USA illustrates how a pest that is relatively unimportant in its country of origin can cause greater problems in a new location. A PRA on *A. glabripennis* indicates that the major pathway in international trade is wood used for packaging and showed, using CLIMEX, that this pest could establish in large areas of Europe. Such an example serves to emphasise that organisms with relatively low pest status in their country of origin may pose a high potential hazard in new locations, but the risks these pests represent is much more difficult to assess. in addition, there may also be unexpected establishment of pests, even though a priori evaluation indicates that risks are low. We illustrate this by describing the discovery of an infestation of the subterranean termite, Reticulitermes lucifugus, in the south-west of the UK. This appears to be just one of an increasing number of examples of pests expanding their ranges beyond the climatic limits previously thought to limit their successful development.

Incursion management drawing on recent New Zealand examples

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Like other trading countries New Zealand has been continually subject to incursions of exotic arthropods and diseases. For the purposes of this paper, the term 'incursion' means an occurrence of an organism not previously known to be established in New Zealand, and does not include interceptions. While it is not always possible to predict the impacts of such incursions, there is no doubt that the number of these is increasing and different approaches are required to their management.

More often than not incursions of forest-inhabiting species are detected in urban situations. Clearly, conservationists, local authority arborists and production foresters favour the implementation of eradication programmes for those organisms that are potentially pests of forest tree species. However, eradication programmes are becoming more difficult to initiate in urban areas particularly with residents' concerns about pesticide use. Moreover, conflicts of interest arise between urban dwellers and programme beneficiaries - obvious programme beneficiaries being the rural forestry and horticultural sectors. Recent New Zealand examples of incursions of particular relevance to the forestry sector include: two lymantriid species, *Orgyia thyellina* (white spotted tussock moth) and Teia anartoides (painted apple moth); Stegommata sulfuratella; gum leaf skeletoniser (*Uraba lugens*); and *Ophiostoma novo-ulmi*, the causal organism of Dutch elm disease. The varying responses to the incursion of these organisms are outlined and compared with recommendations for future programmes.

Invasive Bark and Wood-boring Beetles in Western Canada

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The introduction and establishment of non-indigenous insects in forest ecosystems is a continuing consequence human activity. Ongoing studies of the introduction and establishment of invasive bark and wood-boring insects around the major Canadian port of Vancouver, British Columbia, have shown that six previously unrecognized exotic species of *Scolytidae* and *Cerambycidae* have established in the urban forests. They include species originating from north temperate Europe and Asia, the subtropics, and from eastern North America. Four of these five Scolytidae have also been introduced into eastern North America and/or Europe through commerce.

Within urban forest sites, this recently discovered fauna, along with other previously introduced species, now comprise the major component of survey trap captures. As well, the introduced fauna now dominates the total complement of *Scolytidae* (both individuals and species) attacking some host tree species. One species exhibits a highly restricted distribution within the urban landscape, and two more species have not yet been found outside of urban forests. However, two of the recent introductions have successfully invaded adjacent managed forest lands. Indeed, one of the latter species, that within its native range is only known to attack deciduous hosts, has also been recovered from two species of conifers. Studies are currently underway to determine the extent to which these species have invaded both managed and natural forest ecosystems.

Although the full impact of these recent and other historical introductions is not yet understood, existing information does indicate the potential for some increased economic costs. Limited economic losses resulting from degrade of softwood lumber shipments as a consequence of attack by non-indigenous ambrosia beetles have occurred and attack has been observed in decked timber in managed forests. Preliminary evidence from survey and research trap captures indicates that the existing pheromone-based management systems used to control the levels of damage native ambrosia beetles at mill sites may not be as effective in attracting these exotic species. Thus new management systems may be required.

The biological and ecological impacts resulting from the establishment of these ambrosia beetles, and their associated ambrosial fungi, remains to be determined. These introduced species are now a major component of the scolytid diversity in some forest systems and may impact the diversity of native plant and animal species. The potential for the competitive exclusion of at least one rare native ambrosia beetle exists in British Columbia.

Control methods and management strategy of pine wood nematode in Japan: History and future scope

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In pine wood nematode (PWN), *Bursaphelenchus xylophilus* (*Nematode: Aphelenchoididae*), which causes pine wilt disease (PWD), is believed to be native North America and is thought to have been introduced to Japan in the early 1900's. The main methods of controlling PWD in Japan has been cut & treat (*e.g.* cut & burn, and cut & use sprayor smoke insecticide). Because Japanese pine sawyer (JPS), *Monochamus alternatus* (*Coleoptera: Cerambycidae*), is the most important insect vector of PWN, the purpose of these cut & treat methods are to prevent PWN expansions by preventing the spread of adult JPS. Although it was in the early 1970s that PWN carried by JPS was confirmed to cause PWD, one of the reasons that PWD spread more slowly before the early 1960s was that the cut & burn method had been quite successful because infested dead pine trees were efficiently removed from forests and used for fuel. The spread of PWD accelerated after the 1970s, and PWD has now invaded all of Japan except for Hokkaido and Aomori, the northernmost prefecture of Honshu. Now with our understanding of PWD ecology, PWD would theoretically have been extinguished if all the dead trees were treated properly before the time of JPS adult emergence. According to a simulation by Shigesada et al. (1999), <10% of untreated dead trees may allow PWD to expand its range. Therefore, it is natural to think that there remained <10% of untreated dead trees every year and that this percentage increased after the 1970s. Possible reasons include:

1. Rapid industrialization of Japan made it difficult to treat dead pine trees completely, because the number of forest workers decreased and wood as fuel was rapidly replaced by gas and oil.

2. Many dead pine trees were treated after JPS adults had already emerged, which partially depended on a lack of knowledge of the life cycle of JPS and partially on the budget system; as the fiscal year starts in April making it difficult to perform complete eradication before the start of JPS emergence (May-June).

Because low temperatures cause a delay in host symptom development and a slower rate of both PWN and JPS population increase, the spread of the PWN and the number of infested pine trees have tended to slow down in northern Japan. This fact means that the control efforts and the intrinsic rate of increase of PWD are balanced in the regions it is speculated that the PWN will expand only slowly in northern Japan by the repeating processes of 'spread and establishment into uninfested areas in hot dry summers' and 'keeping the status quo in cool summers'. To stop the new invasion in the hot dry summers is the key to control strategy in the northern extremes of the PWN range. The result of a barrier zone defense project in the expanding front of northern Japan will be presented.

Biological invasion of forest insect pests - a threat to the stability of the world's forest ecosystems

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For millions of years the world's biota has been separated by geographical barriers such as oceans and mountain ranges but humans are ever increasing their rate of world movement and this has caused an acceleration of rates of accidental introductions of species into new areas. Biological invasions represent a particularly major problem to Forestry because invading species often disrupt efforts to manage for natural ecosystem functions and/or for sustainable yield of wood products.

The ecological and economic effects of biological invasions in forestry probably already exceed those caused by either air pollution or climate change and the problem is likely to increase in magnitude in the future. The enormity of the problem appears to be incompletely understood by scientists and inadequately appreciated by policy-makers.

I present here a generalized theory of the ecology of invasions consisting of three related processes: arrival, establishment, and spread. Specific population processes dominate each phase of the invasion process and are affected by life history characteristics such that it is possible to use these characteristics to predict the risk of invasion posed by different organisms. This information can be used to develop optimal strategies for management of all phases of the invasion process. I present a simple model that can be applied to identify optimal management strategies during invasions.

Hemlock Woolly Adelgid in the United States: Status of Ongoing Biological Control Efforts

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Hemlock woolly adelgid (HWA), *Adelges Tsugae* Annand (Homoptera: Adelgidae) was first discovered on hemlock (*Tsuga*e spp.) trees in western North America in the 1920's. It wasn't until the early 1950's that HWA was first reported in eastern North America, near Richmond, Virginia. HWA is considered native of *Tsuga spp*. in Asia, principally, China and Japan. Asian and western North American *Tsuga spp*. are resistant to HWA feeding and are able to sustain colonization and feeding with little damage resulting to the tree. The eastern *Tsuga spp*., (*Tsuga canandensis* (L.) Carr.and *T. caroliniana* Engelm.) are both susceptible to HWA and are often killed when infestation density is high. It was not until the 1980's that populations of HWA began to increase dramatically. Concurrent with that was the expansion of the insect's geographic range. It has spread as far north as Massachusetts and south to North Carolina. Prevailing westerly winds have probably played a role in slowing expansion west of the Appalachian range.

The insect has two generations per year on hemlock and can be found attached to the base of the needles. The insects insert their stylet into storage parenchyna cells below the abcission layer of the needles. New shoot development is impacted, affecting growth of new needles. Trees can be killed in as soon as four years, yet often live longer. Trees that are able to survive may either be more vigorous or less disposed to HWA genetically. Neither explanation has been rigorously tested. The insect secretes white woolly material that cover the insect and serve as ovisacs. The only mobile stage for movement from among hemlocks is the crawler stage immediately following eclosion of the eggs. Crawlers have no wings. Therefore, dispersal is passive. HWA poses a serious threat to eastern forests of North America. Both *Tsuga* spp. play important ecological roles in the forest, especially in riparian areas. The prospects of losing these species are real and efforts to address this problem have been undertaken. The most promising research underway for helping to reduce the impact of HWA is the importation of natural enemies from its native habitat. Searches in Japan and China have yielded numerous predators, most previously undescribed. Two coccinellid beetles show the greatest promise. From Japan, *Pseodoscymnus Tsuga*e Sasaji & McClure, has been studied extensively in the laboratory, and is being mass reared for limited field releases that are currently taking place throughout eastern North America where HWA occurs. This insect has survived in the field for up to two years and has reduced the density of HWA on trees in which it was released. Another coccinellid beetle *Scymnus sinuanodulus* Yu & Yao, has been studied in the lab. It has shown good promise as a predator and is considered ready for limited releases. in western North America, a predator commonly found associated with HWA *Laricobius nigrinus* Fender (*Coleoptera: Derodontidae*), has been imported to Virginia and is currently being studied at a quarantine laboratory located at Virginia Tech. This insect has been able to complete several generations on HWA only. This presentation will report on the latest research being carried out on these predators. Their potential role and effectiveness in regulating HWA populations will be discussed.

Modelling the Spread of pine Wilt Disease in Japan

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An epidemic of pine wilt disease has been spreading in wide areas of Japan for nearly a century. The disease is caused by the pinewood nematode *Bursaphelenchus xylophilus*, with the pine sawyer, *Monochamus alternatus* as vector. We present a mathematical model to describe the host-parasite interaction between pines and pine sawyers carrying nematodes on the basis of detailed data taken from the incidence of pine wilt disease at a study site located on the northwest coast of Japan. With this model we simulate the temporal change in the incidence of the disease and predict how the epidemic could be controlled by eradication of the pine sawyer. Furthermore, the model is extended to study the spatial spread of disease on a large scale, by incorporating short-range dispersal of the pine sawyer together with long-range dispersal through air convection or transportation of logs infested with nematodes. The leap distance distribution of sawyers is estimated from experimental data.

The main results are:
1) There is a minimum threshold of the initial pine density for successful invasion of the disease. However, even if the pine density exceeds the

minimum threshold, the disease fails in invasion due to the Allee effect of the pine sawyer when its density is very low.
2) The minimum threshold density increases disproportionately with increase in the eradication rate.
3) Once the disease is established, its range expands at a constant speed depending on the pine density.
4) in areas where rapid spreads of the disease are observed, more than 10 percent of sawyers are estimated to undergo long-distance dispersal naturally or artificially.

Recent Invasions of Forest Insects Pests in Central Europe

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The eastern part of central Europe (Hungary, the Czech Republic, the Slovak Republic and Poland) is an important transit corridor between Russia and Westem Europe and this causes a high risk for introduction of non native species. This region is heavily affected by anthropogenic factors (*e.g.* air pollution, changing climate) and these changes promote the expansion of species ranges to new areas as well. We describe 3 noteworthy invaders, the bark beetle *Ips duplicatus* C. R. Sahlberg 1836 and leaf miners *Parectopa robiniella* Clemens 1863 and *Cameraria ohridella* Deschka & Dinic 1986.

In 1993, an outbreak of a previously unknown bark beetle species (*Ips duplicatus*) was discovered in the northeastem part of the Czech Republic in stands of Norway spruce (*Picea abies* L.). The native range of this species includes northern Europe to west Siberia, but occasional records exist from Austria, the Czech Republic and south Poland. The outbreak has continued for 5 years and over 0.6 mil. m^3 of trees were killed. Beginning in 1997, pheromone traps have been used to delimit the extent of this insect in central Europe. Data indicate, that this species now occupies the northwestern part of Slovakia, the southern part of Poland and almost all area of the Czech Republic. Out of primary outbreak area the first groups of trees infected by this species have recently been found in the northwestern Slovak Republic and it appears, that the range of this species is expanding through central Europe.

In 1993, a leaf miner, *Cameraria ohridela*, was discovered for the first time in the southwestern of Hungary. The species probably origins from area near Ohrid Lake (Makedonia). This pest attacks the horse chestnut (*Aesculus hippocastanum* L.), frequently planted in parks, cemeteries and in special hunting areas. The pest has 3-5 flight periods during the year and causes heavy defoliation of tree at the beginning of summer often leading to their death after 1- 3 years defoliation depending on their health and weather conditions. in 1996,this species reached the Slovak and Czech republics and during 2 subsequent years infested almost all teitItory of both for the first time in the southwestem Hungary (1978 - 1979). in 1986, the species reached the Slova countries. Also during this period, black locust (*Robinia pseudoAcacia* L.) stands in the region were attacked by the leaf miner *Parectopa robiniella* (this species originales from North America). The pest was discovered k republic and in 1989, the Czech republic.

These examples illustrate the enorrnity of problems with invasive species to central Europe even though extensive quarantine efforts exist. These problems illustrate the importance of preparing the Global Forest Invasive Species Information System as a part of Global Forest Information Service at this time.

Global Spread of Insect-Associated Fungi On Exotic Plantation Pines

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During the course of the 20th Century, plantation forestry in the tropics and Southern Hemisphere has grown dramatically. This growth is associated with increased demand for wood and paper products and also with restrictions on the felling of native forests. Thus, huge industries have been established based on extensive areas planted to highly productive exotic pine species. An important reason for the success of exotic pine plantation forestry is that the trees have been separated from the insect pests and diseases that feed on them in their areas of origin. Pine-infesting insects have gradually begun to appear on trees previously separated from these pests. These accidental introductions have, in many cases, occurred despite outstanding quarantine. An aspect of the introduction (accidental or intended) of pine-infesting insects that is not commonly appreciated, is the fact that many of these insects live in association with fungi that are also detrimental to forestry. These associations range from relatively casual (*e.g. Fusarium circinatum* with cone and shoot-feeding insects) to highly specific (*e.g. Amylostereum* *areolatum* with the wood wasp *Sirex noctilio*). The identity of these fungal associates and the structure of their populations, provide outstanding clues to the origin of the insects. Such knowledge also has important implications for pest and disease avoidance in the future.

7.04.00 Air Pollution Impacts on Forest Ecosystems

Long-term impacts of photochemical smog on forests: Evaluation of effects at stand and landscape levels

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Photochemical (oxidant) smog episodes have been occurring in North America, Europe and Asia for several decades. Negative effects on vegetation have been mostly attributed to ozone, although other smog components such as peroxyacetyl nitrate (PAN) and nitric acid (HN) vapor may also contribute to the observed phytotoxic effects. Long-term photochemical smog-related changes in mixed conifer forests of the San Bernardino Mountains in southern California are well known. The oxidant-related changes in vegetation have also been described in forests near Mexico City, the Sierra Nevada Mountains, the Appalachian Mountains, southern, central and western Europe, Taiwan, and Japan.

Development of injury symptoms (Ozone Injury Index, OII) on foliage of ponderosa pine trees is proportional to a dose of the ozone exposure measured as "SUM O". Passive ozone samplers can be used for measuring average ozone concentrations and calculations of "SUM O" indices for remote forest locations. This allows for development of a monitoring network at a landscape level. in the 1999 summer season concentrations of ozone were monitored at 85 sites located in the mixed conifer zone of the Sierra Nevada Mountains. Based on these monitoring efforts, models of spatial and temporal distribution of ozone concentrations will be developed for the Sierra Nevada range. Ozone concentrations will be correlated with foliar crown injury at selected locations (about 10% of the ozone monitoring sites). Results of these comparisons will be extrapolated to the entire mixed conifer zone of the Sierra Nevada. These results will also be used for prediction of ecological risks related to ozone and other pollutants in the mixed conifer forests of the entire Sierra Nevada mountain range. Similar monitoring and modeling efforts are also in progress in the Carpathian Mountains in Central Europe.

Although information on ozone exposure can be used for predictions of foliar injury, relationships between the pollutant exposure dose to physiological and growth changes in trees are difficult to establish. Influence of other factors, such as inputs of atmospheric nitrogen, water availability, temperature, relative humidity, mycorrhizae inoculation, presence of insects, and complexity of changes at a physiological level, affect tree growth response to ozone exposure. A much better understanding of mechanisms of pollutant effects in complex forest environment is needed before reliable models predicting growth changes and physiological responses of trees to ozone alone and photochemical smog in general may be developed. Rapidly increasing number of motor vehicles in the developing Asian countries will lead to elevated emissions of photochemical smog precursors (nitrogen oxides and hydrocarbons). in conditions of high solar radiation, high temperatures and thermal inversions the areas of potentially phytotoxic levels of ozone and other pollutants will expand. National and international air pollution and forest health monitoring programs should be aided by models that are able to extrapolate results from networks of point measurements to landscape and regional levels. Such models are essential for evaluation of risks and proper environmental planning.

The link between forest critical loads for acidity & nitrogen and the sustainability of forest ecosystems.

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Enhanced sulphur and nitrogen depositions can lead to soil acidification thus detrimentally effecting both trees and forest ground flora by reducing nutrient availability and by increasing Al in soil solution to toxic values. Suitable targets for emission reductions are therefore vital for the sustainability of our forest ecosystems.

The calculation and mapping of critical loads (threshold values of pollutant deposition above which damage occurs to forest ecosystems) for sulphur, total acidity and nitrogen has been a major exercise co-ordinated by the UNECE under The Convention on Long-Range Transboundary Air Pollution. Outputs have informed the decision making behind the most recent protocol for decreasing sulphur emissions and are likely to determine future nitrogen emission controls. The use of the critical loads approach is also extending to developing countries.

For forests different methods have been used for setting critical loads ranging from the empirical, Simple Mass Balance through to dynamic modelling. The choice of model, data collection and model parameterisation requires careful consideration. in the UK a combination of published information and newly collected data are used. These data are also of very major value in predicting the sustainability of forest ecosystems (Freer-Smith, 1998).

This paper will present the approach, which has been adopted in the UK and will discuss the reasoning and implications of the decisions made. Some of the key data sets which are being used in the calculation of critical loads and judgement of sustainability will be presented (nutrient removal in harvesting, calculation of average volume increment, and wood nutrient content, base cation and pollutant depositions, critical chemical criteria in soils i.e. Al:Ca or Al:base cations and mineral weathering rates in forest soils). The experimental and survey work, which provides these data, will be described. Forest soil critical loads maps will be presented for the UK and their implications discussed.

Freer-Smith P H 1998 Do pollutant-related forest declines threaten the sustainability of forests. Ambio XXVII No 2 123-131

Wildland fires as a source of air pollution: recent experience in Southeast Asia

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Keywords: air pollution, forests, fire danger, El Nino, Southeast Asia

Extreme weather conditions like droughts and floods usually result in environmental disasters in different parts of the world costing billions of dollars each year. Though El Nino-related droughts occur every two to seven years in Southeast Asia with varying intensity, the 1997 and 1998 El Nino events produced a prolonged drought in many parts of this region. This phenomenon also caused the monsoon to be delayed, greatly increasing the impact of the drought. Both of these El Nino events were classified as "type one", or the most severe on record. in Indonesia, the impact of 1997 El Nino was most severe in central Sumatra and West Kalimantan, while East Kalimantan received the most severe impacts during the 1998 event. Information on these events was obtained by monitoring hotspots, smoke distribution, fire danger, drought conditions and air quality.

The droughts of 1997 and 1998 resulted in producing heavy air pollution from wildland fires in large areas of Indonesia, Singapore, Malaysia, Brunei, Thailand and the Philippines. These fires burnt an estimated five million hectares during 1997 in Indonesia alone. The sources of these fires were agricultural and land conversion burning. These fires generated large emissions of carbon dioxide, carbon monoxide, nitrogen oxides, ozone, hydrocarbons, particulate matter (smoke) and other pollutants. These emissions contributed to the local and transboundary air pollution issues of visibility, climate change, acidic deposition and smog. Magnitude of the Haze Index (HI) and the Air Pollution Index (API) indicated that the worst air po1lution occurred in Sumatra and Kalimantan regions of Indonesia. Also, air quality readings in Singapore and Malaysia were at record highs. The wildland fires of 2000 also resulted in considerable smoke and haze problems in Indonesia. Since natural phenomenon can not be readily controlled by people, prevention and early detection of fires is the best way to minimize air pollution at the source and the resulting impacts.

In 1999, Canada signed a memorandum of understanding with Indonesia to develop a fire early warning system. The Fire Danger Rating System (FDRS) Project for South East Asia is a Joint Initiative of the Canadian Forest Service (CFS) and Indonesia's Agency for the Evaluation and Application of Technology (BPPT). The project is regional in nature and the participation and support of other countries and organizations in the region has been incorporated. The project will establish appropriate fire danger monitoring approaches at regional, national and provincial/state levels. Smoke estimation, atmospheric dispersion and management techniques are included in the scope of the project. Since the use of danger rating systems have been successful in Canada and other parts of the world, it is anticipated that FDRS project will help to alleviate the fire and haze situation in Southeast Asia.

2000 State of science on air pollution impacts on forests: Applicability to Asian Region

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Keywords: air pollution, forests, forest health, global change

Global change poses one of the major threats to international forest health and sustainability in the 21st Century. Maintenance of forest health is essential for forest resilience to climate change and extreme weather events. Concentrations of tropospheric O_3 (smog) are increasing rapidly in developing regions and more gradually in developed ones. Acid deposition via rain, cloud and in dry form remain of concern despite recent international success at regulation of transboundary transport and in emissions abatement. Nitrogen saturation of forested watersheds is occurring in many regions. Cause-effect linkages may not always be made due to design of existing monitoring networks. Levels of O_3 may largely offset modelled gains in forest productivity from increasing global atmospheric CO_2 concentrations. Future predicted patterns of air pollution coupled with ongoing climate change (global change) may interact to significantly alter forest health and increase susceptibility to other biotic and abiotic agents of disease. in this paper we shall provide a brief summary of state of science on air pollution impacts on forest ecosystems emanating from the 19th IUFRO Research Group 7.04.00 meeting in Houghton, Michigan, May 2000 and other sources. Applicability of science from developed programmes to developing needs in the Asian region will be discussed.

Air pollution in China: Deposition and Effects on Forests

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Over the last two decades, China, a country with a population of 1.22 billion people - one fifth of the world's population, has undergone a period of rapid economic development.This fast economic and population growth, inevitably has been causing a rapid increase in energy consumption. As most of the other Asian developing countries, China has a higher rate of increase in energy consumption (mainly coal), but short of efficient air pollution control facilities, this has been causing a higher increase rate in air pollutant (SO_2, NO_x, particulate and CO_2) emission than that in developed countries. The increasing air pollutant emission already caused an alarming air quality deterioration in many big cities and industrial areas. Air pollution problem is so sever that it is responsible for more than 1 million deaths of people per year in China, or about one in every eight deaths nation wide. China has 134 million hectares of forest, about 14 percent of the total land area. in this talk, we present the up-to-date air pollution (SO_2, NO_x, O_3, particulate and acid precipitation) situation in China and a review of the effects of air pollutant deposition on forests (field evidences and research results) in this country.

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8.00.00 Forest and environment

Interference potential of *Casuarina Equisetifolia* L. in natural forests of North-Western India

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Keywords: *Casuarina*; Allelopathy; Understorey vegetation; Litter; Biodiversity; Seed germination.

Casuarina Equisetifolia L. (Family *Casuarinaceae*) commonly known as Horsetail tree is a fast growing, drought hardy, nitrogen fixing exotic tree with wide adaptability to different environmental conditions. A native of Australia, it has been introduced in various parts of India primarily for fuel, land reclamation and ornamental value. The monoculture plantations of *C. equisetifolia* can be seen various parts of the country including the Northern ones. Apparently, very little vegetation is seen under the canopy of these plantations as compared to the adjoining open area. This little vegetation is also probably due to grouping of the sensitive species with strong interactive ability. The ground, however, is seen covered with litter composed exclusively of cladodes or needle like branchlets, whorled, reduced and scaly leaves or cone like female flowers and echinate fruits. The presence of litter on the ground surface may affect nutrient availability and their accumulation in soil and may contribute alleloc hemicals in the soil leading to depletion in vegetation. Competition alone can not explain the reduction in phyto-diversity under *C. equisetifolia*. Allelopathy which is known to occur in many natural and managed ecosystems can be one of the stress factor. It is known to play an important role in regulating plant diversity, non random distribution of vegetation, zonation and organisation of plant communities. Keeping in view the was, therefore, planned to determine the ecological status of understorey vegetation and reasons of its depletion. The results indicate that the ecological status of the species under the monoculture plantations of *C. equisetifolia* and open area was strikingly different leading to clear cur differentiation. The Importance Value Index of the species, the indices of richness, diversity and evenness also varied. in order to find out the reason the leachates from the needles of the tree which were either fallen on the ground as well as fresh, females cones adversely affected the germination, growth and development of the few sensitive species. Allelopathy was, therefore, demonstrated as one of the causative factor.

Forecast of Forest Ecosystem Dynamics Under Different Scenarios of Forest Management (Mathematical Modelling On GIS-technology basis)

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Keywords: Forest management; Ecosystem dynamics; Modelling; GIS; Forest planning

The problem of forest ecosystem dynamics' forecast was solved within the framework of a program complex DBMS-GIS-MODEL, in which DBMS and GIS accumulate and process the attribute and spatial information for the forest object and MODEL ensures the forest dynamics forecasting. The most important feature of this model is the account of strata position and their mutual influence.

As initial information for the forecast module of the model, we have used the per-stratum data bank and cartographic bank of the forest planning and inventory works, which for particular forest management units, exists in the form of information systems (DBMS or GIS). As a result of the model works as similar information is obtained. To take into account bioecological processes in real forest communities, a large umber of reference databases is used within the simulation. The presented information technology helps to forecast and explain the causes of biodiversity changes in forest ecosystems under impact of forestry activity.

Geographic Specificity of Forest Cover within Side-Enisey Middle Taiga Area

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Keywords: Ecotone; Taiga; Landscape structure; Forest types; Russia.

Side-Enisey Siberia is an unique natural ecotone, placed at the boarder part of the greatest land structures - the young West Siberia platform and ancient Middle Siberia plate. It resulted in complicated landscape structure, which combined both west-siberian and middle-siberian features. Side-Enisey ecotone middle taiga section has been investigated within Central Siberia Biosphere Reserve territory with terrestrial co-ordinates at 62-64° latitude North and 88-92° longitude East. Several landscapes are determined here. I - recent valley of Enisey river, which includes flood-plain (absolute height is 30-60m) and loamy fluvial terraces (60-120m). II - loamy left-bank divides of low hypsometric level. III - piedmont mound-ridge plain. On account of great disparity in height the landscape is divided in two relief steps: IIIa - of low hypsometric level (150-200m) and IIIb - of high hypsometric level (250-300m). IV is the higher hypsometric step - 350-400, 660m. Stook-form mountains and table-form divides (with rock deposits - kurums, placed along the tops and slopes) alternate here with fragments of ancient glacier outflow hollows. Landscapes IIIb and IV are distinguished by severe climate, which results in wide spreading of frost ground forms and vertical differentiation in plant cover.

According to landscape structure forest complexes are defined here:
- scrub tall-herbage spruce forests within flood-plains of low and middle ecologic level;
- herb parvifoliate-spruce forests, combined with frost-mound forest-bog microcomplexes within flood-plains of high ecologic level;
- valley moss-herb parvifoliate-spruce forests, placed along solar high-angle and convex slopes;
- valley herb-moss parvifoliate-dark coniferous forests, placed along shadow gentle slopes and flat interfluves;
- dwarf shrub-moss parvifoliate-cedar forests within divides of low hypsometric level;
- lichen-moss parvifoliate-dark coniferous forests, combined with yernik open forests (along ancient outflow hollows) within divides of high hypsometric level.

The whole of tree species have the ecologic optimum within flood-plains and decrease edificator capacity following land surface absolute height increasing. Cedar (*Pinus sibirica*) and spruce (*Picea obovata*) are the dominating primary tree species. Cedar strengthens its edificator position, following the land surface absolute height increasing. Spruce ecologic optimum comes to nothing more than river valleys. Fir (*Abies sibirica*) as the forest-forming tree-species never exceeds the boundaries of flood-plains with rich and drained ecotopes. Pine (*Pinus silvestris*) timber stands develop within peaty lands mainly. Larch (*Larix sibirica*) spreads all over the territory as admixed tree species mainly and is the most competitive in rocky and perennially frozen sites. Parvifoliate species - birch (*Betula pendula*) and aspen (*Populus tremula*) are the secondary forest-forming edificators throughout the territory. Forest complexes within river valleys are floristically richest. They are specific with high phytocoenotic significance of grass living forms and great numerosity of species, which require rich nutrition and heat provided ecotopes. Forest complexes of divides floristically are comparatively arm at the expense of herbs lack. Cold-resistant dwarf-shrubs and mosses, which stand poor and nun-drained soils, have the heightened phytocoenotic significance instead.

Valley forests are characterised with moss-grass and grass ground cover. Within flood-plains the gramen (*Calamagrostis obtusata, C.langsdorffii*) are very much abundant, while at the terrace flat interfluves - *Equisetum sylvaticum, E. pratense* are. Within divide areas of low hypsometric level forest ground cover is usually formed with dwarf shrubs (*Vaccinium myrtillus, V.vitis-idaea Ledum palustre, Chamaedaphne calyculata*) and two groups of mosses - green (*Hylocomium splendens, Pleurozium schreberi, Polytrichum commune*) and sphagnum ones (*Sphagnum angustifolium, S.nemoreum*) dependently on site drainage. Within divides of high hypsometric level forest ground cover finds north expression thanks to heightened abundance of frost-resistant species - arctic scrubs (*Betula humilis, B.nana*), dwarf shrubs (*Vaccinium uliginosum, Ledum palustre, Empetrum nigrum*), Cladonia and Peltigera lichens, some Hepatica species.

Forest Ecosystem Management and Sustainable Development of Forestry in Northeast

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Keywords: Forest ecosystem management; Sustainability; Biodiversity; Productivity; China.

In this paper, the conceptions and developments of ecosystem and ecosystem ecology were reviewed and summarized. Then, the conception, connotation, objective, and development of ecosystem management were expounded. Based on these discussions, forest ecosystem management was discussed. The viewpoint in this paper was that the former unreasonable forest resources management should be changed, and forest ecosystem management was a suitable way to sustainable development of forestry. The chief research contents were pointed out in this paper, and taking forestry in Northeastern China as focal, strategies on sustainable development of forestry were also advanced Northeastern forest, which has an important effect on national and regional economy development, is the most extensive forest in China and its area accounts 1/3 of the total forest area. But natural forest resources in Northeastern China have been decreasing rapidly and even will be exhausted because of unreasonable development and usage for a long time. in the eastern hilly area of this region, statistics data showed that the area of forest was 36 million hectare in 1935 and most of the forests were broad-leaved Korean pine forest and *Abies-Picea* forest. However, the virgin broad-leaved Korean pine forest and *Abies-Picea* forest have been almost vanished and replaced with secondary forest and artificial forest. Moreover, artificial larch forest has been constructed energetically since 1949. Now, 70-80% artificial forest is pure larch forest. The large area of artificial pure forests caused soil fertility and productivity decreasing and unstable ecosystem. It is another chief problem hindering sustainable development of northeastern forest. So, it is the most important task to conserve and reconstruct reasonable ecosystems, manage the ecosystems scientifically, and reach the objective of sustainable forest ecosystem development and resources utilization. Another important task of northeast forest is to construct the optimized model of sustainable artificial larch forest. Ecosystem management is a serious managing activity aimed at a sustainable development and its application should be guarded by policy, contracts, and factual measurements. On the basis of best awareness to necessary ecological actions and ecological processes that maintain components, structure and functions, ecosystem management focus on studying and monitoring, ensuring the suitability of management. Forest ecosystem management is, with a basis of ecosystem management, some management aiming at forest resources and all the forest ecosystem and it includes all the management and technological measure by which resources can be used sustainably. Forest ecosystem is a complex system, and forest ecosystem management must take maintaining dynamic equilibrium and protecting biodiversity as basis.

A conceptual framework for forest management plans

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Keywords: Forest management plans; Sustainable forest management; Land-use planning; Land evaluation.

Forest Management Plans (FMP) have gained in importance as both experts and donors place more and more emphasis on FMP as a tool for (sustainable) forest management. The Tropenbos Foundation experienced that there seems to be a lot of confusion about the concept of FMP.

In it most simple form an FMP is a plan which describes the management of a forested area in order to reach some (predefined) objectives. But the concepts of what an FMP comprises differs among people. Some plans are more forest management systems in order to sustain a certain logging operation while other complicated plans try to manage forests at a national level. But an FMP is not just a set of management activities. An FMP:

- Justifies the establishment of a management plan;
- Describes the management area, including its resource base (the entire ecosystem, including woody vegetation, fauna, soil etc.), actors and their objectives or needs;
- Provides an evaluation of forest use options;
- Elaborates on the choices made (objectives and activities);
- Describes practices and activities that best meet the objectives;
- Includes a mechanism to respond to changing circumstances and insights.

As such an FMP is not just about resource management practices, but comprises also the process of decision making

A definition of FMP is:

'A Forest Management Plan is the description of decisions and activities to produce anticipated objectives with regard to use and conservation of forest in an area'.

Conceptual framework

The development of an FMP takes place in different stages or levels of planning, *e.g.* strategic, tactical and operational planning. In the strategic plan the decisions concerning the objectives of the management, the allocation of forest land and forest functions, are taken. Societal needs, economic and political forces, current land use, land qualities and locations of the land first determine whether the land is allocated as forest land (kind of land use). An inventory of the resources base and the needs form the actors in the management area are made (land use objectives). Finally, the decisions on the management objectives are matched, resulting in a future desired forest

The tactical plan describes the management activities, which are needed to reach the stated objectives, derived from the strategic plan. The operational plan comprises the actual implementation of the management activities and practices.

Although not explicitly mentioned in figure 1 (not shown), monitoring and evaluation of an FMP and its execution is essential for the management. Management is continuous process. Circumstances and insights may change in the course of the management or assumptions may prove false and need to be adapted.

The conceptual framework will be enriched by operational experience gained by Tropenbos. and the role of research within FMP development will also be indicated.

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Optimization of Parametrics of Ecological Monitoring

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Keywords: Ecological monitoring; Minimization of parameters; Technical diagnosis; Influence on ecosystem

Making ecologically significant decisions is possible if one has reliable information about the environment and its ecological conditions. Measurements of parameters of influence on the ecosystem as well as ecosystem itself must be correlated according to accuracy. Systematic approach is preferable when one can observe and control the most important correlation between parameters of influence on the ecosystem and ecosystem itself. Otherwise it can so happen that there are a lot of monitoring data but little information about actual state of the ecosystem.

Means of land and space monitoring meant for global transnational and regional levels of ecosystems control must be connected by universal methodology based on similar integral and local parameters of ecosystems and their counterparts. Hence the use of principles of technical diagnosis: genesis, diagnosis and prognosis of behavior of technical objects seems useful.

Universal algorithm of minimization of parameters of ecological monitoring:
1 - Setting tasks: inventory of all sources of parameters of influence on the ecosystems and qualitative evaluation of the expected content and amount of toxic substances.
- Single out objects of ecosystem their parameters according to which the reaction of the ecosystem to the influence will be monitored.
2 - Making research: monitoring all informative parameters of influence on the ecosystem.
- Estimation of the coefficient of pair correlation of all informative parameters of influence on the ecosystem.
- Creation of a set of basic diagnostic parameters of influence on the ecosystem.
- Measurement of all informative parameters of influence of the ecosystem.
Calculation of coefficients of pair correlation of all informative parameters of influence on the ecosystem.
- Specification of the set of basic diagnostic parameters of the system.
- Building up of "dose-effect" patterns.
- Evaluation of "dose-effect" correlation, their minimization (most sensitive and less correlated).
3 - At the stage routine ecological monitoring:
- Control of minimized set of "dose-effect" patterns only.
- Criterial evaluation of ecosystem condition.

An Assessment of Multi-data Fusion in Forest Resource Management for the Northern Part Selangor, Malaysia

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Keywords: Forest resource management; Sustainability; Satellite remote sensing; Resource inventory; Monitoring; TM image; Malaysia.

The aim of this research was to evaluate the potential use of fused multi-sensor images to supply information to strengthening the Malaysian forest resources management programme. The work explores the combination of the optical and SAR data using two image fusion techniques namely, Brovey and Intensity, Hue and Saturation (IHS), and assesses their efficiency and effectiveness for forest resource management.

Natural resources, and forest in particular, are becoming increasingly scarce and exhausted. As it was addressed in Agenda 21 of the Rio Convention, June 1992, the concept of sustainable forest management has become critical issue that must be addressed if the impact on the environment and the quality of life is not to be further threatened. To achieve sustainability, forest managers require information, not only about the current status of the forest availability and utilisation, but also about the future trends. The need for information requires continuous inventorying of the resources, in order to plan, manage and conserve the forest resources on a sustainable basis. Satellite remote sensing is recognised as a powerful tool for forest resources inventory monitoring and management.

In Malaysia, the limitations of cloud cover and the sensitivity of optical sensors to atmospheric disturbances hamper the use of remotely sensed data, such as Landsat TM, that use the optical range of the electromagnetic spectrum. in addition, forestry sector faces with difficulties such as broken terrain, multi-storied forest canopies, and few maps and other baseline data. The fusion of optical remotely sensed data with images acquired from radar seems to be a powerful method to optimise and enhance information extraction. Until now, Malaysian experience in the fusion of data sets from different sensor or platform for forest resources monitoring is still in research stage. in recent years, however, more effort has made to take advantage of the availability of both optical and SAR systems.

This research concentrates on the integrated use of Landsat Thematic Mapper (TM) imagery fused with either JERS-1, ERS-1 or Radarsat Synthetic Aperture Radar (SAR) imagery in a test area in Northern Parts of Selangor State, Malaysia. Two images fusion techniques, Brovey and Intensity, Hue and Saturation (IHS) transformation, were used to classify 11 types of forest ecosystem and five types of non-forest classes. The classification of fused images shows that the best overall accuracy (91.4%) was obtained from Landsat TM Principle Component bands 123 fused with JERS-1 through the Brovey transformation. The results indicate that the possibility of extracting more and accurate information from fused images is high and that it proves to be of great benefit to forest management. It helps to reduce the effect of cloud cover and supply more information about multi-stories forest canopy and can therefore directly contribute to sustainable forest management.

Forest Fuel Inventory in Plantation Forest

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Keywords: Fuelwood; Fuel component; Fuel loading; Forest Fire risk; Malaysia.

Forest fuel inventory is a way to describe fuel components, fuel quantity and estimates its volume. This information can be used to detect high risk and hazardous areas. However, the study of this nature has not been conducted in Malaysia. This study was conducted to determine the fuel components on forest floor of two different age stands and to estimate the fuel loading of the various fuel components. This study was carried out at Bukit Tarek Forest Reserve, Hulu Selangor, Selangor Darul Ehsan, at two stand age of *Acacia mangium* of 5 and 9 year-old. Fuel components of downed woody material and duff were sampled along transect lines. Shrubs, litter, herbaceous and small trees (< 3 m height) were sampled from quadratic plots. The results showed that the components of forest fuel and their vegetation on both stands were similar but not in term of their fuel loading and density. The 5 year-old stand showed 23.31 tonne/ha of fuel components (downed woody material, litter and herbaceous), 1.73 cm of duff depth, 37,030 stem/ha of shrubs density and 2,175 tree/ha of small trees. The 9 year-old stand showed 17.42 tonne/ha of fuel components 3.03 cm of duff depth, 39,151 stem/ha shrubs density and 3,515 tree/ha of small trees. Downed woody material made up of 89% and 74% of the total fuel weight for 5 year and 9 year old stands, respectively. Comparison between two different age stands, showed that 5 year old stand has higher quantity of downed woody materials than 9 year-old stand. with 20.66 tonne/ha and 12.82 tonne/ha, respectively. Based on diameter class interval, the weight of downed woody material, diameter class of 0-7.6 cm were higher compared to diameter class of > 7.6 cm. The fuel weight for 0-7.6 cm diameter class were 12.48 tonne/ha and 9.94 tonne/ha for 5 and 9 year-old stands, respectively. Statistical analysis showed that the loading of downed woody material on 5 year-old stand was significantly greater than the 9 year-old stand. However, litter loading was greater on the 9 year-old stand than the 5 year-old stand (P=0.05). The study concludes that in terms of fuel loading, 5 year old stand has higher fire risk than 9 year old stand. This is due to the silviculture activities in the 5 year old stand.

Analysis of allelopathic substances from roots and leaves of *Robinia pseudoacacia*

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Keywords: Allelopathic substance; Leaching; Seed germination; Black locust.

Robinia pseudoAcacia (black locust), whose origin is in America, was introduced to the Korean Peninsula from China in about 1897. This species was planted extensively for fuel in rural areas during the 1970's, and plantations currently cover about 320,000 ha. Black locust now has many additional uses in Korea such as building materials, soil conservation, shade trees, forage and honey production. This tree exhibits rapid growth and is ecologically aggressive with allelopathic effects on other species. We analyzed the allelopathic substances in leachates from roots and leaves of black locust using HPLC, and determined leachate effects on seed germination.

Leachates from black locust roots inhibited seed germination of *Alnus firma* and *Pinus taeda* by more than 50% compared with distilled water. Germination frequency of Lespedeza bicolor was less than 54% of the control in treatments with leachates from fallen leaves of black locust. Seed germination of Arundinella anomala was also highly inhibited by 68% with leachates from live black locust leaves obtained in October.

Germination rate of lettuce was reduced to 10% with a 30% dilution of leachate from leaves (200 g/L distilled water, 24 h extraction). Complete suppression of germination was obtained with a 50% dilution and undiluted leaf leachate solutions. Leachates from root bark (200 g/L distilled water, 24 h extraction) suppressed lettuce germination by 70%. A mixture of leachates from leaves and root bark reduced seed germination of lettuce to 10%.

Phenolic compounds in leachates were analyzed by HPLC using a Microbondapak C18 column (300 x 3.9 mm) with 0.5% acetic acid in distilled water and 0.5% acetic acid in acetonitrile supplied at a flow rate of 1.5 mL/min. Detection was made at 260, 280 and 320 nm. *Robinia* leaves contain about seven times more phenolic acids than *Robinia* roots per unit dry weight. Although paracommaric acid is in lesser quantities in roots (18843 ng) than leaves (42142 ng), this acid accounts for the majority of phenolic acids in roots. in leaves, gentisic acids are the major phenolic component followed by parahydroxybenzoic acid.

Migration Technical Pollutions in Mountain Landscapes of Ukrainian Carpathians

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Keywords: Ecological monitoring; Natural landscape; Toxic elements; Pollution; Ukraine

In region of Ukrainian Carpathians of work on ecological monitoring of forests are conducted UkrMFRI since 1990 under the european program "ICP-Forest". On the first level monitoring (the network of 16 x 16 kms) is incorporated 80 plots of constant supervision behind a condition of forests in Lvov, Ivano-Frankovsk, Zakarpatye and Chernovtsy areas. in 1996 the institute has begun development of the second level monitoring, which purpose is the profound study of biogeochemical laws of functioning of natural landscapes. On all of plots are selected the tests of basic structural elements forestry ecosystems:

soil, litter, herbaceous covering, mosses, lichen, bark and also atmospheric downfalls (snow). in 1997 year are begun researches on biogeochemical indication: estimated absolute contents 39 chemical elements in tests, analyse their deflation coefficients and migration on system "atmosphere - soil - plant".

For contents estimation technical pollutions in tests pressed into the service of method nuclear issue in inductively connected plasma (ICP). Set a presence in all of analysed structural elements of mountain forests of such toxic microelements: B, Be, Bi, Cd, Ce, Cu, La, Pb, Sn, V, Zn. Now detailed biogeochemical estimation develops of vertical migration technical pollutions into mountain landscapes.

Done such previous deductions:

- on regions territory takes place accumulation in forestry ecosystems cadmium and molybdenum, and in atmospheric downfalls - barium, cobalt, to chrome, copper, iron, to manganese, to molybdenum, to nickel and to lead. On all of counted elements set anomalies on their concentrations in environment.

- in territorial attitude all pollutions both in soil and in snow waters characterize by maximum concentrations in more industrial parts of region. This bears witness to dominating role of local sources pollutions in forming of environments contamination.

- checked off exceeding of admissible levels for contents in soils to lead and to chrome, and in snow waters - copper, molybdenum, vanadium and zinc. Analysis of correlation matrices gives a possibility to affirm, that exists a definite elements group, which determines contamination of regions environment, and by them source there are local aerotechnical pollutions.

- calculated a geochemical background for region of Ukrainian Carpathians on contents in soils of analysed microelements. Will check essential off difference on his senses for forest and industrial regions.

- amount of definite microelements most in atmospheric downfalls, and diminishes in row: soil, litter, herbages, mosses, lichen, bark. This shows, that basic by dint of contamination of mountain forests is atmospheric falls.

Important, on our thought there is also fact intercommunication a forests state indexes with environment contamination levels of Ukrainian Carpathians. Consequently, forests defoliation arrives at maximum senses in such regions: alpine parts north - east megaslope, regions of great entranse technical pollutions with atmospheric falls and on territory of south part country between river Dnister and Prut. The minimum parametres of defoliation are marked into north - to western part of Carpathians region. Dechromation of trees indicates on appearance damage (technical pollutions) and reaches to maximum in industrial regions too.

Secondary Forests in Slash-and-Burn Agriculture in Latin America: Opportunities for Rural Livelihoods and Environmental Improvement?

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Keywords: Slash-and-burn agriculture; Secondary forest; Regeneration; Productivity; Ecosystem management

The regeneration of secondary forests (SF) on previously cleared land in the forest margins of Latin America is a promising development within the generally pessimistic scenarios of tropical deforestation. This has stimulated efforts to augment the value of SF to their owners, to induce them to increase the area in SF and delay their re-conversion to other uses. This is expected to improve the livelihoods of the rural poor, while simultaneously contributing to environmental improvement.

This paper synthesizes results from the emerging literature on SF to take the first steps towards the development of a strategy for increasing the value of SF. We present future scenarios of SF by analyzing how SF change as colonist frontier areas develop over time. We identify major problems resulting from these scenarios and the problems which research could significantly ameliorate.

We then make preliminary assessments of possible strategies for ameliorating these problems.

The paper uses a dynamic conceptual framework for analyzing how secondary forests evolve with the development of colonist frontier areas over time. Results draw on interdisciplinary field studies carried out by the authors in areas settled by slash-and-burn migrants in the forest margins of Brazil, Peru and Nicaragua. These include farm surveys and floristic inventories in each of the three countries, with sites selected to provide an international continuum in the frontier development process.

Results available so far show that the area in SF increases over time in areas of low population density. in areas settled about 100 years ago, SF is the only forest cover and covers about 25% of farm area. This implies that deforestation in slash-and-burn farming may be less than previously believed. SF is regenerated primarily to recuperate the soil. Multivariate analysis shows that farmers increase fallow periods over time, because site productivity decreases with repeated cycles of crop production. This gives rise to SF. in older areas, farmers change their strategy and compensate for declining productivity by increasing the area under cultivation, which is achieved by reducing fallow periods. Thus unsustainable agriculture eventually leads to a decline in SF and the elimination of forest cover on farms. If an increase in SF value, could induce longer fallow periods, this could increase farmer incomes, contribute to the sustainability of agriculture and maintain forest cover on farms.

The current potential of SF for timber production is generally limited, as the succession is only occasionally allowed to pass beyond the stage of dominance by pioneers. *Guazuma crinita*, a pioneer tree with an established market in Peru, is one of the few exceptions. Older stands generally have greater timber production potential, made up mainly of species of the long-lived pioneer ecological group. Families also use SF plant species for multiple purposes, with medicinal use and firewood being particularly important.

Well-documented factors such as productivity declines over time may limit the forest management potential of SF. Frequent uncontrolled fires are shown to represent a major barrier to the development of productive stands. These results indicate that innovative ways to increase the value of SF will have to be identified, such as the possibility of using carbon-offsets (under the Kyoto Protocol) to stimulate an increase in fallow periods. Marketing and processing improvements could also contribute, as well as policy changes, such as the removal of incentives for extensive cattle production.

What is needed is not a single "magic solution", but an "ecosystem management approach" which looks for synergies among the multiple products and environmental services that SF are capable of providing, identifies the need for policy changes and harnesses new opportunities at the global level.

A study on the Ecological and Environmental Quality in the Main Managerial Areas of Plantations in China

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Keywords: Plantations, ecological and environmental quality, insect pests and diseases, soil fertility, water loss and soil erosion.

A comprehensive analysis was made on the forest ecological and environmental state and quality by the five years successive monitoring from 46 located monitoring sites of newly established plantations for 7 main species in the managerial areas in China. The results showed that the decisive factors affecting the ecological and environmental quality were water loss and soil erosion soil fertility states and occurrence of insect pests and diseases.

Basing on the statistics and analysis of soil erosion monitoring, the results indicated that the soil erosion mainly occurred in the first and the second year after the plantations established. and about 81% of monitoring sites showed extremely slight or slight soil erosion, 16% of sites showed heavy soil erosion. High intensive site preparation and young plantations tending were the main causes of soil erosion, especially the over all ploughing. The soil nutrient loss was simultaneous with soil erosion. The amount of organic matter loss was the largest, while the amount of available NPK was the least among the total amount of lost nutrients.

According to the observations conducted to the pests and diseases, the occurrence rate caused by both insect pests and diseases in the plantations of masson pine, loblolly pine and poplar were high, while, the disease occurred frequently in *Eucalyptus* plantations either. and only 2.5% of monitoring sites were damaged heavily by insect pests, 5.1% by disease, most of the monitoring sites were attacked slightly. The damage of insect pests and diseases was slight to the main managerial areas of plantations in China.

The study on the monitoring findings of soil fertility showed that the soil available nutrients changed significantly, especially the available P. Fertilization affected the available nutrient of soil, particularly, the available P would increased significantly by the application of P fertilizer. A multiple regression analysis was done on the forest ecological and environmental quality by soil erosion, soil fertility and insect pests and disease, and a model Y=f(x1,x2,x3) between the ecological and environmental quality (Y) and soil erosion (x1), soil fertility (x2), pests and diseases(x3) was made.

Al stress on the photosynthesis of *Quercus glauca* Thumb

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Keywords: Al stress; photosynthesis; *Quercus glauca* Thumb; Ca/Al;

Soil acidification is one of the serious forest environmental problems caused by human activity. The effect of Aluminum on trees is the most critical among the various impacts by soil acidification. Not only the Al concentration but also the Ca/Al ratio in soil solution have been considered as important factors for the assessment of Al stress. Although many studies about Al stress on photosynthesis have been reported, the specific response and mechanisms by each tree species are ambiguous. The purpose of this study is to clarify the mechanism of Al effects on the photosynthesis of *Quercus glauca* Thumb, which is the typical tree species in the Japanese temperate forests.

To investigate the effects of Al concentration and Ca/Al ratio in root environment on the photosynthesis of *Quercus glauca* Thumb, three-year-old seedlings planted in glass beads instead of soil were exposed to various nutrient solutions containing Al at two concentration levels (5 and 10 mM) with three levels of Ca/Al ratios (5.0, 1.0, and 0.16). The pH of the solutions were adjusted to 3.3-3.4 to avoid the precipitation of Al. The treatments were continued for 14 weeks. Before, during and after the Al treatments, photosynthesis activities and chlorophyll fluorescence were measured. After the treatments, the morphology and the water absorption ability of roots were observed The contents of various elements and chlorophyll in the leaves were also determined.

The exposure to the nutrient solutions, in which the Al concentration was 10 mM (Ca/Al=0.16), limited the photosynthesis and caused a decrease in the stomatal conductance. The treatments with 5 mM Al did not affect the photosynthesis even when the Ca/Al ratios were 0.16. The results of the chlorophyll fluorescence and chlorophyll content, which showed no significant differences among the treatments, indicated no effect of the Al treatments on the photochemical processes. This means that the photosynthesis limitation should be due to the stomatal closure and the decrease in the carbon dioxide fixation process. All seedlings treated with Al had increased Al contents in the leaves, decreased P contents in the leaves and decreased water absorption ability in the roots. These results indicate that the Al treatments affected the nutrient availability and function of the roots. However, since the effect on photosynthesis was observed only with the 10mM treatment, it is suggested that the Al effects on the root functions were not correlated with the decrease in photosynthesis.

In addition to these results, the changes in the enzymatic activities due to Al stress will be shown and the mechanism of stress transmission from the root to the photosynthesis function in leaves will be discussed.

Decision making on cutting cycles in neotropical forests in Costa Rica and Bolivia

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Keywords: Logging; Sustainable forest management; Cutting cycle; Neotropical forest.

One of the points of departure for the sustainable forest management is that the logged volume must be equivalent to the growth of the forest in a determinated period of time. in the case of the polyciclic forest management of mixed, irregular forests, this period is the cutting cycle and is determined by the structure of the residual forest and its growth rate. That is the importance of growth studies.

Twelve one-hectare Permanent Sample Plots (PSP) have been established before logging in a rainforest at the Osa Peninsula, Costa Rica. Eighty, one-thousand square meters, PSP were established in a dry forest at Las Trancas, Lomerios Region in Santa Cruz Department, Bolivia (eight hectares sample). in both cases increment models have been fitted by regression.

The models of increment show that in bolivian forest the diametric increment, three years after harvest is 29 per cent lower than that of two years after logging. in the case of costa rican forest the increments, five years after logging are 35 percent lower than the observed in the period of three years after harvest.

The models have been used to predict the growth of residual forests and to determine the time required to growth a volume equivalent to harvest. A spread sheet program has been used in order to simulate growth. Changes in increment rates causes differences in estimated cutting cycle

In conclusion:

It has been observed, and measured, that growth rates of logged forests shows changes in different periods after logging. Then it is necessary to adjust the time period of the cutting cycle, in order to avoid a harvest greater than growth. PSP have showed to be an excellent tool for the monitoring of the main factors that assure sustainability in wood production. It is necessary to make a revision of the Forest Management Plan each five years. Forester must use information from the PSP established in the forest or from other similar forests.

Goals and Goal Conflicts in Forestry

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Keywords**:** integration, environmental goals, goal conflicts, evaluation.

In the European Union, as well as in Sweden, there is now a general consensus to accept the principle of integration, meaning that environmental protection should be integrated into the definition and implementation of other societal policies and activities. In other words, every sector of society - such as transport, energy, agriculture, forestry, and defence - is required to integrate environmental goals with its "ordinary" activities. In Sweden, this principle is closely connected to the introduction of explicit environmental goals. Thus, the national environmental goals are to be broken down into goals for each sector, which is then in principle responsible for their implementation. The process of defining goals on different levels is presently under way.

The Swedish Parliament has decided that the production goal of forestry (producing enough timber and pulp for forest industry) should be combined with environmental goals such as preserving old forests and biological diversity, avoiding acidification and eutrophication, and saving cultural values. The Forestry Board in October 1999 proposed more concrete goals concerning biotopes, ecological processes and functions, cultural values, diversified use of forests, and recycling. These goals are partly quantified, such as the area to be assigned to National Parks and the area of older forests to be preserved.

However, the problem of goal conflicts then arises, including not only conflicts between environmental and other goals (external conflicts), but also conflicts between different environmental goals (internal conflicts). The paper outlines an on-going evaluation of the principle of integration and goal conflicts. The evaluation uses methods from the social sciences, including questionnaires and interviews. The results of these are presently being analysed. One observation is that government agencies, as well as private sector actors, widely differ between each other - a fact which may have farreaching consequences for environmental policies. A number of suggestions to improve sector integration are also being considered, e.g. establishing principles for solving goal conflicts before they occur, more rational goal formulations including alternative goals, a more rational distribution of responsibilities, and better and open information about goal conflicts.

8.01.00 Ecosystems

Net primary production and nitrogen mineralization of 12 forest ecosystems in Shikoku District, Japan

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Keywords: Nitrogen mineralisatiion; Net primary production; Conifer forest; Deciduous forests; Japan

Nitrogen (N) is one of the limiting nutrients for productivity in temperate forest ecosystems. Thus, one could expect that nitrogen availability index such as net mineralization rate is positively correlated with forest productivity. Although many studies have revealed that the productivity of some plantations in Japan is significantly related with soil conditions such as water status and C/N ratio, little is known about the effect of net N mineralization rate. in the present study, we investigated the relationship between nitrogen availability determined by the laboratory incubation technique and forest productivity of 12 forest ecosystems in Shikoku District, Japan. They are composed of four different types of forests; Sugi (*Cryptomeria japonica*) plantations, Hinoki (*Chamaecyparis obtusa*) plantations, pine (*Pinus densiflora*) forests, and secondary temperate deciduous forests.

In addition, we estimated annual N input rates via litterfall for 2 years using litter traps. The study site has the warm climate and high annual precipitation (2800mm), which favours plant growth. Net N mineralization rates during 28-day laboratory incubation ranged from 7 to 207 ugN g^{-1}, which was higher in the deciduous broadleaf forests and lower in the Hinoki plantations and the pine forests. Annual litterfall N input rates ranged from 2.1 to 7.0 gN m-2 yr^{-1}, which was significantly correlated with net mineralization rates ($r=0.79$, $p<0.01$). This indicates the supply of N via litterfall is a crucial factor to affect the net N mineralization rate in soil. Indices of primary production, mean annual diameter growth of canopy trees and mean annual increment of stem biomass, were higher in the coniferous forests and lower in the deciduous broadleaf forests. We found no significant relationship between net primary productivity and net N mineralization in these forests. It is noted that high net N mineralization was observed in the deciduous forests with low productivity. On the contrary, litterfall N input to soil was negatively correlated with net primary production. This suggests the species, which has the high potential biomass production, can reduce N loss by litterfall. Nitrogen loss by litterfall implies the N loss form the ecosystem by leaching due to heavy rainfall in the region. in the deciduous forests, the net N mineralization rate during the 28-day incubation was as much as the annual litterfall N rate. This suggests that net N mineralization is very high and exceeds the plant demand in this ecosystem. In summary, we concluded that net N mineralization rate of soil is largely determined by the litterfall N input, and the effect of species is a primary factor in these forest soils. The differences of the net primary production were largely due to the inherent natures of the species rather than net N mineralization rates.

Relationship between Human Activities and Condition of Floodplain Forest Ecosystems in Central Europe

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Keywords: Flood-plain forests; Anthopogenic effects; Regional comparison; Central Europe

In Central Europe, floodplain forests represent a residual biome that persisted after profound changes in landscape use taking place in the past. The first human settlements were established in the territory of floodplain forests so that their area and nature gradually changed due to the anthropological effects. Floodplain forests in the alluvia of Morava, Dyje and Danube rivers represent today unique biomes which show a high level of production, excellent biodiversity of both plant and animal species, and valuable aesthetic and recreational functions in the landscape. in this territory, there is a national park, several protected landscape and many natural preserves. At present, the responsible organs try to take measures, which would enable their reconstruction, extension and re-vitalisation. Using the ecosystem of Central-European floodplain forests as an example we shall try to describe the extent, present condition and way of use of these forests by man. We have selected floodplain forests in the Litovelské Pomoraví alluvium (Czech Republic) as well as those along the confluence of the Morava and Dyje rivers (Czech Republic and Austria), in the National Park Danube (Austria), floodplain forests along the Morava river in Western Slovakia, floodplain forests near the Gabekovo dam in South Slovakia, and a unique example of floodplain forests situated within an urban region of Leipzig (Germany).

Simulating landscape scale forest management of disturbance-prone forest ecosystems

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Keywords: Forest modeling; Landscape scale; Forest management; Disurbance; Land-use US

Landscape patterns of many unmanaged forest ecosystems are shaped by fire disturbance. These patterns tend to change once forests are managed; for example, forests become denser and large openings no longer occur. Such changes are often detrimental to wildlife species adapted to openings previously created by fire. It has been suggested that the spatial patterns of forest management should be altered so that they resemble natural disturbance patterns more closely. However, very little experience exists with such management, and experiments are difficult to conduct at the landscape scale. Our objective was to simulate landscape scale forest management of the Pine Barrens in northwest Wisconsin, U.S.A, to test how closely different management scenarios mimic natural disturbance patterns. The Pine Barrens region was shaped by fire until European settlement began around 1860. Detailed vegetation assessments of the pre-settlement vegetation are available. Also available is a satellite classification of the current vegetation cover, which is significantly different from the historic landscape due to logging, farming, fire suppression, and forest management. We used LANDIS, a landscape model that incorporates fire, windthrow, succession, seed dispersal and forest management to simulate possible future conditions of the Pine Barrens. We conducted a factorial experiment and changed the variables 'clear-cut size', 'rotation length', 'tree species for forest regeneration', and 'spatial allocation of clear-cuts' within LANDIS. The model was run under each management scenario for 500 years. We summarized the results as the abundance of openings for wildlife, and the volume of timber being harvested. The comparison of different management scenarios allows resource managers to choose the optimal management strategy according to their management goals. Our analysis reveals that forest management options exist that improve landscape patterns for wildlife without decreasing timber production significantly. However, different landowners in the Pine Barrens will manage their lands for different goals. We specified several management areas according to land-ownership and housing density, and conducted further LANDIS runs with spatially variable forest management scenarios. For instance, areas with high housing density and small private landowners are unlikely to be harvested in large clear-cuts. Land owned by industrial forest corporations may be harvested in large blocks, but economic considerations are likely to determine management decisions. Public forestland may be managed to maintain both large openings and commodity production. By allowing for different management practices for different landowners we were able to simulate future states of the Pine Barrens realistically. Landscape scale forest modeling can provide realistic predictions about the future of landscapes. These predictions are important for forest managers when they attempt to achieve multiple goals, such as wildlife habitat and commodity production over extended periods of time, and across entire landscapes. Our results highlight the potential and the limitations of forest management to restore landscape patterns previously created by natural disturbances. We suggest that similar modeling approaches may be suitable for many other forested ecosystems previously shaped by fire.

Long-term chronosequences of Norway spruce primary succession

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Keywords: *Picea abies*; Primary succession; Postglacial rebound; Chronosequence; Old-growth

The Fennoscandian crust is experiencing postglacial land uplift following the weight down by the Weichselian ice mass. A consequence is a perpetual exposure of new ground along the shores of the Gulf of Bothnia, ground on which primary succession is occurring as plants colonize and community forms. The ongoing land uplift provides a topographic sequence equivalent to a chronosequence - the lower the elevation the younger the land with younger, pio-neer communities, the higher the elevation the older the land and the more develo-ped the communities. The uplift amounts to maximum 0,092 m/year in the northern part of the Gulf of Bothnia. On a specific shore, the vegetational gradient reflects the actual course of succession. As long as no major disturbance interferes the primary succession continues progressively towards the regional climax for each ecosite type. The exposure of a specific shore is a key-factor that influences the vegetational gradient, i.e. species composition, initial establishment levels, rate of succession, etc. Thus, islands and peninsulas continue to rise seawards, and con-sequently the ex-posure of a specific shore may change (decrease) over time because of changed (increased) relative shelter. Moreover, as the community matures the importance of allochthonous plant colonization decreases, while the importance of autochthonous resurgence increases. It can furthermore be assumed that early successional processes primarily are under abiotic control while biotic factors take on greater importance later in the sequence. As the condition changes, this may modify the successional sequence by trigging a switch, or maintain a continuous change, in the pathway. Hence, multiple successional pathways should be taken into consideration, as well as disruptions in the presumed chronosequence.

8.02.00 Site: soil carbon

Soil properties under different types of tropical seasonal forests, in western Thailand

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In tropical seasonal forest area, soil moisture gradients are one of the major factors for regulating forest types, so that soil chemical and physical properties would be different among forest types. The aim of this research is to clarify the characteristics of soil properties under different types of tropical seasonal forests in western Thailand. It is necessary to evaluate soil productivity for sustainable management of qualitative and quantitative maintenance of tropical seasonal forest. Sites and methods The study site is located at the Mae Klong Watershed Research Station, Kanchanaburi western Thailand (Suksawang, 1995). Soil type around study site was classified to Ultisol or Inceptisol (USDA 1997). Natural vegetation types around the watershed are mainly mixed deciduous forest (MDF), dry dipterocarp forest (DDF) and dry evergreen forest (DEF). Teak (*Tectona grandis*) plantations (TPF) and grassland that was used for shifting cultivation (GRL) in the watershed were also surveyed. in 1995, seventeen soil profiles under different forest types and topographic positions were described, and soil samples are collected for soil chemical and physical analysis. Nitrogen availability of top and sub surface soil samples were also determined. Results and discussion

Amounts of carbon storage in soil were higher 205t/ha/100cm depth in DEF and lowest 71 t/ha/100cm depth in DDF. The carbon storage on MDF, TPF, and GRL did not vary among pedons. Organic carbon and total nitrogen content in GRL were higher than another soils but these contents among another soil were not so different. in most case, carbon contents decreased gradually from top to lower horizon but the soils under DDF showed drastically decrease in carbon contents from the surface horizons. The same trends were observed for nitrogen distribution patterns in the soil profiles. Available nitrogen contents in soils of MDF and DDF types were 0.45-1.1mg-N/kg dry soil. GRL also had high available nitrogen in soils (1.3-1.6mg-N/kg dry soil) while TPF had low available nitrogen (0.5 mg-N/kg dry soil). in each forest type Soils in lower slopes showed higher nitrogen availability than in ridge and upper slopes. Nitrate nitrogen was major part of available nitrogen. Nitrification rate (nitrate nitrogen to available nitrogen) were more than 80% in almost of surface soil samples. Calcium is a major exchangeable base and following to magnesium and potassium. The content of Ca and Mg were also high in GRL, DEF and lower slope of TPF but were on the lower than those in the soils of limestone plateau near the watershed reported by Janmahasatien et al. (1997).

Conclusion: The results of soil chemical properties indicate that soils in this watershed are relatively fertile, especially for soils under DEF. The GRL also showed high soil fertility although they used to be utilized for shifting cultivation. The soils in TPF contained lower nutrients even though they located on lower slope. The reason is not sure but this may be caused by high nutriment requirement of tree growth or surface soil erosion of teak plantation. We are great thanks to National Research Council of Thailand Science and Technology Agency Japan and Japan International Research Center for Agricultural Sciences for their financial support in this research.

Nutrient Dynamics in the Throughfall, Stemflow and Litterfall of Korean Pine, Japanese Larch and Hardwood Stands at Kyunggi-Do, Korea

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Keywords: Nutrient dynamics; *Pinus koraiensis*; *Larix leptolepis*; Hardwood

The objective of this study was to examine the amount of nutrient input and dynamics by throughfall, stemflow and litterfall among *Pinus koraiensis*, *Larix leptolepis* and hardwood stands including oak forests at Kyunggi-Do, Korea. The nutrient distribution and cycling in a forest ecosystem was strongly influenced by tree species and human impacts including forest practices. The amount of Ca in the aboveground vegetation was the highest, followed by N, K, Mg, P and Na in descending order. Nutrient content in the hardwood stand was relatively high, although its tree biomass was low. The amount of K in the hardwood stand was exceptionally high whereas that of *L. leptolepis* stand was the lowest in nutrient contents. The amount of litter nutrient in the *P. koraiensis* stand was relatively lower than other stands, which seems to be due to the forest practices. The amount of N in the litterfall was the highest, followed by Ca, Mg, P, K and Na in descending order.

Monthly amount of nutrient input by throughfall and stemflow was significantly affected by the characteristics of rainfall and stand structure. The amount of throughfall in the hardwood and *L. leptolepis* stands showed greater than *P. koraiensis* stand while that of stemflow in the hardwood stand did greater than other stands. The differences in the amount of throughfall and stemflow for each of the stands seemed to be caused by its leaf-retaining period and physiological characteristics.

The ion concentrations of throughfall and stemflow showed in the following order: NH_4^+-N>K^+> Ca^{2+}> Na^+> Mg^{2+} for cations and SO_4^{2-}> NO_3^-N> Cl^- for anions. After the precipitation passed through the canopy, K^+ increased most in the hardwood stand, whereas NH_4+-N did most in the *P. koraiensis* and *L. leptolepis* stands.

Ectomycorrhizal fungal flora in the miombo woodlands of Africa: diversity and sensitivity to land-use

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Keywords: Miombo woodlands; Ectomycorrhizal fungi; Mushroom; Thinning; Tap root; Africa

The miombo woodlands occur in the eastern, central and southern African countries. They are found in areas having limited rainfall, experiencing regular wildfires and subject to continuous human disturbance. They are the most extensive vegetation and the most used type of woody ecosystem in Africa. Millions of humans and animals depend upon the miombo woodlands for food, water and shelter. Wild mushrooms are among the most frequent resources and yet the most vulnerable and the most endangered. in order to cope with uncertainties and capture short-lived opportunities, the miombo trees focus on the development of the root compartment. (1) They develop a very extensive and robust tap root system where they store carbon and water. (2) They are associated with ectomycorrhizal fungi, which help extract water and minerals in a hostile physical environment.

The working hypothesis was that sugar reserve in the taproot is a necessary store to enhance and sustain mushroom occurrence during the period when the top is thinned in the cropping season. This kind of thinning is common in the miomo zone. in order to test this hypothesis selective cutting of all ectomycorrhizal trees of the genera Julbernardia globiflora or Brachystegia species was implemented in the middle of the miombo woodlands in Morogoro, Tanzania. Cutting was made just prior to the short rains, which usually start towards the end of October. Subsequent shoots, which sprouted from the stumps, were regularly thinned to zero. Stumps were kept alive. The control plots were demarcated in the surrounding of cut plots. These were left intact. Farms established in the neighbourhood by total clearing of the miombo woodlands were identified. During the short rains and the long rains, which fall sometimes between end of February to the end of May, daily visits were made to the plots and mushroom occurrence assessed in the cleared and the non cleared plots. Similar assessments were made in agricultural lands where miombo trees were earlier cut with regular thinning of sprouts or uprooted and replaced by exotic agroforestry trees. Selective cutting of ectomycorrhizal trees followed by removal of sprouts from the stumps inhibited the occurrence of ectomycorrhizal mushrooms in the site and in the farms. in the cleared plots only saprophytic fungi produced sporophores while a wide range of ectomycorrhizal fungi produced mushrooms in the control. The study revealed the very intimate relationship between the trees and the mushrooms. It showed the sensitive part of the host: the leaves. The study suggests that the energy stored in the root system or in the stem is either unfit for ectomycorrhizal fungal use or is set aside for particular function of the tree prbably to reinitiate sprouting after the long dry season or after top removal. This study carries the message for the sustainable management of the miombo woodlands for multiple uses.

Planting trials of indigenous species at sandy soil area in southern Thailand

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Keywords: Reforestation; Sandy soil; Indigenous species; *Dipterocarps*; Southern Thailand

We have been carried out reforestation trials since 1994 in southern part of Thailand, where infertile sandy soil area is expanded as a result of a failure of agricultural development. We have been trying to plant valuable trees focusing on indigenous species including *Dipterocarps*. Twenty-three tree species have been tried; *Anisoptera sp., Dipterocarpus alatus, D. chartaceus, D. obtusifolius, Hopea odorata, Shorea glauca, Shorea hypochra, Shorea leprosula, Shorea roxburghii, Parashorea sp., Vatica pauciflora, Acacia mangium, Acacia auriculiformis, Anacardium occidentale, Alstonia macrophylla, Alstonia spatulata, Casuarina equisetifolia, Euodia roxburghiana, Fagraea fragrans, Syzygium grande, Syzygium kunstleri, Syzygium oblatum* and *Syzygium spicatum.* The area undergoes a severe drought in dry season and is waterlogged in rainy season. in dry season, the surface soil temperature exceeds 40 oC. The seedlings planted in such area are faced to harsh environmental stresses, resulting in low survival ratio and little growth. Our trials revealed that planting *Acacia mangium* proceeding to the purposed-tree planting improves the seedlings' survival and growth. in *Acacia mangium* forest, light intensity was diminished and soil surface temperature was dramatically lowered than those in open area, which may weaken the photodamage under infertile condition or high temperature stress. *Acacia mangium* itself also suffers from the harsh environment, resulting in low survival ratio in case of no treatment. Plowing brought remarkable improvement of the *Acacia mangium* survival, which confirms its beneficial ability to nurse the subsequently-planted indigenous species. Pot size effects on seedlings' survival and growth were examined on some dipterocarp species. Larger pots brought better seedlings survival without any help of *Acacia mangium*. Ecophysiological studies have also been carried out for better understanding of the planted seedlings' growth performance. Among the dipterocarp species examined for planting at open site, *D. obtusifolius* showed obviously better survival than others. We compared photosynthetic performance of *D. obtusifolius*, D. chartaceus and H. odorata, which revealed remarkably higher light-saturated photosynthetic rates in *D. obtusifolius* than in other two species. Additionally, the light-saturated photosynthetic rates of *D. obtusifolius* were even higher than those of *Acacia mangium*.

Properties of organic matter and the soil adsorption complex in forest ecosystems of Croatia

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Keywords: Organic matter; Humus; Soil adsorption complex; Forest ecosystems

Transformation and movement of matter and energy is a characteristic feature of every ecosystem. A specific correspondence among individual elements of an ecosystem is manifested in a particular manner in the soil. in forest associations, which are in natural harmony with the climate and parent substrate, the properties of physical-chemical soil sorption and the condition of organic matter in the surface part of the soil are very interesting. This is significant pedogenetically in terms of transformation and migration of matter, and physiographically in terms of the nutritive soil status analysis and the related ecosystem diversity.

Research was done on the humus content and the adsorption complex saturation in humus-accumulative soil horizons in characteristic climatozonal associations in the vegetation belts located in flat, hilly, and mountainous regions in Croatia. The results of research have shown that some forest ecosystems have characteristic humus properties, characteristics of the adsorption complex display considerable variability, the correspondence between the properties of humus and the adsorption complex can be explained with internal and external factors, the adsorption complex and humus correspond well to floristic diversity of forest stands, in clayey and sandy substrates (or substrates that release either clayey or sandy material via transformation) an influence can be detected not only on the state of adsorption complex, but also on the state of humus.

Brazilian ecological classification for tree planting

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Keywords: Ecological classification; Brazilian territory; Tree planting

An ecological classification of the Brazilian territory has been developed in order to subdivide the country into ecological regions and sub-regions with the aim to subsidize tree species selection for planting. The classification system was subdivided into two levels: at the first one, the country has been subdivided into ecological regions using the altitude and several climatic variables related to air temperature, precipitation, humidity and some of the Thornthwaite? indices; at the second one, native vegetation types, soil classes, geological groups, relief classes and drainage density have been used to subdivide the country into ecological sub-regions.

In order to obtain the delimitation of the territory into ecological regions, the steps are described as follow. All published data available from meteorological stations have been used. Considering the reduced number of meteorological stations in Brazil, precipitation data have been obtained from pluviometric stations. Estimated temperatures have been obtained for all pluviometric stations lacking this information. At first, these data were submitted to interpolation, using cells of about 15 x 15 km, in order to have an even distribution of the data. This analysis has been developed in blocks of 4o by 4o of latitude and longitude. in the next step, the data were submitted to factorial analysis. Factorial loads with correlation higher than 70% were extracted from each factor to constitute the linear indices, which replaced the original variables. These indices originated the input data for grouping and discriminant analysis, generating the subdivision of the territory into ecological regions. Each region was described based on the average value of the cells contained on it, for each variable analyzed.

In order to obtain the delimitation of the territory into ecological sub-regions, the steps are described as follow. The maps containing native vegetation types, soil classes, geological groups, relief classes and drainage, when available, were digitalized. A net corresponding to 8 x 8 km in the field was designed over the map in order to obtain the proportion of cover of each variable per cell. These data were submitted directly to both non-hierarchical grouping and discriminatory analysis, making possible the delimitation and characterization of each ecological sub-region.

At the ecological region level, the results have shown that three to four factors can be responsible for 80 to 88% of the cumulative explanation of the original data. The first factor usually explains from 40 to 59% of the variance in the original data and is mainly constituted by altitude and temperature variables. The recent inclusion of Thornthwaite? indices improved substantially the delimitation of the ecological region, once most indices were included in the first or second factors, in special for the northeastern region, where water availability is quite variable within very short distances. in the southern region of Brazil precipitation is quite high and uniformly distributed. For this region, humidity was more important than precipitation with all humidity variables used being included in the second factor.

At the ecological sub-region level, the method was already applied to one block of 4o by 4o. The discriminant analysis proved that 94% of the cells were correctly allocated to the ecological sub-regions, using a subdivision into 12 sub-regions. The variables used were complimentary, i.e., when two or three regions were similar in terms of one variable they differed from each other based on other group of variables.

Carbon and Nutrient Cycling in a Mixed Deciduous Forest of western Thailand

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Keywords: Nutrient cycling; Seasonally dry tropical forest; Soil conditions; Mineralization

Nutrient cycling is an essential knowledge for sustainable forest management. Especially in tropical countries, biomass is largely accumulated in aboveground on relatively nutrient poor soils, which indicates that deterioration of forest would directly result in loss of nutrient from the ecosystems. Many studies on the distribution of carbon and nutrient pools in the forest ecosystems were conducted in the tropical rain forests but a few studies are available in seasonally dry tropical forests. Mixed deciduous forest (MDF), a vegetation type of seasonally dry tropical forest, is widely distributed in eastern Asia, from India to Thailand. It is concerned that intensive uses and frequent fire may reduce forest resources and nutrient pools in the ecosystem. The objective of this study is to determine the pool sizes and fluxes of carbon and nutrients in MDF of western Thailand for understanding nutrient dynamics in undisturbed condition. The study was conducted at an undisturbed mixed deciduous forest in the Mae Klong watershed research station, Kanchanaburi, western Thailand. Annual rainfall is about 1,600 mm and it falls mostly from April to November. Mean annual air-temperature is about 27 C. Dominant tree species are Shorea siamensis, Dillenia parviflora var. kerrii, Xylia xylocarpa var. kerrii, and Vitex peduncularis. Most of the forest understory was prevailing with bamboo species. Ultisols are dominant soil types, which are derived from sedimentary rocks and gneiss. in this watershed, limestone is also found. Soils show slightly acidic and lightly clay textures.

In the total ecosystem, carbon was sequestrated 308 MgC/ha. Above and below ground biomass were accounted for 130 and 43 MgC/ha, respectively. Bamboo understory showed 16.4 MgC/ha for aboveground, and 3.1 MgC/ha for belowground. Mineral soil (0-1m in depth) stored 125 MgC/ha. For dead organic matter, a carbon pool in standing dead of trees and bamboos (6.8 MgC/ha) were larger than that in litter layer (2.8 MgC/ha). Annual carbon input was 4.5 MgC/ha by litterfall and carbon release by soil respiration was estimated 19.3 MgC/ha annually.

The amounts of nitrogen in the above and below vegetation were 1,470 and 593 kg/ha. Soil is a largest pool for nitrogen and the pool size was 9,170 kg/ha. Phosphorus was distributed 166 kg/ha for aboveground vegetation and 57 kg/ha for belowground. For cation distributions, vegetation is a main nutrient pool. Around 56 - 60 % of cations were stored in the aboveground biomass. Nutrient pools in the soil were small for available P and exchangeable cations: 13 - 15 % of total pool.

Annual litter production was 9.0 Mg/ha and 66% of the total litterfall was leaf litter. The fluxes of nitrogen and phosphorous by litterfall were 66 kgN/ha and 5.5 kgP/ha, respectively. For cations, 39 kg/ha of K, 129 kg/ha of Ca, and 27 kg/ha of Mg were return to the soil by litter annually. in these nutrient returns, more than 90% of each element was transferred via leaf litter.

MDF contained relatively larger amount of nutrients in aboveground biomass than tropical rain forests reported. Low ratios of biomass: elements in fresh litter also indicate that there was no nutrient deficiency in this ecosystem.

Effects of carbon properties on characteristics of nitrogen mineralization in forest soil

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Keywords: Carbon mineralization; C/N ratio; Kinetics model; Nitrogen mineralization; Nitrogen immobilization

Nitrogen (N) is usually the most limiting nutrient in forest ecosystem vegetation. The amount of N mineralization by microorganisms is an important indicator of N availability in forest soils. in general, the net N mineralization of organic matter is small when the carbon/nitrogen (C/N) ratio of soil is high because inorganic N is immobilized by soil microbes. Nitrogen availability in soil is frequently limited by not only the amount of carbon (C) or the C/N ratio, but also by the amount of available C. in this report, the characteristics parameters of N and C mineralization in forest soils were investigated by analyzing the kinetics model. It was based on the results of the following in vitro incubation. The soil samples were taken from Japanese cedar (*Cryptomeria japonica*) stands (3 plots), Japanese cypress (*Chamaecyparis obtusa*) stands (3 plots), deciduous broad-leaved stands (1 plot) and evergreen broad-leaved stands (2 plots) in Kanto region, Japan. Soil samples were taken at depths of 0-10cm and 10-20cm in each plot. The organic layer (O-layer) samples of forest soil were taken from 5 plots. The fresh soil samples were sifted through a 4mm sieve, and the fresh O-layer samples were cut into about 10mm pieces, and incubated at 20, 25, and 30? for 100 to 200 days. The samples were extracted at 3-30 day intervals, and the amount of inorganic N and the rate of C dioxide (CO_2) evolution were measured. Using Arrhenius' law, experimental results obtained under each temperature conditions can be transformed into a mineralization rate at a standard temperature (25°). Parameters of N mineralization potential (N0), the N mineralization rate constant (k) at 25° and apparent activation energy (Ea) are normally estimated by mathematical analysis using a simple type of kinetics model in forest soil. The N mineralization process in the O-layer of forest soil was fitted to a kinetics model of N mineralization combined with an immobilization. in the case of the O-layer, the potential of gross N mineralization (Nm0), immobilization (Ni0) and net N mineralization (netN0 = Nm0 - Ni0) were examined. The amount of C mineralization was calculated by integration of the CO_2 evolution rate. The integration of C mineralization was fitted to a simple type of the kinetics model, and the C mineralization potential (C0) was examined. The relationship between the C/N ratio and N mineralization parameters was not significant in any of the soil samples. However, in soil samples where the C/N ratio was >20, the C/N ratio and N0 had a negative correlation and the C/N ratio and Ea had a positive correlation. These suggest that N mineralization was limited by the C/N ratio of soil because active N was immobilized in soil where the C/N ratio was >20. in soil samples where the C/N ratio was <20, N mineralization was not limited by the C/N ratio because N immobilization activity in the soil was depressed. There was a positive correlation between C0 and N0; the regression line was C0/N0=20. The potential C/N ratio of available organic matter utilized by microbes was about 20 in the forest soil. k was the greatest and Ea was the smallest when C0 was 7-8% of total C (C0/C). This suggests that there is little C0 available for N mineralization when C0/C<7-8%, and that there is sufficient C0 for N immobilization when C0/C>7-8%. Thus, C properties are important as indicators of movements of the amount of available N in forest soil.

8.03.00 Forest Hydrology and Water Quality

Applying the caesium-137 technique for studying sediment redistribution at basin scale

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Keywords: caesium, sediment yield, tracers

Identifying areas of the landscape that are most sensitive or susceptible to erosion stimulated the study of within-basin variability of the sediment delivery processes and the use of spatially distributed models coupled with Geographical Information Systems.

The progress of distributed models is hindered by the lack of measurements able to establish the link between the eroded soil leaving an area and the patterns of erosion and deposition occurring along the hydraulic path from the considered area to the nearest stream reach. Tracer techniques afford an alternative to the use of plots and a means of overcoming the problems of measurement representativeness and spatial variability.

The tracer most widely used in soil erosion and sediment yield studies is caesium-137, an artificial radionuclide which was released into the environment as a result of above-ground thermonuclear weapons testing. Fallout deposition on the land surface occurred mainly with precipitation. When fallout caesium-137 comes in contact with soil, it is readily fixed or adsorbed on the organic and clay particles and subsequent movement by natural chemical and processes is limited.

In this paper caesium-137 measurements available for two basins with different crop covers, located in Sicily and in Calabria, are used for validating the Sediment Delivery Distributed (SEDD) approach based on the Revised Universal Soil Loss Equation and the sediment delivery ratio of each morphological unit into which the basin is divided. For the Sicilian basin, which is used for wheat cropping, the predictive ability of the SEDD model is positively tested comparing the calculated sediment yield values with the measured ones obtained by the caesiographic map and the proportional method of Martz and de Jong. For the Calabrian basin, which is covered by *Eucalyptus occidentalis* Engl., the testing of the SEDD approach is carried out by comparing the calculated sediment yield and the caesium loss at the morphological unit and basin scale.

Assessment of Selected Water Channels as Affected by Waste Disposal in Nangalisan, Tuba, Benguet, Philippines

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Key words: water quality, biochemical oxygen demand

In the Philippines, water quality assessment started at Irisan, Baguio City (dumpsite) and Calot Sablan, Benguet (piggery farm). The other sampling points chosen for consideration were closely monitored and evaluated as to which tributaries may contribute water pollution to stream and rivers.

The BOD (Biochemical Oxygen Demand) for all water samples collected during the rainy season is within or below the limits of 5 mg/l (yearly average values). The results of analyses during the dry months are also below this limit. The findings revealed that the stream can presently accommodate the approximate quantity of oxygen that will be required to biologically degrade/stabilize the organic matter present but in a specified time and temperature.

On the other hand, the DO (Dissolved Oxygen) in all water samples collected from the sampling points established at various locations during the rainy season is above the limit of 5.0 mg/l. Surprisingly, when it was compared to the results taken during the dry season, it is still above this limit. From laboratory tests, it appears that dissolved oxygen is sufficient to support and maintain all forms of aquatic life. Although it is being contaminated by various combinations of liquid and solid wastes from residences and industrial establishments, aerobic decomposition is still taking place in the presence of oxygen.

Meanwhile, the total coliform organisms detected in colonies per 10 ml of water samples at 24 hours included Escherichia coli, Citrobacter freundii, E. agglomerans and Enterobacter aerogenes. Water samples tested on site have pHs ranging from 6.5 to 8.5 indicating that microbial growth can be accommodated but if the pH falls below 5, microbial activity will cease. No health-based guidelines have been proposed for pH.

Sustainable Management of a Forested Catchment following Conversion from *Eucalypt* Forest to Radiata Pine Plantation

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Key words: water quality, water yield, radiata pine

Australia has a large trade deficit in forest products and extensive plantations of radiata pine have been established as part of a strategy to expand the nations wood resources. Initially, softwood plantations replaced native eucalypt forest, but since the mid 1980s plantations have been established mainly on cleared agricultural land. Associated with this conversion of catchments to intensively managed, fast-growing plantations are changes in hydrology and potential impacts affecting water yield and water quality.

Australia has adopted the Montreal Process of socio-economic and environmental criteria and indicators for the sustainable management of forests. The maintenance of water quality within the range of historic variation is one of the environmental indicators included in this Process.

In the mid 1970s the Cropper Creek Hydrology project was established to study the hydrology of three small catchments of mixed species eucalypt forest. in 1980 one catchment was cleared except for a 30-m wide riparian zone for the establishment of a plantation of *radiata* pine. in the short term this change in land use increased annual water yield by 3.5 ML/ha, but yield gradually decreased to pre-treatment values with time from clearing (Bren and Papworth 1991). Only minor changes in water quality were observed, but export of suspended solids and nutrients in streamwater increased because of higher water yield in response to clearing (Hopmans et al. 1987).

In 1997, the Cropper Creek study was resumed to evaluate the long-term changes in hydrology and water quality of the 17 year-old radiata pine plantation compared with historic data for the forested catchment prior to conversion. This showed little change in water yield and water quality. Present median values for turbidity (3.6 NTU), total suspended solids (4.2 mg/L), electrical conductivity (2.9 mS/m), and concentrations of sodium (2.4 mg/L), potassium (0.6 mg/L), calcium (0.8 mg/L), and magnesium (1.5 mg/L) are in close agreement with historic values. Furthermore, results also showed that the variation (median absolute deviation) for each of these parameters at the mid-rotation stage of the plantation closely matches the historic variation of the catchment under native eucalypt forest. These results indicate that the change in land use to more intensively managed softwood plantations has maintained the high quality of the water from this forested catchment.

Modelling the Water Balance on Small Mountaineous Catchments

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Key words: Water balance, torrent control, deforestation

Land use and management in a catchment can significantly influence rainfall-runoff processes. This effect is even greater on small mountainous catchments with highly fluctuating water discharges and with substantial sediment transport. To reduce the detrimental impacts associated with storm rainfalls, foresters may apply a broad variety of torrent control measures on a catchment.

Expensive hydraulic structures and heavy embankments in river beds are usually less effective than those implemented sustainably over the whole catchment. However, this does not mean that torrent control associated specifically with rivers should be minimized, and land use or forest protection applied exclusively as a safeguarding measure. Foresters are usually well aware that a combination of both technical and biological aspects applied over the whole catchment is necessary for effective torrent control. Such a qualitative assessment is well known. However it is necessary to quantify rainfall-runoff processes and to understand them better before deciding on a final form of torrent control.

To better analyse natural processes in a catchment, the implementation of hydrological models is recommended. With this view in mind the WBCM-5 model (Water Balance Conceptual Model, version 5, Kovar et al., 1996) has been developed. This model can provide a good simulation of the catchment water balance when rainfall-runoff data are available. in the case of ungauged catchments the model parameters can be estimated from hydrological and geomorphological analyses. Furthermore, the WBCM can be used to predict the impact of changes in land use, and forest pattern especially species displacement and age structure. The model is physically based on probability distributed values of parameters over a catchment in respect to their area variability. It has 13 parameters only three of which need to be optimized according to runoff observation or "adjusted" to resemble similar soil-hydraulic conditions. The other parameters can be determined from maps and from commonly available data. The WBCM model considers all substantial interactions between individual horizontal zones as vegetation, land surface, active (root) zone, unsaturated and groundwater zones. It simulates the following processes:

- Potential evapotranspiration and interception
- Surface runoff and active zone dynamics
- Unsaturated zone moisture and actual evapotranspiration
- Saturated zone dynamics, basic runoff, total runoff

In this study, the water balance of a small experimental catchment, CERNA NISA in northern Bohemia in the Czech Republic (area: 1.87 k m^2, length of stream 2.10 km with the slope of 2.3%, average altitude 800 m a.s.l., average annual rainfall 1070 mm, average annual runoff 666 mm) was analyzed. The outlet of CERNA NISA is gauged (profile UHLIRSKA) and the daily flow was first used for the model parameter assessment. Data for the growing seasons from 1980 to 1996 were used to simulate the water balance. The next step was to implement the model further in a simulation of hypothetical scenarios representing changes in land use and deforestation in particular. It has been shown to what extent deforestation can influence individual components of the water balance. It usually decreases interception and actual evapotranspiration, and increases surface runoff. These changes have been quantified by the WBCM model in other places in the Czech Republic (Kovar, 1998). The model can also be used to predict flood levels when the active zone is close to saturation.

The mountainous stream water chemistry from Japan to northern Thailand

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Key words: stream water chemistry

The chemistry of mountainous stream waters from 12 forested watersheds in six regions was evaluated. Three watersheds were selected from Shibecha (43°17’ N, 147°37’ E), Hokkaido Prefecture, two from Takayama (36°11’ N, 137°19’ E), Gifu Prefecture, two from the Mt. Hiei (35°06’ N, 135°51’ E) in Otsu, Shiga Prefecture, three from Kagawa Prefecture (34°12’ N, 134°12’ E), one from Jiulianshan (24°31’ N, 114°28’ E), southern China, and Chiang Mai (18°47’ N, 98°37’ E), northern Thailand. pH was determined by glass electrode; EC (electrical conductivity) by a conductivity meter; Na^+, NH_4^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, NO_3^-, and SO_4^{2-} by ion chromatography; Si (only for stream water) by inductively coupled plasma (ICP) spectrometry. The concentrations of HCO_3^- (meq/L) were calculated from the difference between total measured cation and anion concentrations.

EC and strong acid anion concentrations in stream water increased with low Humidity Index (HI) values, suggesting that dry conditions increased concentrations due to high rates of evapotranspiration. Anion concentrations were also affected by other factors. The Cl^- concentrations in stream waters were higher in those watersheds which had closed canopies and were nearer to the ocean. The NO_3^- concentrations were higher in those watersheds having well developed soils and high moisture conditions, but were lower in tropical and subtropical watersheds which had high rates of nitrogen uptake and for watersheds with large areas of saturated soils. The SO_4^{2-} concentrations were affected by SO_4^{2-} adsorption properties of the soils: at Shibecha, Jiulianshan and Chiang Mai with high adsorption capacities. SO_4^{2-} concentrations in streams were low. High SO_4^{2-} concentrations were found at Mt. Hiei and Kagawa due to the weathering of sulfur minerals and high levels of atmospheric sulfur deposition. Within the regions, SO_4^{2-} concentrations were inversely related to NO_3^- concentrations. However, HCO_3^- concentration did not exhibit a clear relationship with HI. This may be caused by the fact that (a) HCO_3^- concentration is affected by CO_2 partial pressure, pH and geological conditions, and (b) HCO_3^- concentrations may include some organic anions in this study. A comparison among all watersheds exhibited significant positive correlation between HCO_3^- concentration and pH, suggesting that H^+ consumption in deeper soil increased pH and HCO_3^- concentrations. The correlation between pH and EC was clearer than that between pH and HCO_3^- concentrations in stream water. The relationship between pH and EC was determined mainly by that between pH and HCO_3^- concentrations, and partially by the neutralization of strong acid anions in soil.

Water yield from *Pinus radiata* plantations: A review

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Key words: water yield, *Pinus radiata*, plantations, afforestation

Globally, there are fears that the establishment of plantations of exotic forest species for wood fibre production may have a detrimental effect on the environment, especially those aspects relating to water yield, water quality, erosion and sedimentation, soil degradation, and biodiversity, These fears are often raised where *Pinus* and *Eucalyptus* forests are established in the headwaters of catchments in areas where there could be diminished water yields. Arguments can then arise between foresters who 'use' rain water to meet the biological needs of trees for growth, and downstream-users who require water for municipal, stock-water and irrigation supplies, and to sustain minimum levels in rivers for recreation and maintaining-stream habitats, especially at times of seasonally low river flows. This paper reviews data on water yields from catchments with established *Pinus radiata* plantations. The information, mainly from studies in New Zealand, Australia and South Africa, has been obtained from a search of the literature in world-wide databases. A number of these studies report on the differences in water yield between pine-covered catchments and those with other vegetation covers, e.g., indigenous forests, grasslands, and pasture.

Layang Reservoir sorbed-phosphorous loadings estimation

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Key words: phosphorous loadings, sediment yield

Phosphorous (P) and sediment inflow from reservoir drainage areas can accelerate the process of eutrophication or lake aging. The phosphorous and sediment inflows may originate from forests or agricultural activities and plantations around the drainage area. Recent investigations seem to favour phosphorous as the limiting factor for reservoir productivity (Henderson 1979). The purpose of this study was to estimate the rate of phosphorous loadings from the drainage area into Sungai Layang Reservoir situated in Johor, Malaysia. The phosphorous loadings rate at the Sungai Layang Reservoir was determined by using an event-based stochastic model developed by Duckstein and Bogardi (1978).

The area surrounding Sungai Layang Reservoir is covered with palm oil and rubber trees with some portions under primary forest. The remaining land is used for agriculture, cultivation of fresh water fish, etc. Fertilizer was used to increase the agricultural yield. There are some chicken and pig breeding areas which affected the water quality of the reservoir. There are five rivers flowing into the reservoir. However, all of the rivers except the river flowing through Ladang Ban Foo are dry most of the time, but the main channel has water flowing throughout the year. All other rivers have water flowing only during heavy rainfall.

The model described by Duckstein and Bogardi took into account the two types of phosphorous: dissolved-phosphorous and sorbed-phosphorous. Sorbed-phosphorous is also known as sediment-phosphorous. In the precipitation event-based stochastic model the stochastic nature of the nutrient input is recognized. The model also encoded uncertainties in the form of a relative frequency distribution and probability density function (pdf). Daily inflows for the stochasticity estimation are acquired by means of the Mike 11 NAM model. The probabilistic description of phosphorous loadings in terms of relative frequency, mean and variance is sought.

Water samples were taken randomly from both the river and reservoir at the water surface, and the middle, and bottom layers. The water samples were tested with reagent phos Ver 3 phosphate using DR 3000 to indicate the phosphorous content in mg/l. Preliminary studies indicated that dissolved phosphorous concentrations ranged from 0.01 mg/l to 1.07 mg/l from various locations in the river and reservoir. The total average concentration obtained from the study was 0.0410 mg/l @ 41.0 ug/l. Other aspects of water quality were also recorded: average pH was 6.95, while the average DO was 7.19 mg/l. The mean dissolved-phosphorous loadings per storm computed from the event-based stochastic model was 0.095 t/event while the variance was 0.021 t/event. The mean annual total dissolved P-loadings was 4.175 t/yr and the variance was 3.81 t/yr.

Sediment yield was estimated using the Modified Soil Loss Equation (MUSLE) developed by Williams (1975a). The average annual sediment yield was estimated at approximately 400 tons/ha/yr. This value was compared to information given by the Department of Agriculture. The sediment yield value was used to compute the total sediment-phosphorous loadings.

In order to retain overall lake water quality, activities within the watershed should be properly and systematically managed. The various control methods proposed to decrease the content of phosphorous in the lake include soil erosion control, better techniques for fertilizer utilization, the timing, amount and method of application, chemical treatment by alum or copper sulphate, and bubbling oxygen through anaerobic layers of stratified lakes. Wetland construction could be considered as an alternative technique for phosphorous removal besides improving the nature of the landscapes upstream of the reservoir.

Interactions of Woody Debris and Sediment in Headwater Channels of Coastal Alaska

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Key words: large woody debris, timber harvesting

Numerous studies in larger low gradient forest streams have noted the importance of large woody debris (LWD) in relation to fish habitat, sediment storage, and channel morphology. Very few studies have been conducted in headwater channels even though these systems are more directly impacted by timber harvesting. Headwater streams are dynamic environments because of their steep gradients (usually > 10%), susceptibility to landslides and debris flows, and direct effects of land use activities, especially when channels are deeply incised. To address the hydrologic and geomorphic linkages between the hillslope and channel in steep terrain as well as the dynamics of sediment and water movement related to riparian vegetation and woody debris in streams, a series of headwater channels on Prince of Wales Island, Alaska was investigated.

All streams were in steep glaciated valleys; some of the sites were clearcut in the late 1950s, others were clearcut in 1995, and still others were in old-growth Sitka spruce-western hemlock forests. Six of the 15 channels studied were impacted by debris flows: 3 of the channels were scoured by debris flows in the early 1960s several years after clearcutting; the remaining 3 channels were scoured by more recent debris flows in 1993. of the other 9 streams, 3 were in old-growth forests, 3 in recent clearcuts, and 3 in older clearcut areas that were not significantly impacted by debris flows. Riparian zones of channels scoured by earlier debris flows have recolonized with alder. The steep upper portion of these headwater channels, as well as the channels impacted by more recent debris flows, contain less woody debris than other channels. LWD was transported to the lower reaches of these systems where large volumes of sediment collected behind these dams. The recent clearcut sites contain large accumulations of logging slash. While this slash is storing some sediment in these headwater systems, it is doubtful that stability of such small dams will withstand large stormflow events. It appears that the smaller diameter woody material associated with the debris flow and recent clearcut channels is rather effective in storing sediment from more chronic erosion processes, e.g., minor bank erosion, bedload transport, surface erosion from old landslide scars. in contrast, the old-growth sites have less but larger diameter LWD in their channels. These jams trap a lesser amount of sediment, presumably because of the undisturbed nature of the drainage, but the deposited sediment appears more stable. For more episodic events (e.g., large storms, small debris flows), LWD dams may fail sequentially based on structural integrity and position. Additionally, we are investigating the effect of LWD type, volume, and location in these headwater systems on the channel roughness as it affects the routing of water and suspended sediment to larger fish-bearing streams. Such information is useful to help evaluate the effects of timber harvesting in steep terrain on sediment dynamics and hydrology of headwater systems as well as to estimate downstream impacts.

Stream Chemistry and The Sources of Solutes in Rainforest Catchments Underlain By Metamorphic Sandstone

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Keywords: stream water chemistry

Streamwater quality of two forested catchments namely, C1 and C2 was monitored over 3 years at Bukit Tarek Experimental Watershed (BTEW) in the State of Selangor, Peninsular Malaysia. The forest was logged more than thirty years ago and now has fully regenerated. The area is underlain by metamorphic sandstone. Streamwaters were grab sampled during baseflow conditions and sampled by automatic water samplers during storms.

The water is slightly acidic with mean pHs of 5.57 and 5.30 for C1 and C2, respectively. The acidity was significantly higher during high flow conditions and seemed to be governed by NO_3 concentrations. Levels of electrical conductivity (EC) were low with a mean of 8.3 μS/cm. The EC levels increased during storms and were accompanied by increases in the concentrations of major ions (K^+, Ca^{2+}, Mg^{2+}). This indicates that the upper soil horizon could be equally important in providing nutrients/solutes to the ecosystem especially for sites that have low weathering rates. The sources of nutrients in the upper horizon are mainly leached from canopies and forest litter. The concentrations of K^+, Ca^{2+}, Mg^{2+} and Na^+ at BTEW were generally lower than those reported for catchments of different lithologies.

Total ionic contents were higher in the stormflow samples than in the baseflow: 181.4 vs. 162.3 μeq/l in C1 and 189.9 vs. 150.4 μeq/ in C2. This showed that stormflow components were more dominant than baseflow for delivering ions into the streams. The sum of cations exceeded the anions during both baseflow and stormflow conditions. The anionic deficits vary from 10.3 to 37.4% and most probably are due to unanalyzed organic compounds. in both catchments, the baseflow was dominated by Mg^{2+} with slight differences in the cationic sequence as follows:

C1: $Mg^{2+} > Ca^{2+} > K^+ > Na^+ > NH_4{}^+ > H^+$; C2: $Mg^{2+} > K^+ > Ca^{2+} > Na^+ > NH_4{}^+ > H^+$

With Mg^{2+}, Ca^{2+} and K^+ dominating the cations, the weathering sources could be attributed to micas and plagioclase which are common minerals in metamorphic rocks. The sequence shifted slightly during storms with K^+ becoming more dominant than Ca^{2+}, and H^+ took over from NH^+. K is a major element in plant tissues and could be easily leached from the organic horizon. The two catchments shared similar anionic sequences with HCO_3^- dominating the baseflow and NO_3^- the stormflow as follows:

Baseflow: $HCO_3^- > NO_3^- > Cl^- > SO_4^{2-} > PO_4^{3-}$; Stormflow: $NO_3 > HCO_3^- > Cl^- > SO_4^{2-} > PO_4^{3-}$

HCO_3^- is the by-product of silicate weathering from the deeper soil layer whereas NO_3^- was entrained from the upper soil during storms.

It is evident that stream chemistry is influenced by the paths by which water travels to the stream channel. The slower path at the deeper soil profile carries ions from the weathering front whereas the more rapid flow is dominated by ions derived from organic matter in the upper soil horizon.

Hydrologic Effects of Forest Harvest in Northwestern California, USA

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Key words: forest harvesting effects, peakflows, lowflows

Streamflow, suspended sediment, and bedload have been monitored since 1962 in the 473-ha North Fork and the 424-ha South Fork of Caspar Creek. These watersheds are about 7 km from the Pacific Ocean, on the Jackson Demonstration State Forest, 10 km south of Fort Bragg, California, USA. About 35% of the slopes are less than 17° and 7% are steeper than 35°. Elevation ranges from 37 to 320 m. The soils of the basins are well-drained clay-loams, 1 to 2 m in depth, and are derived from Franciscan graywacke sandstone and weathered, coarse-grained shale of Cretaceous Age. About 90% of the average annual precipitation of 1200 mm falls from October through April. Snow is rare and rainfall intensities are low.

Prior to treatment, the watersheds supported a 90-year-old second-growth forest composed of coast redwood (*Sequoia sempervirens* (D.Don) Endl.), Douglas-fir (*PseudoTsuga menziesii* (Mirb.) Franco), western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), and grand fir (*Abies grandis* (Dougl. ex D.Don) Lindl.). From 1963 to 1967, both forested watersheds were measured in an "untreated" condition. in 1967, logging roads were built in the South Fork. From 1971 through 1973, about 65% of the stand volume was selectively cut from the South Fork watershed, while the North Fork remained as an untreated control. Logging began in the North Fork in 1985 and ended in 1991. The timber volume removed from the North Fork watershed approximated that cut from the South Fork in the early 1970s, but clearcutting rather than selective harvest was used. The size of clearcut blocks in the North Fork ranged from 9 to 60 ha and occupied 35% to 100% of individual tributaries.

Logging-induced changes in the South Fork's peak streamflow were greatest for the first storms following lengthy dry periods. There was no significant change in the largest peakflows (>10-year return interval) after selectively logging the South Fork. Peak streamflows following clearcut logging in the North Fork behaved similarly. There was a mean increase of 17% for the class of peakflows with return intervals >0.45-year (>0.004 m^3 s-1 ha^{-1}). Annual runoff in the South Fork increased between 9% and 30% for the first 5 years after selective logging. This is equivalent to an average increase in water yield of 900 m^3 ha^{-1}. The increased annual water yield slowly returned to prelogging levels over the following 15 years. After clearcut logging in the North Fork, the annual increase in water yield varied from 9% to 58% in the first 7 years, with an average increase of 945 m^3 ha^{-1}. This result is similar to that observed following the removal of about the same volume of trees from the South Fork. However, 7 years after clearcutting, there is still no trend of return to prelogging levels.

Selection logging of the South Fork increased summer lowflow by about 0.3 l-s-1-km-2 for each of the first 3 years after logging, an increase of about 80% from that predicted by the pre-logging regression. This increased summer flow declined with regrowth of the vegetation so that within 7 to 8 years after logging, summer lowflow had returned to pre-logging levels. Clearcut logging about 50% of the North Fork produced minimum summer flows averaging 0.4 l-s-1-km-2 (146%) larger than predicted. The increased flow was greatest (250%) during the first 2 years after clearcutting, but 7 years after cutting, summer flow was still 112% above prelogging levels.

8.04.00 Natural disasters

Krottenthaler Graben Landslide - Disaster Documentation - An Approach To A Solution

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Keywords: Landslide case history; Ground water; Preventive measures

The "Krottenthaler Graben landslide" near Geitau, municipality of Bayrischzell, county Miesbach happened on 21 November 1996 at the north - exposed slope of the "Miesing massif" (1,861 m above sea level) orographically situated on the right of the so-called "Krottenthaler Graben". The main fracture area of the landslide lies at an altitude of 1,370 m above sea level, its lowest level at 965 m. The loose masses of a cone-shaped debris slope partly stocked with forest and dwarf mountain-pines were affected by these movements. in all, some two million cubic metres of material covering an area of approx. 50 acres started to move. Whereas between 1,030 m and 1,100 m above sea level the highly piled up masses blocked the Krottenthaler Graben for a short term, eastern parts of the masses were moving downwards the slope in a debris flow manner (see also sketch referring to local and geological situation).

Triggering factors for the slope movement were:
- the saturated debris masses resulting from heavy summer rainfall
- the movement of previously occurring wet snow-falls
- the inflow of karst water and the damming up of water by aquiclude strata underneath.

In November and December 1996 the landslide was still very active, meanwhile it became stabilised. The water of the Krottenthaler Graben discharges without problems below the debris masses. A reactivation of the slope movement seems only possible when the prevalent coarse-grained material is highly soaked. Extreme conditions can, however, lead to the damming up of the Krottenthaler Graben, which may end in a breakthrough of debris flow extending to the valley floor, thus endangering the settlement at the foot of the debris cone and the trunk road B 307.

As a preventive measure the office for regional water management in Rosenheim arranged for the clearing of the retention basins downstream of existing torrent defence works and gravel traps in order to dispose of some 40,000 cubic metres of receiving volume. The costs of these measures amounted to about one million DM.

As further preventive measures the Bavarian State Office for Water Management (LfW) and the State Office for Geology (GLA) prepared an investigation and observation concept. The relevant investigations will be based on previously performed laser-scan air photography in 1998.

Urban growth and geodynamic processes in the high jungle of Peru

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Keywords: Subandean cities development; Agricultural exploitations; Floods and debris flows; Geological setting

The transition area between the andean mountain range and the amazonian plain of Peru is known as forest brow or high forest (*Ceja de selva o Selva alta*). This region is characterized by its relatively narrow valleys and their high slope. The soils plows not very stable and easily prone to erosion.

The climatic conditions and the abundance of humus favour the abundant vegetation and the high biological diversity.

Historically this region has not a significant human occupation, especially due to the existence of illnesses against those the andean inhabitants didn't have defenses. The Inkas didn't end up conquering this region, where small cultures or tribes only existed. The colonization of the high forest begins strongly in the XIX century, after the peak of the rubber, the vanilla and the chestnut. Some valleys were previously only busy for the cultivation of coca and fruits. Due to the social problems of the coastal and of the mountainous regions, as well as for the arrival of European and Japanese immigrants, the colonization of this region acquires great importance and they have been formed the first cities approximately for one century.

The main characteristic of these cities is that they settle in alluvial terraces or in the few places where the rivers form wide plains. These cities have strong dependence of the agricultural and forest activities.

In the last times, several subandean cities shows a great urban growth that induced them to occupy hillsides and unstable terranes. This process goes accompanied by the qualification of new agricultural exploitations in and lives sheer lands it lives. The destruction of the natural forests is quick.

The most tangible effects in this process of urban and agricultural growth are given in the field of the geodynamic disasters. in the last decades the flood episodes, debris flow and big mass removals have increasing, forming natural dams and overflowings. The soils erosion is alarming, the same as the reactivacition of large landslides.

The geological setting favor these processes, because the predominance of the paleozoic materials (mainly Schists), and the Quaternary deposits are not well consolidated. Besides it, the seismic activity is important, due to the existence of active regional faults, like they are those related with the of Abancay and Huancabamba deflexions.

Cities like Oxapampa, VillaRica, Quillabamba, Huanuco, Satipo, etc. are affected almost annually by floods and debris flow. The access highways to these areas are continually off for collapses and landslides. The economic effects are devastating, mainly during the rainy season: the supply of services and the supply of products are disrupted. The lost of crops and the prices increasing accompanies to these phenomena.

Another aggravating factor is the lack of urban planning that disables an orderly growth of the cities. of another side, the ignorance of the soils characteristics and of the geodynamic processes prevents to begin or to organize prevention and mitigation activities. in this way, many cities of the Peruvian high forest go a state of permanent disaster, thanks to the irreversible environmental deterioration that suffer the surrounding ecosystems.

Determination and designation of flood plains in Bavaria

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Keywords: Flood control storage; High water discharge; Aerial photographs

The most effective way to avoid risks for the population as well as flood damages is the prevention of danger potentials in areas, which are susceptible to flooding. Sustainable regional planning can be achieved by preventive flood protection measures, especially by providing special-use corridors which are designed for flooding or must be kept free from settlements or other similar uses. To secure these special-use corridors for flood control storage and high water discharge the designation of flood plains is provided for in the German water laws. in order to fulfill this legal obligation within the scope of a nation-wide initiative, Bavaria started in June 1996 the project "Determination and designation of flood plains in Bavaria" Approximately one third of the required designations have been put in practice. Priority of this project is, however, to determine flood plains along waters of a total length of about 6,000 km and make them ready for designation. It is planned to achieve most of this task until the end of the year 2005. To obtain the necessary actual data and working basis for this project, aerial photographs of flood plains have been taken since the year 1997.

Gold exploitation and erosion processes in the rain forest of southeastern Peru

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Keywords: Peruvian high jungle; Alluvial gold ore exploitation; Forest ecosystems; Soil erosion and contamination; Socio-economic problems

The well-known region as high jungle (*Selva alta*) corresponds to the subtropical humid forest (and*ean piedmont*) and it constitutes the transition area between the andean mountain range and the amazonian plain. The soils of this region are extremely fragile, for their little tickness and their high organic content. The erosion processes is developed quickly by effect of forestal activity, agricultural or mining exploitations. This is favoured by the intense rains concentrated on few months a year.

In this subandean region located at the southeast of Peru, there are very important Quaternary geological formations that possess big alluvial gold ore deposits. Most of these locations are exploited of handmade way. The depredation of the forest ecosystems become highly disturbing. Due to the low tenor of the ore deposits, a very high removal of masses is required. in the last years begun is had to it introduces heavy machinery but without any planning neither control. of another side, in spite of the great thickness of the Quaternary formations, the exploitation is only bounded to the superior strata, while the deepest deposits cannot be exploited by technical and economic questions.

The erosion is heady directly to the rivers (especially the fine silts) while the thick materials form piles where the vegetation difficultly can be regenerated. At the moment there are among 120'000 to 150'000 people working in the gold exploitation in Madsre de Dios department, at southeast of the Cusco. The great majority of these workers comes from the andean region and they develop a parallel agricultural activity to the mining, the same one that is also depredatory since it applies inappropriate technical agricultural for the forest. Equally they hunt species in risk and they destroy unique ecosystems of the subtropical rainy forests. Among the problems caused by this irrational exploitation we have:
- Beginning of a wide desertificaction process, for destruction of the vegetable covering and for the laundry of the fine particles of the floor. The recovery of the forests seems impossible. Neither the agricultural use is viable.
- Appearance of fronts of regressive erosion that affect to the forest and they advance toward areas of more slope.
- Permanent water turbidity that affects to the flora and the fluvial fauna and it produces the elevation of beds, with what the flood dangers increase.
- Strong contamination of the soils, waters and plants for irrational use of the mercury.
- Climatic alteration.
- Contamination of soils for petroleum and oils.
- Biotopes and endemic species destruction, with alteration of the biological general regime of the area.

Besides these effects on the environment, big socio-economic problems announce many great scale conflicts in the future. Another secondary effect is the permanent installation of human groups in the forest, above its soportability limits. After the exhaustion of the auriferous locations or the technical impossibility of continuing their exploitation, the workers opt for the agriculture.

The soils of the forest are not very favorable for the intensive agriculture, for what a process of migrant agriculture begins, where after three or four years of exploitation, people are obligated to leave these locations, to enable new lands, leaving desertified spaces.

Network constructions for wood debris control in torrents

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Keywords: Torrent control; Wood debris control; Construction works

Not only in Bavaria, but all over the europian alps mountain forests are widely not in a good status, moreover the situation tends to deteriorate even more. Consequently wood debris has become an increasing problem in the recent years. Due to blockage of bridges or in the torrent bed itself additional damages are caused, which otherwise would not have occurred.

During the last few years different constructions for wood debris control have been developed, consisting of various types of grid or slit construction. Sometimes they are built in combination with check dams. As experiences in Switzerland (Sachseln 1997) show, this combination may fail in special situations and the retention of the wood debris does not work.

In Bavaria we have been using network constructions for about 10 years successfully in the field of avalanche control. So the idea arised, to transfer the experience to torrent control works for the retention of wood debris. in fact the idea of network or rope constructions for torrential works is not completely new. in East-Tyrol (Austria) this type has been used for about 10 to 15 years. The main purpose here is the retention of bedload.

For the first works carried out we developed a design method based on theoretical considerations. The development of the network construction in practice was accompanied by a physical model at the Water

Research Institut of the Technical University Munich. of course we are aware of the fact, that the simulation of a complex natural process is very difficult. Nevertheless we expected a better understanding of the process and also some information about the influence and sensitivity of different design criteria. Now as the simulations are completed some valuable results and tendencies became obvious. At the moment we are considering another test in a 1: 1 scale in nature. This should serve detailed information about the external static and dynamic load on the construction which couldn't be investigated sufficiently in the model.

Mechanical Estimation of Biotechnical Slope Stability Effect by Tree Root Systems

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Keywords: Suburban Forest, Tree Root Morphology, Tensile Strength, Shear Strength, Slope Stability

In the metropolitan area and the Kansai district of Japan, there are many urban and suburban forests. These forests serve frequently as disasterprevention forests. Recently in Japan, improvement of techniques for the creation and maintenance of disaster prevention forests and urban and suburban forests has been urgent. Accordingly, the existing protection forests of urban and suburban areas were firstly described. in order to find out mechanism of biotechnical slope stability maintained by tree rootsystems, the variety of tensile strength of tree roots between several species was discussed by comparing hillside revegetation works in urban and suburban forests. and the latest topics about the efffect of environmental conservation function of forest from the above mentioned point of view will be comparatively discussed. On the other hand, the shear strength decreases due to distance from a solitary tree and the distribution of shear strength changes at the middle of sample tree were also discussed for the urban forests in Kyoto.

The forests in Japan, in response to the various requirements of the national economy, have an important role in providing steady supplies of timber and other forest products. The forests, on the other hand, possess a function of public benefits as conservation of national land and water resources, filtration of air and water, and promotion of health and recreation for the people. Thus, the forests in Japan have close interaction with the people's life. Especially, as a result of significant economic development of Japan in recent years, the foot of mountains near cities were developed into housing land and leisure facilities in many areas after felling forest trees so that the danger of the occurrence of natural disasters tended to increase. After all, urban and suburban forests around residential areas are more important than remote mountain forests when natural disasters such as landslides, falling rocks, and debris flow are likely to occur. Consequently, it is necessary to improve techniques for the creation and maintenance of urban and suburban forests in order to prevent disasters. With respect to the effects of forests in urban and suburban areas on the surrounding microclimate, the degree and range of the effects of forests on temperature and humidity has been studied based on the balance of solar energy among forests with different tree species and stand density. On the other hand, the estimation of the environmental conservation effect of urban and suburban forests has not studied completely yet. In the present research, the slope stability of forests were generally determined from the incidents of slope failures by investigating the forest conditions in mountainous regions where the failures occurred frequently after heavy rains according to the classification such as planted forest,natural forest, conifer tree, broad leaf tree, tree age and forest density and it confirms that trees are used to control erosion on slopes, to stabilize landslide scars, and to absorb debris flow impacts. Roots due to their tensile strength and frictional or adhesive properties, reinforce the soil, increase soil shear strength. Particularly, the tree roots may anchor into firm strata providing support with the upslope soil mantle through buttressing and arching. In this paper, the latest topics about the effect of environmental conservation function of forests from the above mentioned point of view was comparatively discussed. Then we reported on the results of our survey of the actual situation of urban and suburban forests and we discussed the mechanical evaluation method for the beneficial factors in terms of slope stability due to the presence of urban and suburban forests.

The role of forests in slope stability and preventing landsliding processes

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Keywords: Landslides; Storm precipitation; Ground water in forests; Slope stability; Pore pressure increase

Malaysia's commitment to achieve sustainable forest management in the overall context of sustainable development will continue to emphasize pollution control and prevention, the integration of environmental factors into project planning and implementation as well as incorporation of environmental inputs into resource and regional development. Concerted efforts and development towards sustainable management are diverse and manifold whereby Forestry Departments of Peninsular Malaysia, Sabah and Sarawak and other related agencies will enhance their policies, strategies and programmes towards the attainment of the goals of sustainable development and integrated environmental considerations in decision making process.

The paper describes the present situation elaborating on the role of rainfall and groundwater in landsliding processes and slope stability concern in forestry with special reference to Peninsular Malaysia. Landslides and washouts are becoming a common cause of accidents on the steep terrain areas. Landslides occur naturally in undisturbed areas or are influenced by effects of management and development activities especially with regards to roads. Roads have the capability of altering natural water pathways of subsurface moisture flow and road drainage design as well as maintenance should be a major management concern. It is noted that climate strongly influences landslide occurrences. in addition, landslides rates are strongly influenced by intense precipitation events and saturated antecedent conditions. As such, it is also observed that landslides invariably occur during periods of storm precipitation. Among other occurrences in Malaysia, as reported by the STAR on the 3 July 1995 (Monday), the tragedy of two landslides occurred at the Genting Highlands slip road that took the lives of at least 20 people and injured another 23. The second landslide caused most of the damage of bringing down large volume of gushing water and uprooting a 150 m stretch of trees.

The paper also articulates the need to enhance the understanding of relevant factors such as topography, bedrock geology, the hydraulic properties of forest soil and the hydrologic properties of water that have major effects on subsurface flow processes during large rainfall events.

The paper highlights the important mechanism for causing slope failures which emphasizes the height of saturation above a potential failure plane (and the accompanying increase in pore pressure) decreases the shear strength of forest soils. Lack of information in areas of steep terrain where landslides occur is an issue to be looked into. The matter of concern is our ability to model or predict stream flow responses from rainfall events and our ability to simulate subsurface water levels in landslide-prone terrain.

8.05.00 Forest Fire

A study of fire history and the vegetation change of a lowland, peat swamp forest in the Lake Sentarum Wildlife Reserve, West Kalimantan, Indonesia

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Keywords: Tropical lowland peat land; Biomass burning; Vegetation history; Pollen study

This research provides a long-term perspective on impacts of fires on tropical lowland peatland forest, and record vegetation change in the Lake Sentarum Wildlife Reserve. This study used pollen and microscopic charcoal analyses of sediment cores collected from the peat swamp forest within the reserve. The correlation of pollen spectra with the present vegetation types in the Lake Sentarum Wildlife Reserve was analysed, using correspondence analysis, while impacts of prehistoric fires on past vegetation was valued, using Monte Carlo permutation tests.

Peat land forests in the Lake Sentarum Wildlife Reserve has existed since at least 30000 yr BP. The initiation of peat in Late Pleistocene in this reserve suggests that this area is predominantly ever wet. This study also indicates that prehistoric forest fires frequently occurred in this region. These fire disturbances have minor effects on past vegetation communities, but recent forest fires, probably since 3000 yr BP, seem to have persistently shifted the forest types, from closed peatland forests to secondary forest types. Human activities and recent El Nino phenomenon may have significant roles in this current change.

Fire in Temperate and Boreal Forests-Global Change, Fire Management, and Sustainability

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Keywords: Global carbon budget; Boreal/temperate fire emissions; Management strategies

While the importance of temperate and boreal forests as potential carbon sinks is widely recognized, the role of wildland fire in the dynamics of these sinks is not. in some instances, accurate accounting of fire emissions may completely alter estimates of source/sink relationships. in most of these forest types, surface fires or stand-replacement crown fires have been part of the landscape for thousands of years. These fire patterns are altered by human activities (such as fire suppression, grazing, forestry practices, urbanization, or intentional or unplanned ignitions), by interactions with other disturbances such as insect outbreaks, or by short and long-term changes in climate. Changes in frequency, intensity or size of fires, in fuel structure, or in forest health and composition can have important effects on net carbon storage, on forest health and sustainability, and on susceptibility to future fires. Fires in boreal and temperate forests contribute perhaps 20-30 percent of the global carbon emissions from biomass burning. Fires are also sources of key greenhouse gases, which add to the potential impact of changing fire regimes on global climate. Estimates based on global climate change models suggest that fire hazard in boreal zone forests could increase substantially in the future. Management of global carbon requires a full understanding of the factors affecting carbon release from fires, and of the potentials and pitfalls for managing fire regimes to enhance sequestration. For example, attempts to increase carbon storage through elimination of fire on a landscape scale can lead to increased risk of insect and disease attack, increases in flammable fuels, and greater danger of severe fires in the future. While intensive silvicultural treatments, such as thinning, can reduce these risks, they are not practical on the scale that would be necessary for fire protection across the vast landscapes of temperate and boreal forests. and the ecological impacts of substituting mechanical treatments for fire on a broad scale are poorly understood. Despite the global importance of understanding the role, management, and impacts of fire on forest health and sustainability, we do not have adequate monitoring systems to accurately quantify burned areas, fire severity, or the effects of boreal and temperate forest fires on carbon storage (or trace gas emissions). Forest management, and estimates of global carbon balance, must consider the changing role and impacts of fire and impacts of alternate fire management strategies and changing climate in these temperate and boreal systems.

Forests fire: monitoring and management using satellite remote sensing data

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Keywords: Satellite remote sensing; Forest fire; ASEAN Region; Malaysia

Forest fire has an important influence on the vegetation cover, dependent animal, soil, stream flow, air quality, microclimate and perhaps life and even the world climate. The loss of timber, destruction of wildlife, property and recreation value are also readily perceived. Unfortunately, the damage to the protective values of the forest are not equally discernable. It is quite clear that an innovative approach on forest fire hazard monitoring and management requires the use of new technique to obtain, process and display spatial information in a timely and cost effective ways. The large size, remoteness, and temporal variability in occurrence of wildfires in tropical forest regions make remote sensing/GIS techniques well suited for monitoring and studying wildfire.

In other situation, the information gathered are useful in helping to make decision on the wildfire area. This paper focussed and emphasized on Malaysia and South East Asia due to the frequent occurrence of many forest fires during the past few years. The main objective of this paper is to promote the usefulness and capability of satellite remote sensing as an alternative tool for monitoring, mapping and managing forest fire in the ASEAN region.

Forest Fire Monitoring and Damage Assessment Using Remotely Sensed Data and GIS: A Case Study from East Kalimantan, Indonesia.

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Keywords: Forest fire hazard; Damage assessment; Remote sensing; GIS

Forests are inestimable and renewable natural resource of a nation. They are gaining prominence increasingly day by day on account of their protective, productive, recreational and ecological values. So is the case with the wildlife, of which forests are the abode. Furthermore, soil and water are to be given salience of the highest order as these two support the plant kingdom directly and ultimately affect mankind in its varied dimensions. Thus, soil, water and forests form the trinity which is indispensable for the existence and survival of mankind. But unfortunately these forests of utmost importance are subject to various kinds of injuries, out of which forest fire is the most consequential incite, doing incalculable harm to the forests.

Forest fire has an portentous influence on most of the vegetation and, through it, on dependent fauna, soil, stream flow, air quality, microclimate, and perhaps even general climate. Many of the direct, immediate effects of fire are common knowledge; they are also the reasons why fire is a matter of concern for foresters. The cumulative impacts of the environmental perturbations unleashed by the forest fire, poses insurmountable threat on the supply of natural resources. in an area of wildlife the risk is even more pronounced as they can be devoured by the fire or asphyxiated by the scorching debilitated air.

Indonesia, as a part of Malaysian botanical region, is the richest tropical rain forest in the world. Those forests are second only to Brazil's forest in size, and represent 10 percent of the world remaining tropical rain forest. of its total land area of 193 million hectares, about 144 million hectares or nearly 75 percent are classified as "forest land". More than 95 percent of those forest land are outside Java island (80 percent in Sumatra, Kalimantan, and Irian Jaya). Indonesia suffered from huge forest fires in 1983, 1986 and last year (1998).

Forest fire in Indonesia is a yearly potential caused for forest degradation. Insufficient information available about the main factors that promote the forest fire and information about the forest condition after the forest fire. This is one of the reason why forest area neglected after they are burned. Remote sensing and GIS are helpful tools to provide a quick and accurate data acquisition and that can describe the forest condition after the forest fire.

The objectives of this research were to asses the ability of satellite remotely sensing data to detect, identify and classify forest damage caused by fire and to develop a forest fire hazard spatial model.

Sustainable Management of Natural resources: Forest and Fire (Ghana)

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Keywords: Ghana forest/savanna fires; Fire damage; Control and prevention

This paper describes how the tropical country in the world began to record most of its important forest fire events from the early 1970s which normally spread occasionally from nearby savannah along the northern margin of forest zone. in 1983, fire in the forest zone of West Africa were so severe and extensive that everyone become aware of their importance. The year was notable for prolonged and extensive drought in West Africa and in many of the worlds tropical forest areas.

During that time, the environmental damage from the combined effects of fire and drought was unprecedented with great losses of crop yield and the destruction of an estimated 4 million cubic meters of timber in savannah dry semi-deciduous forests, a middle zone vegetation. Since than fires have recurred in years with unexceptional dry season, carving a progressive degradation of the forest especially on the northern margin vegetation bothering the forest zone in the south and savannah zone in the north which are the two main vegetational types in Ghana.

The major causes of the bush fire have been harsh climate condition and anthropogenic or human activities. Due to this activities forest fire in the countries have had adverse and widespread influence on especially the semi-deciduous forest. Following the drought of 1982-1983, fire has significantly altered the structure and composition of about 30 percent of these forests. The stem densities have been reduced and proportion of pioneer trees in the community increased. The effect of the fire is the considerable reduction of the economic value of forest in terms of stands timber. The measures which have been taken for forest protection through prevention and control include fire risk assessment and publicity, fire breaks, early burning, operational forest fire management and policy and legislation. Therefore a more intensive collaborative approach is being adopted to ensure a better protection of the country forest. There are also plants to intensify the development of more feasible forest fire management action plan and policy which will fully integrated not only. Monitory, research, institutional framework and capacity development but also socio-economic considerations land resources management ad utilization, training and education. It is importance to identify the need to prevent and suppress wildfire and to rehabilitate degraded forest reserves.

Fire-related Regeneration Dynamics in the Moist Deciduous Forests of Western Ghats: A case study

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Keywords: West Ghats; Tropical forest fire impacts; Regeneration; Fire behavior

One of the major causes of degradation in tropical forests and particularly the moist deciduous forests, is the recurrent incidence of fire. It is well known that fire causes extensive damage in the forest ecosystem by affecting regeneration and stocking and ultimately leading to poor status. Impact of fire on regeneration largely depend on the intensity and periodicity of fire and the level of the regeneration. The present paper deals with impact of fire on the regeneration of moist deciduous forest at a location in the Western ghats in Thrissur forest division, Kerala State, India, at varying fire frequencies.

Twelve 0.25ha (50m x 50m) plots were established for different burning treatments, viz. early-burn, late-burn, one year and two-year fire frequencies and control, with three replications. Regenerating elements of tree species (1-10cm dbh) were tagged and enumerated in all the plots. Shrubs with height above 50cm and dbh below 1cm were identified, height measured and recorded from randomly selected 4m x 5m quadrats in each of the plots. Herbs (height below 50cm) were also identified and counted from randomly selected 1m x 1m quadrats. All the observations were taken before and after prescribed burning and compared with the control (no burn) plots.

The intrime results indicate that impact of fire is more in lower diameter classes (1-2.5cm dbh and 2.6-5cm dbh), whereas regeneration above 5cm dbh are less effected. Prescribed burning carried out in the early summer season was found to cause the minimum damage to regeneration, as compared to burning carried out in the late summer season. Shrubs and herbs showed an apparent increase either in total number or species diversity after fire. Fire favoured the growth of secondary tree species, herbs and grasses. This trend was more obvious in late burn plots. Among the different moist deciduous tree species, thick bark species such as Gmelina arborea and Pterocarpus marsupium were found to be more resistant to fire. Air temperature and air humidity play a very critical role in predicting fire behaviour. It is observed that once the fuel quantity and fuel moisture content cross a certain limit which is sufficient for occurrence of fire, further change in fire behaviour is controlled by fuel porosity and fuel continuity. Other factors which control the rate of fire spread are size and thickness of leaves, rate of decomposition, soil moisture regime, wind and presence of grasses. The paper elucidate the different aspects of this experiment and concludes on the possible impact of fire on the status of moist deciduous forests in this part of India.

Haze, Forest Fires and Landuse Practices: An Assessment

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Keywords: Indonesian fires; Transboundary smoke/haze impacts; Cross-sectoral approach

Malaysia and some of her neighbouring countries namely, Indonesia, Singapore and the Philippines have of late experienced one of the worst occurrences of haze. The Problems is mainly caused by poor landuse practices of burning secondary forests and agricultural lands during preparation for agriculture. This phenomenon is not new and has been occurring almost every mainly in Indonesia. However, its severity and impacts have increased to such an extent that environmentalists have called the 1997 haze and forest fires in these region ecological disasters. The fires had resulted in a significant loss to property, loss of income, reduced the quality of the environment and also caused health problems to nearby communities. However, several issues pertaining to the occurrence of the fires has not been properly addressed and the extent of these negative impacts not adequately assessed. It is evident the problems are transboundary in nature and that a collective effort is required to address them. At the same time, the problems are also cross-sector in nature involving a variety of different agencies and ministries and thus an integrated effort would be necessary. This paper gives an assessment of the extent of the fires, its causes and impacts, and efforts that could or that are being made to overcome the problem.

History of Forest Fires in the Province of Pinar del Rio, Cuba

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Keywords: Cuban fire dynamics; Fire causes; Impacts; Fire control efforts

The knowledge of the fire occurrence history in a region is of great usefulness for the efficient planning of fire control activities, because it permits to establish the: i) locals of greater occurrences; ii) length of the fire season; iii) main causes of the fires; iv) types of vegetation affected by the fires; v) extension of burned areas by periods of time; and vi) evaluation of the efficiency in fire control. in this paper the history of fire occurrence in the province of Pinar del Rio during a 22 year period (1975 to 1996) is analyzed in order to contribute to the increase of the efficiency on fire control in the region. Pinar del Rio, region of natural occurrence of *Pinus caribaea var*. *caribaea*, the most important forest species in Cuba, is located between the latitudes 21° 45' and 23° 01' North and the longitudes 82° 51' and 84° 57' West, covering an area of 10,901 k m^2. During the observation period the total annual precipitation varied from 1,089 to 2,229 mm; the monthly average temperature ranged from 21.59 C in January to 26.85 C in August; the mean wind speed ranged from 7.0 km.-1 in August to 12.0 km-1 in March; and the mean relative humidity varied from 76% in April to 84% in September. Pinar del Rio is the most important forest province in Cuba and also the number one in fire occurrence, with 21.48% of the total forest fires recorded in the country. The majority of the fires (93.28%) and the area burned (94.44%) were observed in native or planted forests of *Pinus* spp (76.72% of the recorded fires), *Eucalyptus* spp (11.56%), and *Casuarina* spp (5.00%). Statistical analysis showed that fires were significantly more frequent in forestry plantations than in natural forests. The main cause of the fires was lightning (47.46%) but most of the burned area (39.42%) was due to fires caused by negligence, the second main cause, with 27.38% of the recorded fires. About 83.70% of the fires and 92.40% of the burned area were recorded from March to August, and 69.43% of the fires occurred between 1:00 to 4:00 PM. During the studied period the annual average number of fires was 55.45 and the mean burned area 460.46 ha. Using indicators cited in the literature, the efficiency of forest fire control in the province of Pinar del Rio, when compared to other countries, can be considered very good.

Managing Smoke in Forestry and Crop Estate Sector in Indonesia

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Keywords: Smoke impacts; Fire research; Shifting cultivation; El Nino

The increase of destruction in Indonesian forest fires in 1997 and 1998 totaled around 10 million ha, with damage estimates of US$ 10 billion. Other negative impacts included heavy smoke effecting flora and fauna, humans, and relations between other countries. Law enforcement was weak, proving that the management of forest fire prevention, suppression, mitigation and rehabilitation was neither satisfactory nor effective. Even with highly advanced equipment used to fight, millions of US$ spent, and many international groups and thousand of peoples involved, the fire did not stop, ending with heavy rains at the end of May 1998. It was found that Indonesian forest fire management lacked useful data rooted in forest fire research, making effective action against forest fires very weak. There was also a weakness in the interest of the people who working in the forest plantations and agricultural activities such as rubber and oil palm plantations that use fire in land preparation without any clear guidelines. There is no alternative solution for shifting cultivators who have been using fire for land clearing for thousand of years. There is also a loss of control from the government side which cause rules and laws become absurd. This situation has remained for a long time, even there were a large forest fires in 1982/1983 which destroyed 3.6 million ha. Unfortunately forest fires have occurred every year from small to large scales as happened in 1994, destroying 5.4 million ha of forest and land. Shifting cultivation and El-Nino would be blamed for those fires, without any clear solution on how to solve the problem. To solve this problem, the management of Indonesian forest fires must be based on information sources from research; and not just those directly translated from other countries experiences without any adjustments. The local people who live near the forest must also be approached, giving them the best alternative solutions, so that their life style will be highly appreciated. Full attention must also be

focused on the peoples working in the forest and with agriculture activities using fire. They must be given clear guidelines and law enforcement must be defined and established correctly. The government side should give full support for this mechanism, including their official staff not only in the forestry and environmental sectors but also from the justice side along with other sectors.

Fire Research and Society Interest as Limiting Factors in Minimizing Large Forest Fires in Indonesia

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The Interest of Students on Forest Fire Studies (Bogor, Indonesia)

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Keywords: Forest fires; Insects; Disease; Regeneration; Fire danger rating; Forestry students

There are about 32 undergraduate thesis of the students of the Faculty of Forestry, Bogor Agricultural University, Indonesia on forest fire in the period of 1984 to 1998. Though the figure seems to be fluctuating during the period, however it indicates a positive tendency of the interest of the students on forest fire studies. The studies were conducted in forest plantation as well as in natural forest in Java, Sumatra and Kalimantan which consist of varies areas of forest fire such as: forest fire impacts (12 titles or 37.5 %), fire danger rating (9 titles or 28.1 %), fire season (3 titles or 9.4 %), fire causing factors (3 titles or 9.4 %), fire behaviour (2 titles or 6.3 %) and control (3 titles or 9.4 %). of which 2 titles (6.3 %) were laboratory studies while the other 30 titles (93.7 %) were field works. The studies on forest fire impacts were primarily emphasised on soil and vegetation damages, appearance of pest and diseases, forest regeneration, besides on socio economic condition of forest dependent people. Forest regeneration and inventory of dead trees and injured trees, which are classified by species and diameter classes, were common studies in the last few years. Besides, the studies on the appearance of pest and diseases in fire affected areas were also get interest by the students. While, the impacts of fire on soil were still on early stage of which emphasised on soil properties and erosion. Economical loss of forest resources, wood and non-wood forest products, gets more attention in recent years. Fire danger rating was the second most interesting study of the students. The following are some examples of the studies: the application of fire danger meter types such as 8-100-0 and Rocky

Mountain, Drought Index calculation, determination of relationship between Vegetation Stress Index and Normalised Difference Vegetation Index, and determination of relationship between Drought Index and Normalised Difference Vegetation Index. Close to the study is fire season, which had also been an interesting study of the students. Since almost all forest fires in Indonesia are caused by human factor, the study on fire causing factors seemed to have little attention. The study in Java stressed on clarifying the socio economic background of forest dependent people as the most common fire-causing factor. On the other hand, the study in the other outer islands more focused on classification of activities using fire in land clearing for plantation, timber estates and traditional agriculture. Besides, there was a study on the role of cigar on forest fuel burning in laboratory scale. Though fire management is an important area in the study of forest fire, it seemed that the students had paid lees attention on the area. The studies were still in the preliminary study, which is focused on fire prevention, such as: vegetative fire breaks, fire prevention system and fire application techniques in land clearing. Similarly, the study on fire behaviour got also less intention. So far, only two titles concern with the area, namely: the influence of wind velocity and aspect on fire spread and the influence of forest fuel characteristics on fire spread.

Based on the above information, it can be highlighted that there is still lack of studies in the area of: fire behaviour and fire characteristics, fire management including forest fire prevention and suppression, and also fire ecology. Therefore, it is required to imply some efforts in encouraging the students in conducting their studies in those important areas.

8.06.00 Wildlife

Planning for conservation of biological diversity: lessons learned from Sri Lanka

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Keywords: Biological Diversity; Conservation; Protected Areas; Conflict Resolution

Sri Lanka, though one of the smallest nations in Asia harbours biological diversity of global significance. Its varied topography, diverse physical environment, unique biogeographic location and tropical conditions have given rise to extremely high levels of biological diversity, higher than in most other tropical Asian countries, when measured per unit area. Much of this diversity is endemic, presumably a reflection of the island's separation from the Indian subcontinent since the late Mesozoic. More than 3650 species of flowering plants, 300 species of *pteridophytes*, about 400 birds, almost 100mammals and more than 160 reptiles are known to occur and new species, of even higher plants and animals, are still being discovered. Sri Lanka is also one of the Asia's most densely populated countries and much of its natural forest has been cleared for settlement, cultivation, development and timber production. The forest area per capita has declined from 1.3 ha in 1900 to less than 0.1 ha in the 1999. Sri Lanka fortunately has a strong tradition in conservation and its system of conservation areas is one of the most extensive in Asia and covers about 14% of the total land area. These relatively impressive area figures notwithstanding, a number of deficiencies beset the conservation of its biological diversity and management of wildlife and protected areas (PAs). These arise mainly from the Department of Wildlife Conservation (DWLC), the agency responsible for the management of PAs, not being able to keep pace with the drastic demographic, land use, socio-economic and political changes that have come about since its inception in the mid 50s. Management of PAs is largely ineffective and suffers from inadequate scientific inputs and weak institutional structures. The situation is further compounded by a majority of PAs being small (30% of PAs are less than 100 ha and 54% are less than 1000 ha) and isolated, reflecting the fragmented nature of the remaining natural habitats.

No systematic PA management plans exist which could meet the scientific requirements of wildlife and biodiversity conservation, as well as relate to the ground realities of the pressures and problems of the local communities. It is widely recognized that a good management plan is a pre-requisite for good management as the plan provides strategies for resolving conflicts between conservation objectives and prescribes actions for achieving the management objectives. Realizing the importance of the management plans for scientific and efficient management of PAs, the Global Environment Facility (GEF) project of the DWLC initiated the process of management plan preparation for its PAs in 1996.

The paper discusses the lessons learned in the preparation of scientific management plans for PAs in the dry zone of Sri Lanka. New strategies for maintaining the integrity of PA boundaries, organizational strengthening, conflict resolution, mitigation of man-elephant conflict, ecodevelopment, ecotourism, research and monitoring have been adopted in the planning process. It is felt that the speedy implementation of these strategies would go a long way in conserving the rich and varied biological diversity of this island nation.

Wildlife conservation amidst development: challenges in Indian scenario

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Keywords: Hydropower projects; Wildlife conservation; Biodiversity impacts; Socio-economic impacts; Mitigation planning

India with varied attributes of geology, terrain, hydrology and climatic regimes, harbours approximately 7% of the world's flora and 6.4% of the world's fauna on approximately 2.2% of the global land that actually represents 0.5% of the total world's forested area. India also enjoys the dubious distinction of being the world's second most populous country supporting 16% of the world's population (846.3 million) and 14% of the world's livestock population (415.8 million). Given the constraints imposed by the adverse ratios of people to land and wildlife species to wildlife habitats, setting aside of 4.5% of the country's geographical area and subsequent proposal for an increase to 5.6% for the conservation of wildlife in protected areas has been a formidable undertaking.

Incongruities and aberrations in landuse continue to remain and are increasing. These, coupled with unsound development strategies have led to increasing challenges in wildlife conservation which so far have been partially achieved against several odds. The existing inadequacy in the coverage of wildlife areas under Protected Areas, and the loss of forest due to diversion of land for agriculture (2.6 m ha.), river valley projects (0.5 m ha.), transportation and infrastructure projects (0.8 m ha.), industries (0.13 m ha.) and other miscellaneous uses (1.0 m ha.) in last one decade, have severely jeopardized the wildlife conservation efforts in highly man modified environments of the wilderness areas of the country.

This paper illustrates through some select examples, the inherent inconsistencies between development and conservation that are linked to generation of hydroelectric power projects. The creation of valley bottom water reservoirs is now an integral part of the planned development in India. Developments of this form undoubtedly place the greatest demands on some of the country's finest forests and wilderness tracts. Experiences of impact assessment studies of most of the water resource projects in the country suggests that the diversion of forest land and the non forest wilderness areas for river valley projects and their associated losses of wildlife and genetic resources may lead to some irreversible ecological trends. These trends if not halted or arrested, can lead to the genetic impoverishment of some of the wildlife areas of the country.

The growing economic instability of the forest dependent society, generally induced due to the marginalistion of the land and the shrinking resource base that supports the sustenance driven demands of the local people is another undesirable dimension of water resource development projects.

Given the present scenario of disparities in development and conservation interest, pressures will continue to mount to both use and conserve our resources, as a result of which it may not be possible to fully prevent the impacts of development. The paper suggests the need for evolving and implementing more pragmatic approaches for mitigating biodiversity losses that involve the enhancement of productivity of croplands and the increased protection in the residual wilderness areas.

Importance of Bird Species in Forest Reproduction

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Keywords: Primary forest; Logged forest; Frugivorous bird; Seed-trap; Disperse

Selective logging has created great impact to flora and fauna in Malaysia (Nordin and Zakaria 1996, Zakaria 1994). Although only the timber species were harvested, non-timber species were also destroyed during logging. Most of these non-timber species were fruit trees important for birds (Howe and Smallwood 1982). As a result most of the fruit-eating birds (frugivores) were less often observed feeding on fruit trees in logged forest compared to primary forest (Zakaria and Nordin 1998). Chapman and Chapman (1995) asserts that when frugivore community was no longer intact, recruitment of fruiting trees might be reduced and thus, the long-term persistence of tree species is questionable. However, there was no evidence to show that fewer seeds were dispersed in logged forest compared to primary forest.

Thus, in this paper, results of an 18-month detail study on the amount of seeds dispersed by frugivorous bird species in primary and logged forest were presented. The study was conducted at the Ulu Segama Forest Concession, in the state of Sabah, East Malaysia. Two study sites were chosen - a primary forest which was located within the Danum Valley Conservation Area (DVCA), and a two-year-old logged forest which was located adjacent to the DVCA. Seed traps were used to estimate the number of seeds being dispersed in both study sites. Each trap was made-up of four PVC pipes (75cm long) and a net (100% polyester cloth) of about 1 m^2 in area. The net was raised at each corner by the four PVC pipes to about 30cm above the ground, depending on the ground level. Fifty traps were placed at random in each study site.

This study clearly shows that more of the smaller size seeds (less than 5mm in length) were being dispersed in logged than in primary forest. This is consistent with earlier study that found that in logged forest there were abundant of small size birds particularly bulbul species (Nordin and Zakaria 1996). Bulbuls are colonising species and prefer to feed on small size fruits especially of secondary or pioneer species such as Macaranga. in primary forest, bulbuls were uncommon and mostly dominated by larger size frugivores such as barbets, myna, bluebirds and hornbills (Zakaria and Nordin 1998). This suggested that they prefer to eat larger size fruits and thus, dispersed larger size seeds (more than 5mm in length). Larger size fruits are normally produced by primary plants species (pers. observations). This is probably the reason why higher number of large size seeds was obtained in primary forest.

The implication of this study is that more seeds of the secondary species were being dispersed in logged forest. Vice versa, more seeds of the primary species were being dispersed in primary forest. Logged forest would then be dominated by secondary species of plants. This would eventually change the species composition as compared to the primary forest. Therefore, the survival of frugivorous birds is vital to the survival of fruiting trees and in maintaining the biodiversity of our tropical forests.

As a result re-establishment of original stands particularly of primary fruit tree species important to birds would take longer period of time in logged forest. If they fail to establish and become mature within 30 years, many of the fruit tree species might become extinct since the next cycle of logging would happen in 30 years. These species might not have an opportunity to produce and disperse their seeds because it has been shown that many species require more than 80 years to mature and reproduce (Liew 1978). Thus, it is concluded that logged forest might be able to regenerate, but it might not be able to fully recover as the original species composition.

8.07.00 Biodiversity

Biodiversity assessment and monitoring: an adaptive management approach for forest conservation and development

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Keywords: Forest biodiversity; Conservation and development; Multi-taxa; Forest assessment and monitoring

The Smithsonian Institution/Monitoring and Assessment of Biodiversity Program (SI/MAB) and Shell Prospecting and Development B.V. Per (SPDP), in cooperation with national and international organizations, joined efforts for the environmentally sensitive development of world class reservoirs of natural gas and condensates. The area is located in the heart of Amazon rain forest hot spot for biodiversity. For sensitive development and forest conservation, two main goals were established: 1) through the forest biological assessment of six taxonomic groups (vegetation, aquatic systems, invertebrates, amphibians and reptiles, birds, and mammals), to obtain baseline information on the distribution and abundance of species for long-term monitoring in order to determine possible changes due to the industrial operation; and 2) to provide SPDP with the information necessary to make decisions concerning their operation. The assessment started in August 1996 and ended in November 1998, when SPDP and the Peruvian government failed to reach an agreement concerning the full development of the area. We found high diversity in all groups studied, and published reports have being distributed widely. Through adaptive management, we influenced SPDP in three important decisions: 1) the location for the development of a gas plant; 2) the continued use of an "off-shore" policy by using helicopters rather than building roads; and 3) the depth in which the proposed pipeline had to be burried for immediate revegetation with native species. A forest biodiversity conservation and development model was developed.

The BEAR-project: Indicators for monitoring and evaluation of forest biodiversity in Europe

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Keywords: Biodiversity indicators; European forests; Biodiversity evaluation tools; Assessment and monitoring methodology

The need for Indicators and Biodiversity Evaluation Tools

European countries have agreed upon a common goal to conserve the biodiversity of forests. This is essential for the sustainable use of the forests as well as for preserving forest ecosystem functions. European forestry is diverse, ranging from industrially managed forest areas supplying wood to export industries to private forests treated to meet the owners, specific needs.

Furthermore, forests may primarily be managed with respect to multiple socioeconomic goals, like recreation, beauty, biodiversity, historical value, water protection etc. Grazed areas are currently being transformed into forested land. Sustainability with respect to timber harvesting is since long an accepted prerequisite for European forestry. The sustainable management of forests is further developed in a panEuropean cooperation signed by the Forest Ministers ("The Ministerial Process for Protection of Forest in Europe"). The environmental awareness of the customers of forest products has resulted in certification procedures. Forest management and silvicultural methods are thus currently being further developed in order to satisfy the increasing environmental awareness, including the conservation of biodiversity. Landscape approaches are introduced, in which the arrangement in time and space of forest types and ages are considered when the planning of forestry operations. Biodiversity Evaluation Tools (BETs) are required to make these new planning and silvicultural methods effective. The BEAR-project will formulate an integrated system of indicators of forest biodiversity that are applicable over a wide range of European biogeographic regions, and at regional, landscape and stand levels.

The work procedure will recognise potential indicators of forest biodiversity by: (1) Identification of key parameters with respect to biodiversity according to forest structure and dynamics in a wide range of European forest types, (2) Identifying potential indicators of forest biodiversity for these forest types, (3) Agreeing on the preferred methodology for assessing these indicators. (4) Performing a dialogue on feasability with endusers (5) Packaging the results as Biodiversity Evaluation Tools (BETs).

In the conference, the followings will be presented;
1) What are indicators and BETs?
2) How will we work?
3) The BEAR-workplan

Species Diversity and Stand Structure of Secondary Forests after Different Disturbance Events

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Keywords: Deciduous broad-leaved secondary forest; Disturbance events; Fire-oak hypothesis; Prescribed fire; *Quercus serrata*; Selective cutting; Species diversity; Sprouting capacity; Tree species composition

The patterns of species diversity are due to the effects of different disturbance regimes on life history strategies (Denslow, 1980). The forest structure is also dependent on the pattern of forest development following major disturbances (Oliver, 1981). in this study, the species diversity and stand structure were examined in deciduous broad-leaved secondary forests dominated by *Quercus serrata* and the other species in western Japan, with an emphasis on the effects of different disturbance events on the species diversity of trees in the secondary forests. Although the substrate and topography are fairly homogeneous in both forests, they have different disturbance histories. The secondary forests established after different disturbance events (fire and selective cutting) showed different patterns in species composition and stand structure. Lower diversity with even-aged structure dominated by *Q. serrata* was shown in the site after fire whereas higher diversity with many sprouts was shown in the site after selective cutting.

Fire and selective cutting are a large-scale and a small-scale disturbance, respectively. Large-scale disturbances are likely to contain relatively few species adapted to patches with the size and environmental conditions created by fire (Denslow, 1985). The domination of *Q. serrata* and even-aged structure after fire must be an evidence of the fire-oak hypothesis (Abrams, 1992). As establishment patterns and species composition affect stand development patterns (Cobb et al., 1992), the *Quercus* domination will have a profound influence on the growth and development of other species.

The stand seems to be in the understory reinitiation stage of the forest stand development (Oliver, 1981) from the point of stand structure with two strata. The lack of *Quercus* in the understory suggests its shade-intolerant and early successional traits (Goebel and Hix, 1996). *Quercus*, however, may be able to regenerate in the old-growth stage after several decades or more (Sano 1997).

Impact of selective logging on avian community with respect to environmental and habitat condition in Wanariset Sangai, Central Kalimantan

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Keywords: Selective logging; Dipterocarp forest; Avian community; Species at risk; Impacts of forestry practices; Species Diversity

In Indonesia there are approximately 25-30,000 species of flowering plants, 750 mammals species and 1250 birds species. Logging and clearance for agriculture had threatened the island of Kalimantan or Borneo which known as the most extensive remaining *Dipterocarps* forest remaining within the region. Selective logging is likely to deplete the density of bird species that may cause to the extinction of some sensitive species. Still, no one know precisely on what extent that several birds species can sometime survive suffering such a heavy disturbance or some would easily gone even after experiencing the light one. This study is aimed to further examine the effect of selective logging on avian community and find out its relationship between vegetation structure. Field study was carried out within a logging concession in the Lowland *Dipterocarps* forest of Central Kalimantan. We looked over three location of one unlogged and two logged over forest for comparison (3 and 8 years) within 3000 ha concession areas. Environmental model was used to predict the availability of physical resources necessary for plant growth. The use of this method has advantages over field observation in that it can calculate attributes that are not readily observable in the field. It was shown from research result that logging become the most important factor in determining the vegetation structure. The aspect of vegetation structure affected may be grouped as follows: canopy/understorey structure (height and furcation index of trees, frequency of poles and sapling), abundance of lianas, volume and state of dead wood and leaf size classes. These vegetation structure variables were correlated with various indices of bird species diversity. Under further analysis, number of species is not significantly differs among the three sites but species composition within guild are changing with respect to logging. It was recorded that 7 species from unlogged forest disappeared including 2 endemic species, 19 new species were added within 3 years over logged site (1 of migrants) and 5 new species appeared in logged over 8 years site. The vegetation structure caused by different intensity of logging may create diversity of microclimate preferably to certain bird species and cause to the distinction in species composition and high variability in number of individual per species among the sites. Other factors for example differences in landscape formation prevailed on any single site may contribute to such and influence as well. Some common species to the primary forest that found within logged over forest indicating that the environment is not much differ from the pristine site or it may due to the less intensive logging prevailed. It is clear that every single species may response differently based on their capability to adapt with the environmental changes and these will be further discussed in the full paper. Hence, to find out the underlying causes of animal dynamic in some extent need to justify the sample sizes, which that for birds will certainly require much larger study areas. It is recommended to conduct further study on specific bird species within particular guild sensitive to disturbance.

Plant Species Diversity of Larch Ecosystems of Siberian Cryolithic Zone and its Post-fire Transformation

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Keywords: Species diversity; Siberian forest ecosystems; Fire disturbance; Larch forests

Larch ecosystems of Siberian cryolithic zone are characterized by the lowest plant species diversity among the forest ecosystems of the Northern Eurasia. It has resulted from the small heatrovision and geological youth of the subpolar landscapes. The phytodiversity of the northern forests has been forming at the permafrost conditions. The ground wildfires are the main disturbing factors of the region. They destroy the millions of the forested area annually.

Plant species diversity (diversity according to R.H.Whittaker (1977)) of Siberian larch ecosystems has a number of the peculiarities. There are many evolutionary primitive plants in their composition. The share of the wooden plants is usually more than a half (56%) of the total species number. The mosses and lichens occupy almost all forest habitats. Their amount can vary from 27 till 45% per each larch association. Subarctic and boreal species (their ratio is equal to 53.7:58.2%) combine in the floristic composition as well.

Northern larch associations have very complex structure. There are 4- species groups in them which differ in dominance degree. As a result, the dominance-diversity curves have the multistep shape. Such species composition has resulted from the cryogenic microrelief as well as from mixed hydrothermal and edaphic conditions.

The ground fires considerably change plant species composition of larch associations. in 3 years after the fire the number of the vascular plants is 1, 2, 3 times more as compared to that of beforefire association. Both the appearance of the new plant species and their families as well as the restitution of beforefire plants are responsible for such increase of species diversity. The initial plant species diversity has usually regenerated in 3 postfire years. Green moss and lichen species composition is completely changed after the fire. It regenerates extremely slowly. The pioneer moss species of the permafrost burned areas is Marchantia polymorpha.

Temporal and spatial structure of larch associations begins to change only in 2 years after fire. The dominance-diversity curve analysis witnesses this fact. The following years the microrelief destroyed, the permafrost depth decreased, the hydrothermal and edaphic conditions of the habitats changed as well. Structureless plant associations are characteristic of such postfire progressive stages. They include annually change single dominant species and a large number of the separate plants of small abundance. The first structural elements of the new secondary communities appear in four years after the wildfire. Plant species diversity of 90year old larch associations is the result of the interspecific competition. The experimental distributions for such associations are more similar to the geometric series distribution.

8.08.00 Forest and Climate

Interconnection between environmental change and forest on the mountainous territory of the South Central Asia.

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Keywords: Environmental change; Mountain forests; Desertification; Reforestation; Drought

One of the biggest parts of the mountainous territory of the South Central Asia is the Pamirs-Alai mountain system. The most investigated area of this system is situated on whole territory of Tajikistan 93 % of territory of our republic compose of mountain ranges which altitudes come up to 7500 m above sea level. The insignificant violation of fragile mountainous ecosystem always can lead to many catastrophic consequences. At the beginning of century the area of forests of Tajikistan was in several times bigger than it is at the moment. The modern position of wood and bush vegetation is damaged by human activities and it is necessary to start the intensive restoring processes. Otherwise the climatic drought and desertification (erosion processes) can be really strengthened and their consequences would be very tragic. The main role in the mountainous ecosystem play wood and bush vegetation. This is because the mountainous forests are the main components in the mountain landscape formation. The insignificant negative anthropogen influence of human on mountainous landscape can lead to many negative consequences. The connection between changes in environment and forests takes place by such scheme: first of all the destruction or cutting of wood and bush vegetation <=> desertification (degradation of soils) and dynamic processes <=> the changes of water balances <=> changing of climate <=> biodiversity etc. All elements of environment are tightly connected between themselves and forests are taking the main place in this structure. in the different parts of South Central Asia the connection between wood and bush vegetation with another components and their changes was investigated. It is determinated that the main role in this process plays human. in different climatic zones it happens differently and depend on complex of some natural, anthropogenal and economical factors. The huge tracts of forests are in good conditions only in the zones there the big coalfields are found. The local population is sparing the mountainous forests. The lack of fuel is lead to destruction of unique mountainous forest- massifs and valley tugays. By the time the peoples don't think about future consequences and about life of next generation. They don't execute the reconstruction of these forests. The

Tajikistan in some conditions has the really big possibilities for reconstruction and widening of forest- and rarely forest- areas. The interconnections between mountainous forests and mountainous river- balance, dynamic processes and degradation of soils, intensive cattle grazing and etc. parameters were determinated.

The recommendation of plantation of new wide leafed and small leafed antierosion forests was compiling. in the low mountain and middle mountain zones the big attention spared to pistachio and nut plantations and in middle and high mountain zones to juniper plantations.

For the first time in Tajikistan the map of environment change degree which found under the influence of anthropogen factors (cutting and destruction of forests, degradation of soils in forest zones, intensity of watershed agriculture) was compiled.

The common scheme of interconnection between forest formation with another natural anthropogen components and of their degree of influencing on environment were compiled.

Environmental changes recording in Russian protected areas

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Keywords: Nature reserve; Environmental monitoring; Global change; Natural disaster; Biodiversity

By end-1998 Russia had 99 strict nature reserves (zapovedniks) and 34 national parks taking up respectively 32.6 and nearly 7 million hectares (other kinds of protected nature areas corresponding to the IUCN categories III, VI number several thousands and occupy tens million hectares). State zapovedniks and national parks are territories of Federal importance. The purposes of these two categories are determined in the Law no as to protect and to study unique and typical natural complexes and features, remarkable natural formations, features and gene pool of plant and animal life, processes in the Biosphere and to monitor changes in its state. Since the beginning, the main task of Russian State Nature Zapovedniks research consisted in carrying out stationary year-round interdisciplinary studies in situ of unimpeded course of natural processes and phenomena.

Recording of every changes in the natural environment of the Nature Zapovedniks forms a special document called Chronicles of Nature. It is a yearly master data register of the state of the protected areas, of all biogeocoenological observations. Some of Zapovedniks have been keeping records of their Chronicles over 60 years. This work is to be performed in all Zapovedniks following an unified programme agreed by researchers throughout the country. The programme was prescribed to mark not only common, usual phenomena, but also extraordinary ones. The document should mark various deviations in the natural environment: droughts, severe winters, avalanches, high floods, downpours, forest fires, epizooties, etc. The data obtained in such a manner are united each year in the book called Charonicles of Nature, and once in 5 years a summary book is compiled. The highly developed network of biotic observation posts and stations given by the State Nature Zapovedniks has allowed to obtain reliable information on biodiversity changes in selected territories in all natural zones of Russia.

Research carried out in most State Nature Zapovedniks and in some National Parks differs from that in other forest areas, first of all, by almost complete exclusion of experiments in nature. in this respect, forest research in these two categories is in opposition, and at the same time, a complement forest experimental stations. Research in protected areas is a conditio sine qua non for environmental monitoring. Unspoiled plots are ideal points of reference for surveying natural and anthropogenic changes in the natural environment.

Even excluded from direct econimic use, the Zapovedniks of the central areas of Russia situated less than 50 km from large cities and major industrial centres are appreciably affected be human impacts, acid rains, alien wildlife species intrusion, increased concentration of game animals that leads to degradation of vegetation and soil cover. Research in remote Pas allows monitoring background changes in the natural environment.

Modifications in Microclimate and Litter Fall Production and Decomposition Caused by Forestry Use of Natural *Nothofagus pumilio* Forests in Magallanes, Chile

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Keywords: Forest; *NothoFagus pumilio*; Intervention; Nutrient; Litter fall; Decomposition; Biomass

The use of a forest ecosystem under sustainable assumptions implies the need of evaluating the distribution and total amount of existing products feasible of being extracted from a forest with each forestry intervention. The productive capacity of a forest site may be determined through quantification of existing biomass (dry weight unit/surface unit). This information may be supplemented with the study of nutrient accumulation in trees to optimize forest resource use.

In order to estimate the effects of natural *NothoFagus pumilio* forest management on biomass and nutrient extraction, two stands - one pure, uneveraged of the species, and another one mixed, uneveraged with *NothoFagus betuloides* - were studied, both located in the Province of Magallanes, Chile.

In order to estimate existing biomass in each stand, allometric equations providing the dry weight of the different tree components were adjusted using BHD and their total height as predictive variables. Nutrient accumulation was estimated by weighing biomass amount with nutrient concentrations determined in tissue subsamples. Forestry intervention in each stand was simulated using extraction rates accepted under Chilean legislation, estimating biomass and nutrient amounts extracted, to remain standing, and to remain as waste on the forest floor, comparing two treatments: one with and the other without barking.

Total accumulated biomass in the pure stand was 421.8 t/ha (85.1% boles and 14.9% crowns). Total estimated aerial mineralomass reached 5,572 kg/ha (96% accumulated in woody tissues and 4% in leaves), with percentage distributions of 55.2, 29.2, 6.7, 4.4, 2.2, 1.6, 0.3, 0.4, 0.7, and 0.03 in Ca, N, K, Mg, P, Mn, Fe, Zn, B, and Cu, respectively.

The mixed stand exhibited a total accumulated biomass of 322.2 t/ha (81% boles and 18.6% crowns). Total estimated aerial mineralomass was 3,480.2 kg/ha distributed on a percentage basis in 52.9, 27.2, 9.7, 4.5, 3.6, and 1.1 of Ca, N, Mg, K, P, and Mn, respectively. The remaining 1% corresponds to Cu, Fe, Zn, and B.

When simulating application of a protective felling (shelterwood system) on the pure stand with a 49.6% reduction in the basal area and a protective canopy of 161 trees to remain standing, 129 t/ha of biomass would be extracted and 79 t/ha would remain as harvesting waste. An amount of 521 kg/ha of mineralomass (97.9% macro-nutrientes and 2.1% micro-nutrients) would be removed. A figure of 1,935 kg/ha of nutrientes in the waste would remain on the forest floor. If extracted boles were barked on site, extracted biomass would descend 7.2% and the removed mineralomass amount would be 422.5 kg/ha.

When simulating application of a protective felling on the mixed stand, with a 45.2% reduction in the basal area and a protective canopy of 176 trees to remain standing, 146.2 t/ha of biomass would be extracted and 30.4 t/ha would remain as harvesting waste. Development would remove 1,125 kg/ha of mineralomass (98.2% macro-nutrients and 1.8% micro-nutrients). A figure of 564 kg/ha of nutrients in the waste would remain on the forest floor. If barking is considered, extracted biomass diminishes 9.6% and exported mineralomass amounts to 462 kg/ha.

Estimation of soil erosion levels

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Keywords: Soil erosion; Deforestation; Tropical forests; Land-use change; Satellite observation; Biodiversity

In Peru, nearly 1,800 acres of tropical and subtropical forests are cut daily, amounting to 670,000 deforested acres each year; this phenomena eliminates critical habitats for wildlife and plants species (Peru ranks number two in the world in bird diversity, number three in mammal diversity and number five in plant diversity, within its borders exists 83 of the worlds 114 natural community types). An accurate and up to date assessment of forest area and rates of depletion is fundamental to the development of improved national forest management strategies. Satellite observations provide an objective and quantitative approach to the measurement of land-cover change; a research is proposed in order to determine the land use change, the conversion from active agriculture to secondary forest (re growth), infer the patterns of land use by type in the long term considering the past and present trends, and propose an ideal map of sustainable land use according to the ecological and socioeconomic characteristics of the site, in a representative area of Peruvian tropical rainforests (Iquitos region, a 75km x75 km area located in the Amazon watershed at 3*43*46 South Latitude, 73*14*18 West Longitude) using JERS-1 images. The Japanese Earth Resources Satellite ?1 has been continuing to observe and collect data since 1992 with a mission data recorder by the high performance Synthetic Aperture Radar (SAR) and Optical Sensor (OPS); TNT mips will be used in order to process the images, a processing system for geo spatial analysis with fully integrated GIS, CAD, TIN, desktop cartography and geo spatial database management.

Monitoring of the Forest Damaged by the Salt-winds and the Gale of the Typhoon

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Keywords: Forest; Wind damage; Salt-wind; Typhoon

There was a great deal of damage throughout Japan caused by typhoon No.19 in 1991. As the peak gust records in many of the meteo-rological observatory were renewed, a great deal of damage was caused by gales. Damage to the forests in the northern part of Kyushu and the western part of Chugoku were very severe, and salt-wind damage was added in Chugoku.

The damaged forests near Tokuyama Experimental Forest (T.E.F.) were investigated. The southeast gales came over the ridges. The heavily damaged forests are situated on the ridges, on the slopes of the valley and in the depths of the valleys. The leaves of bamboo around T.E.F. were changed to yellow or white and those of needle-leaved trees in the edge of forest turned brown. Three years after, the leaves damaged by the salt-winds seemed to have recovered, but the leaves and trunks damaged by the gale had either not recovered or had some after effects of injuries.

The change of a damaged forest, which is situated in the depths of a valley has been observed. This forest is the 28 years old plantation of Hinoki (cypress) and has about 400 trees. According to annual numbers of dead trees and the stem analysis of those, remarkable affections by the typhoon is clear.

The Effect of Reforestation and Forest Plantation Programme On Carbon Sinks

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Keywords: Carbon sink; Tropical forests; Reforestation; Forest plantation

Although deforestation in the tropics has been identified as one of the main contributing factors, very few studies have actually been made on the effect of reforestation and forest plantation programme on carbon sinks. Since the early seventies the debate on the increase of carbon dioxide concentration in the atmosphere and its predicted impact on global climate has been the focus of many national, regional and international discussions. The large amount of carbon in its vegetation and in its soil has made forests to be one of important factor to be considered in regulating climate. It has been acknowledge that the release of carbon from this vegetation and soil due to human activities could have significant impact to the climate. This paper highlights the important contribution of forest ecosystem to the total carbon budget including absorption and release of carbon in Malaysia. Preliminary results from a study conducted in Malaysia show that tropical forests particularly the undisturbed forests, play an important role as a carbon sinks in the global carbon cycle. Based on the analysis using COPATH method in the project under Sustainable Forest Management, result shows that total carbon above ground portion for Superior Forest based on third National Forest Inventory in Peninsular Malaysia is about 205.8 million ton. Thus, any form of destruction (burning) or reduction in area of these forests will lead to a substantial increase of carbon dioxide concentration in the atmosphere. It is anticipated that carbon sinks will be increased through appropriate reforestation and forest plantation programs.

A Free Atmospheric Carbon Enrichment Experiment on Short Rotation. Intensive Poplar Plantation

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Keywords: Plantation; Poplar; Global change; Agroforestry; Productivity; CO_2

The mechanistic and process-based responses of trees and tree communities to global change, particularly in response to the predicted increase of atmospheric [CO_2], will be crucial in determining the ability of woody plantations and natural forests to sequester carbon at the global scale. Despite the key role played by trees and forests within the terrestrial biosphere, we still have very limited information on the total responses of agro-forestry and forest systems to enhanced CO_2 because of the complex web of possible interactions. The few studies conducted at the whole-tree and community scale indicate that there will be a marked increase of primary production, but this increment will be mainly allocated into below-ground biomass. However, the proportionality of this response may well depend on nutrients and water availability in the soil and, also, on genotypic characteristics. A fundamental issue of the research on global change effects on terrestrial biosphere is the need to appropriately design the experiments to be conducted at the community and ecosystem level. The FACE technology has the great merit of not altering the general microclimate of the test area and allows to conduct the research on impacts of global change truly at the ecosystem level; however, FACE facilities should be combined with adequate forest tree systems in order to avoid such drawbacks as lack of replication, large genetic variability and delayed response of already adult trees. The aim of this research is to improve our understanding of the effects of elevated [CO_2] on forest ecosystem, using a short rotation intensive plantation of poplar trees as a model system. Poplar trees represent a unique opportunity to study processes and mechanisms determining biomass production at the ecosystem level, since they are extremely fast growing, have genetic reproducibility and a short life-cycle, especially when grown as short-rotation coppice. Therefore, the research we present is rather unique because we combined a fast growing, agro-forestry ecosystem, capable of elevated biomass production, with a large-scale FACE system. The performance of the FACE system together with the growth and physiological responses of three poplar clones grown under CO_2-enriched atmosphere will be discussed.

The forest fire transformation of soil cover condition

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Keywords: Forest fire; Ground vegetation; Boreal forests; Soil structure; Soil chemistry

To study changes in forest function of growth and qualities of forest soils, subjected to fires, two types of burned-out forest lines were defined. Each line was presented by five burned-out plots (from latest to 25 year-old ones) and a test virginal plot. The type of fire is low with elements of debris layer and humus. Variants with low and high fire intensity were observed. These experimental plots were located in Leningrad region in different forest growth conditions. The first line consists of *Pinetum hylocomosum* of the IV age class and III quality of locality class, which grow on semipodzol rough (coarse) sandy soils typical for these sites. On the plots subjected to the high degree of fire intensity the soil is damaged to great extent: the ground vegetation and debris layers burn out and the lower podzolic mineral horizon A2 uncovers. It leads to the considerable loss of soil productivity. On the plots with low fire intensity only partial damage of top soil cover is observed: ground vegetation and part of debris layer (the thickness of debris layer is 1-3cm on this plot and 3-4cm on the test virginal plot). The second line is presented by *Picetum myrtillosum* of the V age class and II quality of locality class, growing on the peaty podzol loamy sandy and loamy soils. in these moistening conditions thicker debris layer and A2 horizon are formed, which are the high-quality combustibles in the dry period of a year. When the organic horizon is destroyed by fire, spruce rots burn out and the tree falls down. in the burned-out forests of this line there are such spruce trees. in this case, on the plots subjected to fires of high intensity the vegetation layer and debris layer and peat horizon that is organic synusia and the organic burn out. The plots subjected to fires of low intensity can be referred to the category of slightly damaged debris layer and peat horizon is only partially destroyed. Thus influence of fires on soils is versatile. Intensive debris-humic fires cause the greatest damages, changing morphological qualities of soils. Soils under investigation have an acid reaction. Organic and A2 horizons are characterized by higher acidity (pH3,25-3,90). in the lower soil layers its level evidently decreases (pH 4,57-5,52). Soil-colloidal complex has a low degree of base richness (saturation)-less than50%. in the organic soil horizons the content of carbon is 32-37%. The great quantity of carbon is concentrated in the debris layer. The content of humus in the top soil layer varies from 0,72 to 2,45%. The supply of podzol soils by the elements of mineral nutrition wholly depends upon their level of humicilization (presence of humus). The quantity of nitrogen available in hydrolyzed organic compounds makes up 15-20 mg/100g in debris layers and 0,7-1,8 mg/100g in top mineral layers.

After the fire which partially or completely destroys organic part of soil a new pirogenic horizon appears. Thus, the top soil profile is characterized by neutral and alkaline reactions (pH 7,0-8,0), low exchange and hydrolytic acidity and high quantity of exchange bases. The content of carbon, nitrogen, phosphorus and potassium is lower than on the test virginal plot. Carbon losses make up 10-14 t/hectare. The level of trophogenic soil productivity decreases. Deterioration of soil conditions influences the general state of forest stand.

The researches carried out on the burned-out forest plots showed that as a result of forest fires, acidious indicators get to their norm in 8-10 years, whereas neutral and alkaline reactions transform into sub-acid reaction even in 2-3 years. Restoration of mineral nutrition and humus contents is a slower process. Five years after the fire the content of carbon makes up about 2,5-3,0 t/hectare (15-20%) of the initial quantity. It will take no less than 25-30 years for complete restoration of carbon. According to our data, restoration of flora and phytocoenosical structure of vegetation layer will take about 25 years. Only then differences in debris layer on the test virginal plot and experimental plots completely disappear.

Effects of global warming on the mountain vegetation in Japan

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Keywords: Mountain forests; Natural vegetation; Global warming; Litter decompostion; Spatial distribution; Snow cover

Studies on effects of climate change on mountain vegetation were conducted in mountains of central and northeastern Japan. Among the topics, thermal conditions and soil properties, alpine dwarf pine scrubs, snow patch vegetation and beech forests have been dealt with in detail.

1. Effects of temperature on soil properties on Mt. Akaishi

One of the studies evaluated the effects of thermal conditions on soil properties, measuring thermal and soil conditions along a slope from the montane (1120 m a.s.l.) to the alpine zones (2725 m a.s.l.) of the Akaishi Mountains, central Japan (Kobayashi et al. 1996). These results suggests that the global warming will accelerate litter decomposition rate at higher elevation in subalpine and the acidity of topsoil will be more neutral.

2. Alpine dwarf pine scrubs on Mt. Kinpu

Kajimoto et al. (1996) studied the effects of temperature increase caused by global warming on the population dynamics of the alpine dwarf pine (*Pinus pumila*) in relation to the predicted upward shift of subalpine conifer trees on Mt. Kinpu, central Japan. It is suggested that subalpine confers expand into alpine regions, but hardly succeed the vegetation zone where well-developed *P. pumila* scrubs had already occupied, even under the higher temperature conditions.

3. Snow patch vegetation on Mt. Zarumori

Two studies focus on the snow patch vegetation on Mt. Zarumori, Northeast. in snow patches formed by snowdrifts, the spatial distribution of the snow depth is mainly affected by the interaction between topography and the prevailing wind direction in winter. One study on microclimate and phenology of snow patch plants revealed that the phenological stages of Faulia crista-galli, that is one of the dominant species in the snow patch, are closely related to the effective accumulated temperature which is determined by locations on the slope and vary mainly with the distance from the snow patch (Ohtani et al. 1996). It appears that the F. crista-galli changes its phenological stages with an increase in the effective accumulated temperature. Another study reconstructed past climatic conditions by means of alpine-subalpine meadow soil stratigraphy, which records past snow disappearance time in nivation hollows (Daimaru and Ikeda 1996). The analysis of fossil peat soils suggests that "Medieval Warm Period" was prevailed in the meadows in Northeast Japan. When the warming will exceed 2 C (BC, snow patches and the alpine-subalpine meadows will shrink considerably and when it will be accompanied by decreasing snowfall and snow accumulation, the shrinkage will be accelerated and many meadows will disappear.

4. Beech forests in the Pacific Ocean and the Sea of Japan sides

Similar to the cases of snow patch vegetation, but in the larger scale, the distribution area of beech (Fagus crenata) is affected by snowcover as well as by temperature. There is a climatic gradient of snowfall between the Pacific Ocean side and the Sea of Japan side of the Honshu Island as well as a temperature gradient along latitude. in view on the time scale of more than 100 years, the present pattern of beech distribution may shift upward in response to the global warming if the precipitation conditions do not change. On the other hand, changes in winter precipitation may affect beech distribution, even if the thermal conditions do not change. in the Pacific Ocean side, an increase in snowfall may assist beech to expand its habitat along elevation and increase its dominance in forests. in the Sea of Japan side, a decrease in snowfall may reduce its elevational distribution and dominance in forests. in conclusion, these researches indicate the importance of snowcover and topography as controlling factors of vegetation distribution as well as temperature. Effects of global warming on vegetation will not only induce the shift of vegetation zones toward north and higher elevation in macro-scale, but also complex changes depending on the diverse controlling environmental factors in smaller scales.

Long-term carbon dioxide and water vapour fluxes of European forests and interactions with the climate system

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Keywords: Carbon absorption; Gas fluxes; Eddy covariance; European forests

The EUROFLUX program, funded by the EU for three years (1996-98), investigated the relevant biosphere atmosphere exchanges of European forests.

The quantitative estimation of fluxes is needed to develop surface parameterizations and aggregation schemes in order to scale up from the patchwork of landscape evident in Europe to regional and, ultimately, global scale. Atmospheric exchange of European forest ecosystem deserve special attention due first to their potential mesoscale effects on rainfall distribution and soil water storage, and also because of their potential role in the long-term CO_2 uptake from the atmosphere and carbon storage.

The long-term continuous measurements of atmospheric fluxes by means of the eddy covariance technology are a powerful tool for investigating the overall ecosystem exchanges and hence to determine the annual budgets of carbon and water. Furthermore the possibility to analyze the response of the ecosystems to climatic and biotic perturbations, in a variety of conditions, including extremes events, represent a unique framework for biogeochemical models evaluation and improvement.

In synthesis the general objectives of the project can be summarized as follow:

1. Characterize long-term fluxes and energy exchange of representative European forests in order to provide useful parameters to modelers and to analyze the variables that determine energy partitioning by forests in different climatic conditions;

2. Determine the sink strength of European forests for carbon and analyze the variables that determine the gains are the losses of carbon from different forests;

3. Analyze the response of European forest water and carbon fluxes to climate factors in order to aid regional scale modeling designed to predict impacts of global environmental change on forests;

4. Provide objective data for the validation of forest models, related to growth, partitioning of primary production, water cycling and hydrology;

5. Recommend management strategies for the conservation of carbon stores in forests.

The project was carried out at 15 representative forest sites encompassing the entire range in European climate, species distribution, and site conditions. in addition 2 sites with external funding have joined the consortium. Common protocols and hardware requirements have been defined and implemented, as well as data quality checking and missing data interpolation policies. The variation of the ecological parameters and climatic factors is rather interesting and allow to explore the ecosystem responses along environmental gradients.

There has been also a modeling component within the Euroflux program. The aims of Euroflux in this respect were to develop tools be used for interpolate missing data, extend in spatial scale the flux measurements and establish a bridge between our project and other existing initiatives.

The presentation will describe the project with more details and results from 1996 to 1998 will be presented. Overall, the results indicated a greater carbon uptake of temperate forests versus the northern boreal forests, with a pronounced internal variability site by site.

8.09.00 Human impacts on tropical rain forests with long term view

Effects of selective logging on understorey butterflies and flower visiting beetles after 30 years

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Keywords: Balloon trap system; Attractant trap; *Scarabaeidae*; *Dasyvalgus*; Canopy fauna

Lowland tropical forests should be preserved because of the importance of genetic resources for future human beings. On the other hand most of all tropical lowland forests have already been developed. Therefore, one of the best ways to preserve bio-diversity in tropical forests is to practice sustainable use of secondary forests based on thoughtful consideration for bio-diversity.

Though selective logging is the most typical forest treatment in tropical forests, there is little data on the effects of the treatment on bio-diversity in tropical rain forests, especially a long time after logging. Also, we do not know how many years it takes to recover the primary arthropod assembly of tropical rain forests after selective logging. Therefore, we attempted to estimate effects of selective logging on bio-diversity of forest arthropods. Comparative analysis of flower visiting beetles and butterflies were carried out between primary and secondary forest logged about 30 years ago, in Pasoh Forest Reserve, Peninsular Malaysia.

Ten plots to research on flower visiting beetles were set from edge to core along a path in Pasoh Forest Reserve. Two attractant traps to catch flower visiting beetles using flower flagrance, linalool and eugenool, were hung from emergent trees at the height of 20m and 10m in each plot. The number of *Dasyvalgus* spp., one of the main flower visiting groups, in the core area (primary forest) was significantly greater than that in buffer area (secondary forest), whilst *Mecinonota*, another dominant flower visitor, showed no difference. Species structures of *Dasyvalgus* were different from each other. We established research plots (100m X 100m) in secondary forests selectively logged 30 years ago (S1) and in a primary forest (P1). We set flower fragrance attractant traps on forest canopies in plot S1 and P1 for flower visiting beetles. Numbers of dominant species of *Dasyvalgus* in the primary plot (P1) were greater than those in secondary plot (S1).

We compared the assemblies of understorey butterflies, as representatives of understorey insect herbivores, between two primary (P1, P2) and two secondary (S1, S2) plots. We placed every 8 fruit-bait traps around the 1 ha square plots to attract and catch understorey butterflies. Twenty-two nymphalid species were captured, with 0.65 individuals per day per trap. The similarity in species composition was very high between the two secondary plots, though they were most distant from each other. On the other hand, it was low between the primary plots, thus the total number of species captured in the primary plots (19 species) was about 1.5 times that in the secondary plots (13 species). It is most likely that the assembly of understorey butterflies and flower visiting beetles has not completely recovered after selective logging about 30 years ago. Understorey butterflies can be quantitatively sampled with the traps and are rather easily identified by non-specialists, thus they should be counted as one of high priority indicator groups for the monitoring of protected or disturbed forests, in addition to birds and mammals.

Recovery assessment of logged-over forest areas in Negeri Sembilan, Malaysia

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Keywords: Forest recovery; Logged-over forest; Malaysia

Over the years, large tracts of tropical forests in Peninsular Malaysia have been deforested mainly for the expansion of crop-tree plantations. The remaining forests are under constant pressure from commercial and illegal harvesting. These forest stands require some kind of assessment as to their natural recovery and succession. Forest recovery assessment based on phytosociological vegetation studies was made in the state of Negeri Sembilan, Malaysia to elucidate the state of natural recovery of the degraded, logged-over forest areas. This approach called for vegetation surveys to be conducted on logged-over areas (harvested in 1950s, 1960s, 1970s, 1980s and 1990s) as well as primary forests in the state. A total of 35 phytosociological releves were made in four forest reserves during the two-year study period (early 1997 to the end of 1998). The natural recovery is very slow for areas that were heavily logged and compacted, such as sites formerly used as logging roads and timber landings during forest harvesting. Only highly adapted, early-successional species, such as METLAstoma, Eupatorium and Paspalum, managed to inhabit the sites. Such sites with very poor environmental conditions will take a long time to recover their pristine original state, unless intensive rehabilitation is carried out. Similarly, sites that were harvested from 1963 to 1973 with conventional harvesting techniques (under the Malayan Uniform System) have shown a relatively slow recovery rate. The sites have small average coverage by emergent and dominant trees, and only a few *Dipterocarps* occupy this layer. However, the stands have recovered in terms of species abundance and dominance. in these stands a few more years are required for the dipterocarp species from the lower layers to reach dominant and emergent sizes. On the other hand, the sites harvested in 1984 under the Selective Management System recorded an average ST-layer coverage of 12% and fairly even coverage in the tree (dominant), tree understorey (co-dominant), shrub and herb layers. Due to lack of dipterocarp species in these forests, the forests require replanting of dipterocarp species to enrich them. The 1996 stand is in the beginning of its recovery following harvesting recently. As in the forest harvested in 1984, this 1996 stand requires replanting of some dipterocarp species. The only complete recovery was achieved by the stands harvested in 1950s. The stands have recovered both in terms of canopy structure and species abundance and dominance. The mean emergent height in these stands is 47m which is similar to the natural stands, and the average canopy coverage (of emergent and dominant) is insignificantly different from the primary forests. The study shows that it takes at least around 40 years for the logged-over stands to recover to the original state. It is proven through this study that the phytosociological vegetation study approach is very useful to assess the present status of natural recovery (succession) of the deforested area.

Monitoring of CO_2 flux above Pasoh Forest

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Keywords: CO_2 flux; Eddy correlation method; NEE; Rain forest

The CO_2 flux over tropical rain forest was measured by an application of the eddy correlation method. The forest for our study was in Pasoh Forest Reserve, Forest Research Institute Malaysia, located in the center of Peninsular Malaysia (2ø58N 102ø18E). The elevation of the gently undulated terrain was approximately 120 m. The forest had a complex canopy, i.e. the general height was approximately 35 m, although emergent trees exceeded 45 m. A 52 m tall tower constructed in the forest was used for the platform of the meteorological observations. A three dimensional ultrasonic anemometer-thermometer (DAT-600, Kaijo) and an air inlet were installed on the tower at a height of 52.6 m. The fluctuation of CO_2 concentration in the air was measured by the closed-path CO_2 gas analyzer (Li-6262, Li-Cor). Data were recorded at the sampling frequency of 10 Hz. The CO_2 concentration at the different 6 heights above and within the forest was also measured to calculate the storage changes. The net ecosystem exchange (NEE) was a main interest of the observation. The NEE is defined as NEE = Fc + Qc, where Fc is the CO_2 flux at the reference height. and Qc is the storage term that the temporal change of the CO_2 storage below the reference height. The diurnal change of the CO_2 flux, storage and NEE were obtained for the representative days.

The maximum CO_2 flux was approximately 0.3 mgm-2s-1 and 0.8 mgm-2s-1 for the release in the night time and the absorption in the day time, respectively, on a fair day in March. The magnitude of the storage term was comparable to that of the flux. The CO_2 flux rapidly changed from release to absorption at 10 MST, and it showed the maximum absorption at around 13 MST. After 13 MST, the CO_2 flux (absorption) gradually decrease until 18 MST, and then it changed to release. However, the CO_2 storage rapidly changed from increase (release) to decrease (absorption) approximately 2 hours earlier than the flux, and it showed the maximum absorption at 10 MST. The storage term decreased rapidly after 10 MST, then it showed almost zero at 13 MST.

In the early morning, the large CO_2 absorption by the ecosystem was initiated when the decrease of the stored canopy CO_2 in the night time seemed to be the main contributor. This continued approximately for 2 hours, then the CO_2 concentration of the canopy air decreased. in the day time after 10 am, the flux played the main contributor for the ecosystem absorption. The daily NEE showed absorption ranged from 7.4 to 8.1 $gm^{-2}day^{-1}$ through the observation period.

Effect of Selective Logging on Canopy Structure and Tree species diversity in a Lowland Dipterocarp Forest in Peninsular Malaysia

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Keywords: Canopy structure; Lowland Tropical Rainforest; Selective logging; Species Diversity

In order to study the impact of selective logging on the tropical rain forest, canopy structure and species diversity were compared between primary and regenerating forests in Pasoh Reserve, (2o58'N, 102o18'E) in the state of Negeri Sembilan, about 70 km southeast of Kuala Lumpur, Malaysia. For the primary forest, a data set taken in a 50-ha plot in 1995 was used. For the regenerating forest, a 6-ha plot was selected in 1997 in an area at the southern end of the reserve that was selectively logged under the Malaysian Uniform System (MUS) between 1955 and 1960. in both plots, all woody plants of 1 cm in diameter or larger within these plots were identified, measured, tagged and mapped to the nearest 10 cm. The canopy height was determined every 2.5 m intervals from aerial photographs taken at a scale of 1:6000 in February 1997, which covered the entire part of the 50-ha and 6 ha study plots, and canopy digital elevation model (CDEM) was made for both plots. Canopy surface area was acquired in every 10 x 10 m mesh based upon CDEM. Crown size of trees in canopy layer was determined by tracing the crown edges shown in the aerial photographs.

There was no distinct difference in the mean canopy height between the primary (27.4 m) and regenerating forests (24.8 m). However, the variance of the mean height was much larger in the primary than in the regenerating forest. This implies that there are many more emergent and canopy trees > 40 m in height and many more canopy gaps in the primary forest than in the regenerating forest.

The mean canopy surface area per hectare in the primary forest was 27844 m^2, 1.5 times as large as that in the regenerating forest (19288 m^2). The mean crown size of individual trees of the canopy layer in the primary forest was 95 m^2, which was twice as large as that in the regenerating forest (43 m^2). The number of trees whose crown size >300 m^2 was 3.3/ha in the primary forest and 0.5/ha in the regenerating forest. On the other hand, the number of trees with smaller size crown (<100 m^2) was 49.5/ha in the primary forest and 177.5/ha in the regenerating forest. However, the species area curves derived from the tree map data were not distinctively different between plots. The two plots did not differ in the ten families having the largest number of species. The stem density was not distinctly different between the two plots; 6418 individuals /ha in the primary forest and 6067 individuals/ha in the regenerating forest. The basal area in the primary forest was 42.2 m^2/ha and 43.3 m^2/ha in the regenerating forest.

These results suggest that selective logging under MUS regime did not significantly change tree species components and diversity, but resulted in monotonous canopy structure which was formed by small canopy trees growing in high density. These findings also imply that gap formation and structural development take a long time in a regenerating forest, owing to the time taken for self-thinning among the trees.

Species assembly and site preference of tree species in a primary Seraya-Ridge Forest in Peninsular Malaysia

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Keywords: Cluster analysis; Ordination; Indicator species; Seraya-Ridge forest

The paper describes the use of common species as the criteria to classify forest sites using multivariate methods. The main objective is to clarify indicator species and its site preferences in a typical primary Seraya-Ridge Forest. The sample is based on a contiguous 150 subplots of 20 m x 20 m from a six hectares plot (200 m x 300 m). The group of sites was detected using hierarchical clustering analysis and site ranking by ordination method. The indicator species analysis determined the characteristic species of that particular site group. Eight site groups were identified. The ordination results showed a strong correlation with elevation gradient. Most of the characteristic species showed a strong association with elevation gradient and topographic positions, while generalist species showed a weak correlation. The indicator values of thirty-nine characteristic species at each step of hierarchical structure were computed and tested with the mean indicator value obtained from a Monte Carlo randomization procedure at P-value 0.01. The characteristic species which have broad niche breadth in the higher elevation were *Shorea curtisii Lithocarpus wallichianus, Eurycoma longifolia,* etc., while in the lower elevation the characteristics species were *Pimelodendron griffithianum, Antidesma cuspidatum, Artocarpus lanceifolius,* etc. These species were responsible for similarities between habitat and for the nested hierarchy structure in the site typology. Several species such as *Drypetes polyneura* and *Gironniera parvifolia* had been identified as requiring narrower site preferences. The diagram of hierarchical cluster and associated indicator species provides a simple and intuitive way to express species assembly, while the ordination helps in explaining their site preferences.

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Excess nitrogen in a fragile montane forest ecosystem

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Montane forests on calcareous limestone are fragile ecosystems of the Alps. We investigate, if there are already indications for nitrogen saturation and derive its consequences for the regional water quality. The soils are mostly shallow and often have a low water holding capacity. The growth of most of these forests has been limited by nitrogen until now. The nitrogen demand of the forest stand and the herbaceous vegetation was high enough to almost fully exploit the nitrogen supplied by the soil solution. The last few decades have modified the biogeochemistry forest ecosystems in Europe. Due to the increase in combustion processes and the increase in N emissions from agricultural sources the availability of nitrogen has generally increased. The recently shown increase of growth rates of European forests is understood as a consequence of a nitrogen eutrophication. Ecosystems, that used to be a sink for nitrogen, will no longer retain it fully. Consequently nitrogen is lost from the ecosystem, primarily dissolved as nitrate in seepage water, and secondarily in gaseous form as nitrous oxide. The surface waters draining montane forests have so far been of the highest chemical quality and have been suited as drinking water without further treatment. So settlements, as potential polluters, had access to water of highest purity and local pollution was diluted to water of still good quality. If nitrogen leaks out of montane forests indeed, this favorable situation may be history. Society will be able to rely to a lesser extent on the water purification by montane forests.

Our study site is located in the province of the Tyrol. It is a mature spruce forest with some true fir and beech. We monitor the quantity and chemical quality of precipitation above and below the stand canopy, soil temperature and moisture, and emissions of trace gases. The assessment of geochemical fluxes is especially difficult, because soils are gravelly and shallow. Karst phenomena inhibit the direct measurement of stream water because an unidentified quantity of groundwater leaches into subterranean caveats. We therefore use a combined soil chemical- physical simulation program, UNSATCHEM, to derive a nutrient budget. We intend to present both the results of our locally valid case study, but also extend our results to a bigger picture, that considers the regional water balance. Moreover we intend to present the remedies, that can be offered by silvicultural management practices, that help to improve the utilization of the available nitrogen.

Keywords: nitrogen deposition, eutrophication, montane forest

The adaptation potential of Central European mountain forests under scenarios of climatic change - an ecological risk assessment

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Keywords: risk assessment; climate change; climate change impact; mountain forests; patch model;

Central European forests comprise a wide range of ecological site conditions from high altitude coniferous mountain forests to low elevation forests dominated by broadleaved species. These forests in general have to serve a multitude of functions and in particular play an irresistible role in maintaining alpine landscapes. Discussions on a likely global climate change give rise to questions on possible impacts on forest ecosystems. So far model applications to assess the potential impacts of climate change on forests suffered from several shortcomings: (a) simulation studies for individual more or less synthetic site conditions conducted with forest succession models of the gap-model type miss the spatial dimension and coverage, (b) risk asesment studies with static vegetation-site equilibrium models miss the individualistic nature in the formation of vegetation composition, and (c) the non-consideration of todays forest composition and structure in climate change related simulation experiments. To circumvent these limitations in this contribution a risk assessment procedure for the identification of potential impacts of climatic change on mountain forest ecosystems in the Eastern Alps in Austria is presented.

In our approach a newly developed 3D-patch model is employed to simulate vegetation development at approximately 3.000 sample plots of the Austrian Forest Inventory (AFI) under current climate and under climate change scenarios. The model runs are initialized with ground true site (slope, aspect, water holding capacity, pH, C/N-ratio) and vegetation (species, diameter distributions regeneration) data provided by AFI. The sampling scheme of AFI with more than 10.000 of sample plots all over Austria allows to sample from the multi-variate space of vegetation/site-combinations of Austrian forests. Current climate data were interpolated from a network of more than 800 climate stations of the Austrian weather services. Simulated vegetation development under current climatic conditions is used as a control-run. For each involved sample plot several climate change scenarios were derived from global circulation model (GCM) output by statistical downscaling techniques. No management interventions are assumed to capture the potential natural transient behaviour of current forests. To synthesize the various model output variables as rational as possible the analytic hierarchy process (AHP) and multiple-attribute-utility-methodology (MAUT) were utilized. Indicators used in this approach represent both the transient as well as the longterm response of current forests, and comprise shifts in the potential natural vegetation composition (PNV), short- to midterm vegetation development (species, accumulated biomass) and detailed thermoenergetical indices of potential biotic stressors such as phloem feeding insects.

In a demonstration example for a subregion in the Eastern Alps substantial shifts of the potential natural vegetation under altered climate occured indicating changes of the ecological site potential. Under the climate as produced by the global circulation model ECHAM4 under the "business as usual run" of the IPCC just at a small portion (11.7 %) of 409 simulated sample plots included in the example abrupt changes in species composition or biomass occured, thus indicating forest dieback events due to the underlying climate change scenario.

From our experiences we conclude that the presented methodology is well suited to identify potential problem areas where the functioning of forests might not be granted under the assumed climatic changes. We found it especially important to evaluate the possible range of forest responses to a changing climate by using several different climate change scenarios, thus covering the uncertainties involved with predictions of future climates. To derive management scenarios to mitigate possible adverse impacts of a climate change and to secure the sustainable functioning of alpine forest ecosystems forest management has to be considered explicitely. However, it is important to note, that optimized silvicultural response strategies within the frame of a multiple purpose forestry have to be planned at spatial scales beyond the stand level.

Modeling Tropical Deforestation and Carbon Flux Scenarios

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Keywords: tropics, deforestation, carbon fluxes, modeling, scenarios

The purpose of our paper is to make quantitative scenario analyses on tropical deforestation and its consequences to carbon fluxes up to 2025 and 2050. The study comprises natural tropical forests, which means that plantation forests, trees outside forests and other wooded lands are excluded.

The empirical source of forest, land and ecological zone data is FAO's FORIS-database, which covers 117 tropical countries and about 600 subnational units. The original inventory year data from 1953 to 1998 from the FORIS database are used. The number of countries was reduced to 62 when more independent variables were included in the modeling.

Scenarios are based on trends and multiple regression models for tropical Africa, Asia and Latin America. The trend scenarios assume that deforestation continues as in the 1970's and in the 1980's. The linear trend with equal deforested area in the future is adopted as a base scenario (zero alternatives). Three other trends were computed including another kind of linear and two non-linear trends.

The regression models were estimated using ordinary least squares method (OLS) with standard statistical tests. Cases were weighted with forest areas because in the scenario making this would reflect in a more valid way the different roles of the small and large countries and their subnational areas in the deforestation process.

Regression scenarios until 2025 were computed by continents. The results indicate that forest area would decrease in Latin America by 29-39, in Africa by 37-41 and in Asia by 31-36 percent. Accordingly, tropical America has the largest potential for carbon conservation (40-55GT C) if deforestation is decelerating, followed by tropical Africa (21-23 GT C) and tropical Asia (15-17 GT C).

New modeling of deforestation scenarios was made for this conference. The model has not only income, population and reliability of forest data variables as changing independent variables but also agricultural productivity and the openness of trade as key independent variables. The other - time-invariant - independent variables consist of moist and dry ecological zones, total land area as well as two dummy variables for island and African identification.

The model is operational and statistically sound. It nearly doubles the previous degrees of determination (R2 = 0.79 in this latest model). The previous regression scenarios are respectively revisited. in the conference paper proper we shall report primarily the results from this new modeling.

The new provisional scenarios indicate somewhat lower scenarios on deforestation and carbon fluxes than the previous results. Increasing agricultural productivity is decreasing deforestation whereas the growth of openness in foreign trade tends to expand deforestation under tropical land tenure conditions where often open access to forests is existing. This effectively slows down the appearance of competitive stumpage markets which would automatically decelerate deforestation.

Our results indicate higher deforestation than FAO has modeled for 1990-1995 in the State of World Forests in 1997. We have the following explanation for this difference. in the two studies different models are applied - in our case regression modeling with log-log transformation of the variables and Chapman-Richards-model by FAO. Our model has some more relevant variables, such as an income variable, which are missing from the model by FAO. We believe that our modeling approach is more relevant for this purpose.

Wood-to-ethanol: process options and targets for commercialization

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There is growing concern that the continual build-up of atmospheric CO_2 is contributing to global climate change. The combustion of gasoline in transportation vehicles represents a significant source of CO_2 produced anthropogenically. Several groups around the world are researching ways to convert forestry and agricultural residues to ethanol as a way of displacing gasoline for transportation vehicles.

When ethanol is produced from renewable sources such as biomass it can both decrease urban air pollution and reduce the accumulation of carbon dioxide. Thus replacement of gasoline with ethanol, derived from renewable biomass feedstocks that sequester carbon dioxide during growth, is expected to reduce carbon dioxide emissions by 90-100%. Researchers in the U.S. estimated that enough neat ethanol could be made from the available local cellulosic biomass residues to replace twice the amount of gasoline consumed within that country.

The bioconversion of lignocellulosics (including wood) to ethanol is a complicated and strongly interdependent series of process steps. Currently there are no true examples of commercial or totally integrated demonstration-sized plants which can convert lignocellulosic materials to ethanol. Although some of the current and past pilot plants have been able to demonstrate the successful operation of entire sets of process steps, these plants have not been able to operate over a prolonged period of time.

Through our association with the International Energy Agency (IEA) we have come in contact with a number of groups researching and commercializing various lignocellulosic-to-ethanol processes. We are aware, through this association with IEA, that there are currently a number of commercial interests building pilot and demonstration facilities to technically prove a number of the process steps. However, at this time, there does not seem to be a single group that possesses all of process steps required to provide a complete continuous process particularly when presented with a number of different lignocellulosic feedstocks (agricultural, hardwood and softwood residues). This presentation will review some of these attempts at demonstrating biomass-to-ethanol process elements and provide a likely scenario for the future.

Our group at the University of British Columbia (UBC) has been researching the potential of using softwood sawmill residues as a feedstock for producing fuel ethanol. Our recent techno-economic modelling work has shown us that it is crucial for economic viability to recover as much of the original cost of the feedstock in the form of marketable products. Most of the past research (agricultural residues and hardwoods) concentrated on processing only the cellulosic component to a marketable product (ethanol). The lignin component was assumed to be burned to produce energy and steam for the rest of the process and the hemicellulose component was discarded or only minimally utilized to produce a marketable product (ethanol). Our more recent research has focused on optimizing the recovery and utilization of all three main components as marketable products and developing new processing methods for softwoods (processes that were developed for hardwoods and agricultural residues are not effective for softwoods). This presentation will provide a summary of current worldwide research directions.

Greenhouse gas (GHG) emissions from the forestry sector in Malaysia

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The world community has many needs for reliable estimates of greenhouse gas (GHG) emissions as it discusses global climate change. Emission estimates can be used to compare the relative contribution of different emission sources and different GHGs to climate change, and to ascertain the portions of emissions attributable to individual countries and different regions of the world.

A preliminary GHG inventory for the country was first carried out in 1995, in which the emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) were estimated from the various sectors. However, in that inventory, the component on land use change and forestry (LUCF) was not included due to lack of appropriate data at that time.

The present study was therefore carried out to fill in that missing gap. The objectives of the study were to estimate the GHG emissions and sinks from the LUCF sector, and to determine if Malaysia was a net CO_2 emitter or sink in as far as the LUCF sector was concerned. in carrying out the study, the following procedures were adopted: 1) the collection of relevant secondary data, 2) the preparation of the inventory using the 1995 Intergovernmental Panel on Climate Change (IPCC) Guidelines, and 3) the comparison between the emissions and sinks for the years 1990 to 1996.

From the inventory exercise carried out, it was found that in the LUCF sector, Malaysia was a net CO_2 sink. Keywords: Greenhouse gases (GHGs), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), land use change and forestry (LUCF), Intergovernmental Panel on Climate Change (IPCC).

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Characterization of Agroforestry Experiences with Coffee in the Zona da Mata of Minas Gerais, Brazil

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Agroforest systems are alternatives in natural resource management in which woody species (trees, bushes, palms) are utilized in deliberate association with agriculture and/or animal husbandry in the same area, either simultaneously or sequentially, with significant ecological and economic interactions between components. These alternative systems can use natural resources to augment or maintain land productivity without further degradation beyond that already seen in the elevated degree on occupied and cultivated lands that do not permit such augmentations to food, fiber, energy, or other products. Agroforest systems are viable practices that can be utilized to recuperate landscapes degraded and fragmented by farming and grazing, common situations in the Zona da Mata. The Zona da Mata is characterized by centuries of agricultural occupation, traditional agricultural practices, and a preponderance of smallholder production. The resulting landscapes are insufficiently productive for natural recuperation to their productive potential. For many local farmers, coffee cultivation still represents the principal source of income to meet family needs. Many agro-ecosystems of the Zona da Mata are characterized by declining productivity and low soil fertility derived from the adoption of technologies ill-suited to the region.

The central objectives of this work are to contribute to an ecologically and economically efficient agriculture, strengthen coffee cultivation, and create conditions in which the cultivator may diversify and sustain production through agroforest systems. To these ends, surveys were undertaken of agroforest systems and trees associated with coffee in the Zona da Mata to describe their predominant functions, the phyiological comportment of coffee under the shade of these trees, and the establishment of a system to record descriptive and quantitative information on the systems and species located.

To develop this work visits were undertaken to properties where the concept of agroforest systems were integrated in the method of production and coffee was the principal product. Twelve experiences of family production, one experimental area of the Federal University of Vicosa, and one experimental area of the Vicosa Family Agriculture Group were studied during the years 1997-98. The visits utilized Rapid Participatory Diagnosis through the technique of semi-structured interviews characterized by a few pre-established questions to provide a line of discussion and a basic structure connected to themes in which all subjects were permitted. in this way the interviewees were considerd the "experts" in their respective areas of activity and in the way in which they related their opinions, thoughts, and desires. The protocol used covered History (land use, degree of awareness of adoption, reasons for adopting the system, natural vegetation prior to implantation); Resources, including natural (solo, water, temperature, exposure, et cetera), agricultural (size, quality, and ownership of land; skill and availability of labor), capital (financial physical,), and productive; and Systems, including species (objectives for the components, interactions, spatial and temporal arrangements), management (species comportment, succession, silvicultural techniques), and evaluation.

The majority of experiences were initiated four years prior in areas of low carrying capacity. Vegetative species numbered 115, representing 49 plant families. By category of use, these species were implanted in different stages of soil recovery, succession, and agroforest production and furnished foods, medicinals, and other products such as fuelwood and sawtimber. Diverse types of systems were identified, from simple associations of coffee with two forest species to more complex systems involving 76 species with a variety of objectives (rapid production, green manures, nitrogen-fixation, shade production, advancing natural succession, et cetera). Conclusions include both ecological and economic benefits (reduced erosion, greater soil moisture and organic matter, reduced use of agro-chemicals, and reduced labor expense at later stages) described by the interviewees as well as limitations related to management and economics.

Global Distribution of Mountain Forests

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Despite constituting only a small proportion of the world's forests, mountain forests are especially important in providing resources that benefit human populations and are particularly susceptible to damage and loss. The importance of sound management of mountain forests has recently been recognised increasingly in international policy fora; a thorough understanding of their global distribution is critical to identifying policy and management issues that need to be addressed at international scales. in this paper we present the results of an analysis combining global forest distribution and protection data with topographic data to generate the first mapped dataset on the distribution and protection of mountain forests world-wide.

The importance of mountain forests for mankind is multifaceted. They are vital as sources of water for irrigation and power generation. They intercept and store water from rainfall, mist and snow, and release it slowly, thereby reducing soil erosion and downstream flooding impacts. Mountain forests are very important as repositories of biodiversity. The proximity of many different ecosystem types in steep topography and an evolutionary history of climatic fluctuation and species migration, have led many mountain forests to develop diverse and complex faunas and floras. Because they are usually isolated from similar ecosystems by steep terrain and intervening lowlands they are frequently sites of high species endemism. That very isolation and the increasing pressures on the forest below make many mountain forest species very vulnerable, a fact reflected in the occurrence of many mountain forest species on the lists of the world's most critically endangered species.

Mountain forests are often highly threatened by the activities of growing human populations around them. Some of the most densely populated areas of the world are mountain zones, where demands for land to grow crops, for fuelwood for cooking and heating, and for construction materials combine to exert high pressure on remaining forests. FAO (1993) has estimated the annual loss of forest from upland regions in the tropics to be 1.1%, 30% higher than elsewhere in the tropics.

Despite the importance and vulnerability of mountain forests their distribution has been poorly understood. The first global digital map of forests was published by WCMC in 1996, but this did not identify mountain forests. While subsequent versions did identify some mountain forests based on classifications in the source data, coverage of these important ecosystems was not consistent.

Global forest data are constantly being updated both at WCMC and through remote sensing programmes (*e.g.* EROS Data Centre in collaboration with FAO and WCMC), but explicitly identifying mountain forests in a globally consistent manner has not previously been included in any of these efforts.

The analysis presented in this paper addresses a number of the difficulties inherent in considering mountain forests. While globally accepted definitions of "forest" exist, the problem is with identifying those that fill the important roles and characteristics of mountain forests. Though it is not in itself sufficient, elevation is one key component in defining mountain forests. A newly available global digital elevation model (DEM; GTOPO30) provides new possibilities for defining and identifying mountain areas; elevational difference as a proxy for slope and total local altitudinal range were employed to try to include those mountain forests that occur at relatively low elevations as a result of the "Massenerhebung effect" and related phenomena. By developing such methods of identifying mountain areas using the DEM and combining the result with digital forest cover data, it has been possible to produce a preliminary map of mountain forests in order to highlight regions of potential conservation concern.

Wild Edible Herbs and Maple Sap as an Income Source in Mountain Areas of Korea

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Characterized by four distinct seasons and mountainous topography, extending southward from the northeastern part of the Asian continent, China and Russia, the Korean peninsula has a wide range of habitats and corresponding vegetation types - located at the latitudes 34° 40' to 43° 39' N and the longitudes 124° 0' to 132° 42' E. of these plants, wild edible herbs widely distributed in mountain forests are useful and valuable as sources of food or for their medicinal effects or commercial attraction.

However, only a small minority of wild edible herbs has been studied by biologists or for their role in the local economy. This paper presents a case study on wild edible herbs in mountain forests, conducted at Mt. Gariwang (about 5000 ha, Pyungchang-gun Kangwon-do, South Korea) with a focus on their distribution and contribution.

At Mt. Gariwang, there were 58 species of wild edible herbs and 80 species of wild medicinal herbs. These are important beneficial species - their high economic value makes them highly attractive to mountain villagers. However, increasing market demand for such resources has resulted in their rapid depletion in recent years.

Of the 58 species of wild edible herbs, *Pimpinella brachycarpa*, *Ligularia fisheri* and *Codonopsis lanceolata* provide the largest source of income. The distribution of herbs was diverse and distinctive: *P. brachycarpa* was distributed mostly in mixed broadleaved forests; *L. fisheri* in clear-cut areas, meadow and oak forests; and *C. lanceolata* randomly. *P. brachycarpa* and *L. fisheri* were found under wet soil-moisture conditions, and slope orientation was one of the major determinants of distribution. *C. lanceolata* was generally found on north-facing slopes. Most species of wild herbs were absent from conifer plantations.

Leaf production of wild edible herbs differed with forest type: *P. brachycarpa* yielded 37.9 kg. ha^{-1} in oak forests, 34.5 $kg.ha^{-1}$ in mixed broadleaved forests and 2.5 kg. ha^{-1} from clear-cut areas and meadow. Leaf production of *L. fisheri* was 30.3 $kg.ha^{-1}$, 24 kg.ha-1 and 34.6 kg.ha-1, respectively, while that of *C. lanceolata* was 2.5 kg.ha-1 in oak forests and 1.5 kg.ha-1 in mixed broadleaved forests. Annual leaf production of wild edible herbs was estimated as follows: *P. brachycarpa* yielded 48 t.year-1 fresh weight (10 t.year-1 dry weight). Annual leaf production of *L. fisheri* was 40 t.year-1 and 9 t.year-1, respectively, while that of *C. lanceolata* was 2 t.year-1 and 0.5 t.year-1, respectively.

Overall, 25% of households collected wild herbs, with an average of 1.2 collectors per household. The collection period was from mid-April to early June and the mean number of collecting days was 12.6 per year. The mean amount of wild edible herbs collected by mountain villagers was estimated to be 12 kg.day-1.person-1. of this, 58% was sold and 42% consumed by the household. (73% raw 27% cooked).

A survey of mountain villagers found that 71% considered wild edible herbs highly profitable. For 28%, the economic contribution of wild edible herbs to total income ranged from 10% to 20%. Half of the villagers questioned expressed great concern regarding the rapid reduction of plants due to over-collection, and increasing numbers of collectors from outside the area.

The geographical distribution, habitat, growth, field characters and chemical contents of wild edible herbs should be further studied. Based on well-established biological information on wild edible herbs, economic potential of the plants can be much enlarged. Considering its demand as the essential source of food and relative rarity in amount, marketability of wild edible herbs is brisk and steady. Therefore, development of appropriate cultivation methods in mountain areas is indispensable to meet the increasing demands and help maintain sustainable production of the plants concerned. in particular, utilization of marginal agricultural upland areas, which are expanded by 30,000 ha per year countrywide, can be advantageous to the economy and environment of the local communities.

Maple (*Acer mono*) saps were collected below 800m of Mt. Gariwang during 10 - 15 days in March. Mean amount of saps per day was 2,250 ml from maples with DBH of 12 to 25 cm and mean amount collected from single maple tree ranged from 22.5 to 33.7 litters. The collecting period at Mt. Gariwang was later than that at Mt. Baekwoon located in Southern areas of Korea and the collecting amount at Mt. Gariwang was greater by 20 litters than that at Mt. Baekwoon.

A total of 231 trees in Mt. Baekwoon and Mt. Chiri were monitored for daily sap flow from 1993 to 1995 to understand factors affecting spring sap flow of *Acer mono* Max. Major factors were tree size, tapping methods, weather and site conditions.

Annual mean sap flow per tree was 6.73 liters in 1993, 11.20 liters in 1994, and 11.30 liters in 1995 with mean DBH of 21.4cm. Sap flow increased with increasing crown diameter, DBH and tree age, with a correlation coefficient of 0.52, 0.49 and 0.56, respectively. Size of tap hole did not affect the sap flow, but number of tap holes per tree from one to two holes increased sap flow substantially. Maples in north-facing slope produced more sap than those in south-facing slope. A large temperature fluctuation between day and night raised sap flow. Night temperature below freezing point, clear sky of the daytime and slight breeze considered favorable weather conditions for sap flow. Day time for heaviest sap flow was observed during 2 to 4 p.m. As of July 1997, there were a total of 99,347 A. mono trees in 16,211 ha: 6.1 trees/ha. Mean frequency of A. mono was 20.7%. The 73.9% of maple trees were younger than 40 years with less than DBH of 20cm. Therefore, sap production is expected to increase naturally with tree age.

Further research on maple sap production is needed to develop strategies for sustainable management of Acer mono; to promote its natural regeneration and to grow them in artificial plantations.

Multifunctional management in the Alpine mountain forests

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Management of the mountain forests has changed gradually over the last few decades: sylvicultural objectives characterised by the primary aim of timber production have been replaced by the development of multi-functional cultivation models designed to satisfy a range of new and differing needs.

The interest of the community for other forest functions has been increasing and at the same time a naturalistic type of sylviculture (near-to-nature) has developed, attempting to harmonise differing and sometimes opposing interests which tends to:
- search for cultivation equilibrium characterised by a high degree of naturalness and stability;
- maximise the different functions exercised by the forest;
- reduce conflicts that may appear among the different functions;
- favour forest self-defence capability against both natural and human attack.

Cosequently forests are managed according to management plans prepared by the Province's or Community's forestry technical office. Adapting traditional forest management practices is deemed essential: one must develop techniques that are cost -effective, that respect the typical structure of the stand and that allow a continued maintenance of these forests, so that they can exert at best their protective, productive and recreational roles. Moreover, considering the different roles of mountain forests, one must approach the silviculture and the harvesting of these stand in an holistic, coherent and objective way, in order to implement the most effective strategy for each specific objective.

This is the approach of a particular experimental project, carried out in the Italian Alpine region by a multi-disciplinary team of silvicolturists, forest managers and harvesting experts.

One of the experimental sites was chosen in a secondary valley (Sadole) of Fiemme valley (Province of Trento), where, because the high slope, the forest cover has a primary role of protection for the people and the infrastructures, limiting the breakdown and the rocks rolling caused by the steepness of the slope. The forest cover is also a source of wood production. Besides it has an additional role in landscape and recreation.

The forest is represented by pure spruce stands or, in some cases, by stands of prevailing spruce with larch and Swiss stone pine.The structure partition of the stand is almost even-aged; mature over mature stand and adult trees prevail. The one stored structure of the stands depend on the natural tendency of the primary species present (*P.abies*). in this site the rules adopted for the forest planning are based on the sylvicultural needs of the various stands.

It was decided to begin a regeneration phase of the mature and over mature stands, starting from the groups that are in the best site conditions in regard to the stability of the stand. With these remarks, in the area the general rules of forest system are followed, using the clear cutting by hole inside the older stand to stimulate the regeneration of spruce and larch, and in the same time it is tried to satisfy the multi-functions of the area (protection, recreation, landscape and wood). A first felling was carried out during 1996 in two holes. The timber was yarded by using a sky-line crane.

The operation was a complete success because it was possible to apply the sylvicultural forest system as designed, in an attempt to reach a number of goals. The important hydrological function of this forest was left intact. Releasing a number of green screens along the cut was extremely effective in this respect. After two years no erosive problems interested the slope. No rockfalls have reached the valley bottom. Furthermore the cut did not detract from the scenic value of the landscape. Although rather large, the patches were managed in a way that they are screened if observed from the most popular observation points. The adequate space of each opening will certainly favour the regeneration of spruce and of other less common species, such ass Swiss stone pine and larch which could increase the local biodiversity and the ecosystem level.

In conclusion, this trial gives us a founded hope that the most part of Sadole forest could be successfully rejuvenated in the next years. That entails that if a large regeneration effort must be conducted in a short time span, it may be worth planning some improvements that will make the operation even more effective.

Enjeux écologiques et financiers de la revégétalisation des mines en Nouvelle-Calédonie

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Un grand massif de péridotites s'étend sur un tiers de la superficie de la Nouvelle Calédonie faisant de ce Territoire le troisième producteur mondial de nickel. Jusqu'à récemment les entreprises déversaient systématiquement les stériles dans les pentes. A l'impact environnemental de première grandeur – stérilisation des terres, pollution des cours d'eau, dégradation du paysage, pollution du lagon – s'ajoute une perte progressive de la biodiversité, le milieu possédant une flore unique au monde avec 90% des espèces végétales endémiques.

Aujourd'hui les sociétés minières adoptent une attitude beaucoup plus respectueuse, mais faute de réglementation contraignante les travaux de revégétalisation n'ont réellement commencé que vers 1993. Chaque société intervient à sa guise, selon des priorités qui lui sont propres. Certaines affichent une volonté de maintenir avant tout la biodiversité et la conservation d'espèces emblématiques des lieux où elles exercent leur activité. D'autres, plus préoccupées de corriger la dégradation du paysage et de réduire l'érosion choisissent une revégétalisation considérée comme plus pragmatique, à plus grande échelle. Pour y parvenir, elles interviennent au moyen d'espèces, parfois même introduites, dont l'utilisation avec des techniques appropriées permet des résultats rapidement visibles et relativement fiables.

Cette dualité entre un contexte d'urgence et le maintien de la biodiversité est au cœur de la problématique posée par la revégétalisation sur le Territoire.

L'environnement industriel et financier évolue sensiblement avec une baisse structurelle des cours du nickel et l'arrivée de compagnies internationales. Il imposera une approche beaucoup plus économique de la revégétalisation.

Les recherches menées par le CIRAD – Forêt en Nouvelle Calédonie doivent permettre de définir des itinéraires techniques qui soient un compromis satisfaisant entre la biodiversité et le coût de réalisation. En effet la revégétalisation des talus est difficile en Nouvelle-Calédonie et nécessite pour l'essentiel l'utilisation d'espèces endémiques dont la mobilisation est onéreuse. Ces expérimentations devraient garantir à terme (dans les vingt à trente ans) une variabilité d'espèces suffisante, mais aussi l'installation d'une couverture végétale complète qui diminuera rapidement l'érosion et apportera rapidement une forte amélioration paysagère, avec des coûts d'installation convenables.

On a montré, par exemple, que deux espèces ligneuses locales, *Acacia spirorbis* et *Casuarina collina* avaient une croissance rapide sur ces milieux dès que l'on apportait de la matière organique et formaient aisément des peuplements denses et fermés. Ces deux espèces faciles à multiplier permettent actuellement le meilleur rapport résultats-coûts. Il est cependant possible d'ajouter quelques autres espèces à développement moins rapide et de définir des modes d'installation et de gestion qui vont garantir une diversification propice au développement naturel d'autres espèces et à la durabilité du système. Les travaux menées en microbiologie autorise à espérer des avancées rapides dans la maîtrise des associations bactéries ou mycorhizes avec les espèces plantées.

Rehabiliation of Degraded Forestlands by the Poor Families in the Hills of Nepal: the Community-based Action research

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The paper summaries the results of community-based action researches in the Leasehold Forestry and Forage Development for poor in which process has been developed for the rehabilitation of degraded forestlands remained barren for long period and degrading each year. All the researches have been conducted between 400-2000 metre altitude from average sea level (asl) mostly in sloppy hills and mountains of Nepal which are most fragile. These forestlands are now a good source of income for poor families with a new concept of forage farming in multiple product forestry. The technologies and processes are simple but effective that include: (a) zero (no) grazing in the degraded lease land; (b) forage farming (with proper inoculation) of perennial species preferably legumes with a minimum tillage, (d) establishment of legume hedgerows that also provide forage, (e) cut-and-carry system for animal rearing, (f) application of A-Frame to find out contours and planting of fast growing multipurpose tree and fodder species along contours, (g) multiple product forestry that render both short-term and long-term products and benefits to rural poor.

The institutional arrangement for the action research encompassed: (i) formation of small functional groups of families living below poverty line ranging 5-10 families, (ii) land tenurial ownership of degraded forestland to these groups up to forty years and renewable of another term, (iii) participatory action research facilitated by the Nepal Agriculture Research Council (NARC) involving leasehold groups members (poor families), (iv) minimum input supply including seeds and planting materials and training to the leasehold members, (v) research plots in the open degraded lands without fencing and protection responsibility of the leasehold members, (vi) assurance of ownership on products (forage and tree) to the leasehold groups but harvesting of crops at the presence and observation of researchers for data recording.

The action-research package contains Integrated Research, Development, Extension and Training (IRDET) which covers research with poor farmers at open forestlands (without barbed wire fencing). Field staffs and farmers are trained in this aspect and lessons learned are replicated in other areas as well.

The results of action researches are obvious that the project, on its initial three-year exploratory phase, initiated and tested the technologies and processes in four project districts. High level Mid-term Evaluation Mission (including representatives from the (FAO/IFAD/HMGN) evaluated the findings and very interesting lessons were learnt from the action-researches. Now the concept of leasehold forestry for poor and its technologies have been successfully replicated in ten hilly districts of Nepal. in total 4268 hectares degraded forestlands have been brought under productive area that accrue a good source of income to the poor families chiefly through improved animal rearing. of the ten species tested, Stylo (*Stylosanthes species*) and molasses (*Melinis minutiflora*) are found the promising species for eradicating forest killer (*Eupatorium odoratum*) and improving soil. Other species that stabilizes the degraded forestlands and also provides short-term benefits to poor families are: broomgrass(*Thysonaleana maxica*), bamboo (*Dendrocalamus*), Arunodnaria and suitable fruit trees in the locality. Shrub species like Flemengia, sunhemp (*Crotalaria juncea*) are found suitable leguminous hedgerow forage species in the restoration of degraded forestlands.

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Sustainable Forest Management

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Research Establishment and Maintenance of Access Racks' Network in Relation to tending Operations of Young Sessile Oak Stands

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Sessile Oak (*Quercus petraea* (Mattuschka) Mill.) is one of the most valuable forest species in Romania, covering about 720,000 ha (3 per cent of the forest area). Usually, it is naturally regenerated by using group shelterwood system and young stands are extremely dense (tens of thousands of seedlings per hectare), pure and impenetrable.

Taking into account some of its main characteristics (e.g., high stand density; relative intolerance of shade; danger of epicormic brancing; quite slow growth), the silvicultural models traditionally applied to the Romanian young sessile oak stands, before the first commercial thinning, includes low moderate intensity weedings and cleanings, reducing stand density down to about 80 per cent.

Based on research works carried out in different sessile oak-based stands from the Tirgoviste Branch of the Romanian Forest Administration since 1992, a new approach is proposed and includes:

- opening and maintenance of access racks, 0.8 - 1.0 m wide (seedling stage) up to 1.5-2.5 m wide (thicket stage), made at intervals also depending on development stage (between 6-12m in seedling stage in 25-40 m in thicket stage);

- weedings and cleanings of various intensities (e.g., moderate in highly dense stands, non-treated from the very beginning, with high slenderness indices (over 120-150), where stand density is reduced down to about 85 per cent or moderate-high in continuously treated stands, where stand density can be reduced down to 80 or even 75 per cent).

Costing Study of Implementing Selective Management System (SMS) for an Integrated Timber Complex in Peninsular Malaysia

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The current practice of forest management in Peninsular Malaysia is based on Selective Management System (SMS) with the objectives of optimising the management objectives of economic and efficient timber harvest, sustainability of forest and minimum forest development cost, under prevailing conditions. The practice requires the selection of management regimes based on inventory data, which will be equitable to both logger and the government, as well as ensure ecological balance and environment quality. This paper deliberates on the costs incurred in implementing the current SMS practices incorporating Malaysian Criteria & Indicator (MC&I) verses conventional SMS in an integrated timber complex in Peninsular Malaysia. The actual costs of forest management activities were collected using data from thirty-seven logging compartments for the period 1992 to 1997. The cost of forest management activities was computed for eight activities: pre-felling inventory; tree marking; boundary delineation; road and log yard construction; harvesting; closing report; post felling inventory; and silvicultural rehabilitation cost. The breakdown of the logging cost components was reported and cost equations of each of this forest management were estimated using linear regression model. The cost function was estimated using the ordinary least square technique. Results of the study show the cost of implementing the SMS varies by different forest management activities. Timber harvesting and administration costs accounted for about 62.37 percent of the total cost, either per hectare of area logged or per cubic meter of timber harvested. The average cost of timber harvesting and administration is estimated at RM2, 454.10 per hector (RM50.41 per cubic meter) and Rm1, 746.79 per hectare (RM37.30 per cubic meter), respectively. The higher proportion of cost incurred by these two activities is due intensive forest management activities during harvesting and planning stags. Regression analysis indicates that such factors as timber output, area of the distance of forest to the main road and altitude affect each cost component in a different manner. The depends on the nature of forest management activities carried out by the Concessionaire. If the logging concessionaires were to comply with the sustainable forest management guidelines using the MC&I, higher costs would be expected since many additional activities and specifications of forest management activities will have to be followed by the concessionaire. The implication is that the incremental cost would have significant effects on the economics of timber harvesting and forest management. Suggestions on appropriate policy to ensure long term benefits of sustainable forest management resulting from incremental cost of forest management activities is also highlighted in the paper.

Elementos tecnicos para la producción sostenible de recursos vegetales no maderables del bosque tropical

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Desde 1989 el Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) estudia la problemática del aprovechamiento sostenible de los bienes del bosque diferentes a la madera, como alternativas para el desarrollo. La experiencia de estos años de investigación se ha sistematizado en una metodología para incorporar especies vegetales en procesos de manejo forestal diversificado, entendido como un manejo técnico de las poblaciones naturales y no como algunas prácticas extractivas tradicionales, carentes de indicadores sobre la capacidad y limitaciones productivas del recurso. Esta metodología esta basada en estudios sobre plantas con diversos tipos de producto y hábitos de crecimiento.

El desarrollo de nuevos criterios de manejo en el bosque tropical debe ser paralelo al aprovechamiento, por lo cual la selección cuidadosa y sistemática de las especies a incluir en ese proceso constituye el primer paso del mismo, y se basa en su capacidad de adaptarse a los objetivos últimos del plan de manejo. Considerando la gran gama de combinaciones de las especies no maderables en cuanto a hábitos de crecimiento, órganos cosechados y tipos de mercado, la definición clara del producto a cosechar en cada caso y sus normas de calidad es el segundo paso, sin el cual es imposible definir las herramientas del trabajo posterior, solo debe salir del bosque la biomasa que será aprovechada.

El tercer paso es la definición del proceso productivo, esto incluye el conocimiento mínimo de la especie en cuanto a su hábito de crecimiento y requisitos ambientales generales. Posteriormente se desarrollan herramientas para caracterizar su estructura de población, es decir variables prácticas de medición que permitan diferenciar estados de madurez de los individuos, calificarlos como productivos o no productivos y estimar la cantidad de producto de cosecha por unidad de área. La información que se obtiene a partir del diámetro a la altura del pecho de los árboles maderables puede obtenerse de otro tipo de variables en el caso de especies no maderables, como número de cepas por macolla o dimensiones de una hoja. El desarrollo de un sistema silvícola y plan de aprovechamiento para cada especie en particular implica determinar la respuesta de la especie a diferentes condiciones ambientales y tratamientos de manejo, así como sus tasas de crecimiento y regeneración de la biomasa de cosecha.

El cuarto paso se refiere a la integración de varias especies dentro del proceso de aprovechamiento integral del bosque, es decir la concepción del sistema de manejo diversificado del bosque. Para ello se deben definir metodologías de inventario diversificado que reduzcan los costos y determinar la compatibilidad o antagonismo entre especies en función de su respuesta a los tratamientos silvícolas. La experiencia de CATIE demuestra que este proceso es práctico y factible de realizar, como una forma de contribuir a la valoración y conservación subsecuente de la biodiversidad en bosques tropicales.

Vers des Aménagements Forestiers Villageois de Concepcion Evolutive

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En 1992, le projet Energie II a initié l'aménagement de plusieurs forêts du Sud-Niger au profit des populations riveraines. Des groupements villageois denommés "Marchés Ruraux" (M.R.) ont été créés pour commercialiser le bois de feu.

Six années plus tard, en 1998, une évaluation technique et socio-économique de ces aménagements et des organisations villageoises denommées "Structures Locales de Gestions" (S.L.G.) a été réalisée.

Il s'avère que certaines S.L.G. ont fait preuve de dynamisme tant dans le domaine des réalisations sociales au profit du village que dans celui de la gestion des forêts villageoises. D'autres au contraire se sont rapidement essoufflées dès que l'encadrement du projet s'est retiré.

Les notions de quota, de parcellaire, de rotation, d'espèces protégées, de diamètre minimum et de hauteur de coupe ainsi que les techniques simples de régénération (paillage) ont été assimilées et réappropriées par la majorité des bûcherons.

On constate que les aménagements ne peuvent être durables que s'ils sont conçus de façon évolutive afin de pouvoir s'adapter aux aléas climatiques (nécessité d'exploiter d'avantage à l'occasion des années d'alimentation déficitaire) et aux nouvelles connaissances acquises par l'encadrement ou par les bûcherons eux-mêmes. La composition de la S.L.G.

doit également être revue régulièrement. L'aménagement doit donc pouvoir être modifié légèrement en cas de nécessité et, plus profondément, à chaque rotation de coupe.

En général, lors de la création d'un M.R., les villageois sont méfiants par rapport à l'administration ou au projet et ne veulent s'imposer qu'un minimum de contraintes concernant la gestion des forêts. Ce n'est qu'au bout de quelques années de fonctionnement de la S.L.G. qu'une confiance mutuelle peut s'établir entre l'administration et cette structure. Cette dernière peut alors imposer aux bûcherons des règles plus contraignantes. On peut ainsi passer d'une gestion très simplifiée, à un aménagement préservant l'écosystème et garantissant une production soutenue. L'Etat peut alors accorder des baisses importantes de taxes, sur le bois provenant de ces forêts, pour encourager cette démarche patrimoniale. Il doit alors être vigilant sur le contrôle de son application réelle sur le terrain.

On comprend donc que les états qui se sont engagés dans ce type de stratégie de gestion décentralisée doivent tout faire pour que leurs fonctionnaires apportent un appui effectif aux structures locales de gestion.

Mots clés: Aménagement Forestier, Gestion participative, Sylviculture, Niger, Décentralisation

Development of Criteria and Indicators for Sustainable Management of Forest in India: Bhopal-India Process

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Over a hundred years ago India adopted the principle of sustained timber yield management from its forests. The other dimensions of sustainability, though considered during the development of management plans for forest divisions, were given lesser priority. However there were major changes and some reversal of priorities in the National Forest Policy (1988). The main focus of forest management from now on was to maintain environmental stability through preservation and restoration of ecological balance and the conservation and enhancement of biological diversity. Direction of forest management has to be focussed towards the increase in forest productivity and to meet the basic requirements of fuelwood, smallwood, fodder and non-timber forest produce of the rural and tribal people. Sustainability in the Indian context is the dynamic and complex interaction of the existing social, economic and ecological conditions. Well being of the forest dependant communities along with the well being of the forest health is the key to figuring out sustainability of India's forests. However, there was no mechanism to monitor the progress of achievement of sustainability as envisaged in the 1988 Forest Policy.

A hierarchical framework of "Criteria and Indicators" (C&I) is being used in eight different regional processes as part of the UNCED sustainable forest management (SFM) initiative. Due to the unique nature of the socio-economic and forest conditions in India it was found that none of the earlier regional processes would be appropriate to assess sustainability in Indian conditions. For Sustainable forest management (SFM) of India's forests, a separate set of C&I was designed to provide cost-effective information for helping in the sustainable management of forests in conditions of the South Asia subcontinent. A set of eight criteria and fifty-one indicators was developed under the Bhopal-India process. Assessment of the sustainable development of India's forest and simultaneously the achievement of the forest policy principles is to be done at the national level by using these C&Is. Though these indicators would not directly establish whether management is sustainable or not, the direction of change of indicators would provide insights into the directions of change towards sustainable forest management. This would help in developing or revising policies and legislation and refining national forestry programs.

The eight criteria identified in the Bhopal India process were based on the principles enunciated in the 1988 forest policy. These are the extent of forest and tree cover, forest ecosystem and vitality, biodiversity conservation and soil and water conservation. and also other criteria like forest resource productivity, forest resource utilisation, social cultural and spiritual needs and policy, legal and institutional framework.

This paper deals with the method of evolution and development of each criterion and its associated indicators and verifiers. The paper also discusses the research needs required for each criterion and the development of norms or standard for some verifiers and indicators. The applicability of these criteria and indicators at the regional or state level is discussed and the type of changes required to adapt these C&I at the forest management unit level is also discussed.

Sustainability of remaining forest fragments in the Atlantic forest region

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The floristic, successional stage and landscape characteristics were studied in four secondary forest fragments within the Atlantic Forest domain in Minas Gerais State, southeastern region of Brazil. Fragments 1 and 2 are elongated with an area of 12 and 13 ha, respectively, and fragments 3 and 4 tended to round with an area of 23 and 18 ha. All fragments were mostly located on the upper part of the slope.

The point centered quarter method was used to obtain the data. Three approach levels were taken into account to proceed analyses: height: 3 m and DBH: 5cm; 5 cm DBH: 10 cm; DBH 10 cm.

It was sampled 57 species in the fragment 1 and 77 in the fragment 2, which are elongated, and 85 in fragments 3 and 4, which tended to round.

The initial secondary species group predominated in all fragments, however, these fragments present different successional stages. The fragments 1 (elongated) and 4 (round) exhibited the earliest and latest successional stage, respectively. Lianas were present in all fragments and represent a serious barrier for natural regeneration, and imposed high mortality of trees.

The biodiversity was deeply depreciated in all fragments due to their small size, strong edge effects, low surround permeability (roads, crops, pastures) and high antropic pressure, specially for the fragment 1. The fragment 1 presented 19.3 % of species with a population smaller than 50 individuals with height greater than 3 m. The values for fragments 2, 3 and 4 were 14.2, 0.0 and 10.5 %, respectively. These results indicate that fragment 1 presents the lowest sustainability, followed by fragment 2, both with elongated form and small size.

Ecosystem Management of Forests in Russia: Strategy of Forest Account Works

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Economic reforms in Russian are conducted to delimit mechanisms employed in State management and economic development. in all branches of economy they are directed, first of all, on a decentralisation of management and of decision-making procedures. However, as regards the forest management and system of forest accounting, first of all, with inventory and planning, the most persistent inertia survives in preserving centralisation of planning and financing regardless of real needs of regions. Enlargement of approaches, completeness and depth in realisation of the whole complex of forest accounts needed.

The sustainable forest management is connected, first of all, to the economic activity. Transition to anew quality of human interrelations with forests from "using" to "management", brings on the first plan the interconnection of ecological, social and economic process. The economic aspect, thus, moves from the first to the last place in the system "Nature - Society - Economics". The estimation only of timber resources concedes a place to a complex estimation of forests as ecosystems. Therefore, traditional use of existing base of knowledge on forests becomes insufficient for sustainable forest management.

Forest, these spatially distributed natural features, require a geographical approach (i.e. use of extract co-ordinates for the describing and updating data); that is especially important for ensuring sustainable development of land and forest uses. Besides, and influenced by economic activity and environmental changes, is necessary. It needs urgently to fix priorities concerning depth completeness and timeliness of the information on forest.

It is obvious that t the State level (federal and Regional) of forest management we should have the possibility to assess truly key parameters of the forests' dynamics. This issue could be carried out with a system of State Forest Inventory (SFI), budget-fed irrespective of the pattern of ownership of forest parcels.

SFI should provide for collecting, transmitting, processing and analysing information on forest and for selective driving it to bodies of forest management and of nature conservation, as well as to various users. The information is intended for duly revealing of changes in the forest state, their estimation, prevention and elimination of consequences of negative processes. It will be also an practical opportunity to integrate data of Russian forests into world information system of world-wide forest resources assessment.

Accuracy and the reliability of the SFI will guarantee bodies of forest management against making strategically faulty decisions, they will allow to reliably assess contribution of Russian forests into global processes of climatic changes and preservation of a biological diversity.

Task Force 4
Management and Conservation of Forest Gene Resources

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Genetic Impacts of Forest Fragmentation in Northwestern Costa Rica

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Since the sixteenth century, grazing and agriculture have transformed the landscape of the Bagaces Valley, northwestern Costa Rica; where once was forest interrupted only by rivers, there remain only riparian and non-riparian forest patches embedded in pastureland, sugar-cane and rice-fields. As genetic diversity of forest trees is thought to influence their population viability the genetic characteristics of fragment populations have important implications for the conservation of biodiversity in such landscapes. We report on such characteristics, concentrating on two species. *Plumeria rubra* (*Apocynaceae*) is a wind-dispersed, hawkmoth-pollinated pioneer. Within the study zone, it is typically found on the exposed rock of the many river canyons, with outliers on similar, but non-riparian, habitats. *Anacardium excelsum* (*Anacardiaceae*) is bat- and gravity-dispersed and pollinated by small-to-medium-sized insects. It is found predominantly as the dominant species of the gallery forest, but also occurs as non-linear, discrete fragments. We report on allozyme diversity, effective sizes and mating systems within fragment populations of these contrasting species, and their relation to variables such as fragment size, shape and degree of isolation. in our conclusions, we address the implications of our results for biodiversity conservation.

Genetic Consequences of Intensive and Alternative Silvicultural Systems

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The effects of various intensive silviculture options such as tree improvement delivery systems and alternative silviculture methods such as partial cutting and commercial thinning on genetic diversity are assessed. Intensive management methods of parent tree selection before and after progeny testing, genetics of seed orchards and seedling production are evaluated. More importantly, seed orchard "after-effects" that are resulting from the common practice of moving seed orchard parents by several degrees of latitude from their origin to locations that are suitable for seed production are assessed and reviewed. Alternative silviculture systems such as seed tree, shelterwood and patch cuts were compared to clear cut and control old growth forest and the genetic quality of natural regeneration is determined. Finally, commercial thinning practices are evaluated and their impact on tree species' genetic diversity and the understorey plant species community dynamics are evaluated.

Impact of logging on tropical forest resources

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Tropical forests are found in more than 80 countries and account for about one third of the world's forest cover. Although deforestation occurs in all types of tropical forests ranging from lush rainforests to arid thorn woodlands, logging is more predominant in the humid tropical forests. Annually more than 4.0 million hectares of tropical rainforests are logged for timber. The volume of timber extracted varies from region to region according to the stocking of commercially valuable stems. The damage to the stand is generally related to the number of stems harvested per hectare and the nature of the logging operations. Logging not only has an impact on the timber species being harvested but also on all other goods and services provided by the forest viz, fuel food, fodder, shade, shelter, environmental stabilization, and amenity, cultural and spiritual values. Hence, a continuous assessment of damages to the biotic and abiotic components due to logging is important for sustainable management of forests for its goods and services. This paper will address the impact of logging on forest genetic resources, mainly the plants which form the base for most life forms.

Reduction in basal area of trees from different size classes due to a single logging event can range from 13-56% in tropical rainforests with large tees of low abundant limber species being most affected. However, recruitment of seedlings and presence of saplings are generally high in immediately logged-over forests. A decrease in genetic diversity ranging from 5-23% has been detected in adult individuals of timber and non-timber species immediately after logging. An evaluation of young regenerants of three tree species immediately after logging revealed high genetic diversities. Pedigree analysis of regenerants in one species showed substantial contribution of genes from neighbouring stands in the logged stand. No significant change in genetic diversity has been observed for a number of plant species in regenerated forests after about 40-45 years of logging. Implications of these and other demographic and genetic diversity changes on harvesting practices and sustainable management of tropical forest genetic resources will be discussed in this paper.

Task Force 5
Water and Forests

Coordinator

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Terrestrial Biosphere Models and Forest-Atmosphere Interactions

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The terrestrial biosphere, encompassing vegetation and the adjacent soil and atmosphere, is a biogeochemical crossroads. Here the fluxes of water, carbon, energy and nutrients all interact and influence one another, to an extent greater than practically anywhere else in the cycles of these entities. To understand the transfer of any one entity through the terrestrial biosphere, say water, it is necessary to recognise the relationships among these crucial fluxes. Why are they crucial? From the standpoint of a catchment or forest hydrologist, the cycles of water and nutrients through vegetation exert crucial influences on vegetation growth, catchment water yield, and water quality. From an atmospheric standpoint, the energy and water fluxes at the earth's surface largely control atmospheric motions and the global hydrological cycle. From the standpoint of the biogeochemistry of the earth system, key fluxes through the terrestrial biosphere include those of chemically or radiatively active gases such as CO_2, methane, N_2O, volatile organic carbon compounds (VOCs) and particulates.

Because of these diverse motivations, transport processes in terrestrial biosphere are important in meteorology and climatology, plant physiology, agricultural science, ecology, remote sensing science, and hydrology (including forest hydrology as an important sub-discipline). However, these disciplines have developed views of essentially a single set of processes which are surprisingly distinct. When encapsulated in model form, the resulting descriptions are often known as terrestrial biosphere models, or sometimes as SVATS (Soil-Vegetation-Atmosphere Transfer Schemes). Examples of extant terrestrial biosphere models include SiB, Century, Biomass, Biome-BGC, SCAM, WAVES, and others.

The task of this chapter is to review the current state and development of terrestrial biosphere models, especially from the standpoint of forest hydrology, and to highlight some directions for future development. A theme throughout is that there is a great deal of convergent evolution between terrestrial biosphere models arising from different parent disciplines. This is happening as a small part of a much larger movement towards a unified study of the earth system, in which the interactions between components (atmosphere, oceans, soils, terrestrial water, ecosystems and humans) are the primary focus of study rather than processes within any of these components.

The chapter begins with a description of a terrestrial biosphere model, followed by a description of the key processes operating in the system. We then consider the integration of these process descriptions to canopy scale, and introduce the new phenomena that need to be handled at this level of integration. These include nutrient distributions and light use efficiency, gross and net primary productivity, and plant growth and resource allocation. We describe new techniques for parameter estimation which move away from the traditional view of a model as an *a priori* predictor from specified data on the meteorological variables and process parameters. Finally, we demonstrate how the terrestrial biosphere (as a complex system described by a terrestrial biosphere model) exhibits simple or at least understandable behaviours at large (canopy and greater) scales. These behaviours emerge from the negative feedbacks exhibited by the system, and are manifested as quasi-equilibrium states.

Forest Management Induced Leaching of Nitrogen from Temperate Forests

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Nitrogen leaching may potentially cause eutrophication of surface water and contamination of ground water. Generally, water from forests is of good quality with a relative low concentration of dissolved nitrogen. Water resources from forests are already in use for drinking water purposes in several regions and this use may increase in the future since other land use (agriculture industry and urban use) expose a high risk for contamination of ground and surface waters. Afforestation on agricultural land takes place, *e.g.* in Northern Europe, to improve the water quality and to secure water resources in the future.

Temperate forests are generally considered nitrogen limited and they are characterised by a very tight nitrogen cycle. Losses of nitrogen are low with background levels less than 0.3-0.5 mg N l^{-1} in soil water. Often the losses mainly occur as organic nitrogen. However, low concentrations of nitrogen in seepage water from forests may not per se be expected. Several investigations show concentrations of nitrate in the soil solution and stream water well above the background levels.

In parts of Europe and North America, air pollution with nitrogen compounds is the main reason for increased nitrogen leaching. Inputs often above 10-20 kg N ha^{-1} yr^{-1} increase nitrogen concentrations in foliage and foliage litter, increase nitrogen mineralisation and thus accelerate the nitrogen cycle. Recent advances in the understanding of nitrogen cycling in forest and the effect of nitrogen deposition have identified the conditions where there is risk for nitrate leaching from mature forests at least for coniferous forests. As an example coniferous sites with nitrogen concentrations in needles above 1.7 mg g^{-1}, total nitrogen input to soil (throughfall + litterfall nitrogen input) above 80 kg N ha^{-1} yr^{-1} and/or forest floor C/N ratio lower than 25 were leaching nitrate if nitrogen deposition was elevated.

Other reasons for elevated nitrate leaching may be related to forest management. The classical experiment at Hubbard Brook in the 1960s with clear-cut and herbicide treatment of a whole catchment illustrated the potential vast impact on water quality (leaching of 140 kg N ha^{-1} yr^{-1}) at extreme forest disturbance.

Forest management induced leaching may result from one or a combination of the following impacts on the nitrogen cycle:

Increased input of nitrogen (fertilisation, planting of N_2 fixing trees)

Decreased biological uptake (clear-cut, thinning, weed control)

Increased net mineralisation (liming, soil preparation, ditching (lowering of groundwater)).

Following the Hubbard Brook experiments forest research in Europe and North America have substantially increased the knowledge on impacts of forest management. Especially the impacts of clear-cut are well established demonstrating that the risk for nitrogen losses is highest at nitrogen rich sites. High nitrogen losses have been demonstrated after liming and ditching, as well as after planting of coniferous species on former deciduous forest soils.

Afforestation on former agricultural land will be an important silvicultural activity at least in Europe during the next century. Modern agricultural soils are characterised by high pH, high amounts of nitrogen bound in organic matter with a C/N ratio often below 10 and nitrogen mineralisation dominated by nitrification. in the first years after afforestation nitrate leaching will occur until the plant cover has developed. The question is how the nitrogen cycling will develop in the long-term on these types of soils. Recent studies of forests developed on formerly cultivated soils have shown that the soil still have nitrogen cycling characteristics more comparable to cultivated soils than to soils with continuous forest cover even 100 years after afforestation.

In the paper, findings on the impact of silvicultural management on soil solution chemistry and freshwater quality from the temperate forest regions will be synthesized. The interaction between management and air pollution nitrogen input will be discussed as well as ways to reduce the impact of silviculture on water quality.

Effects of disturbance on nutrient export from forested catchments in the humid tropics

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Site fertility affects the productivity, structure and functioning of tropical forests. Consequently, the maintenance of site fertility is an essential biophysical element in the sustainable utilization of forest resources in humid tropical landscapes. Disturbance events (both natural and man-induced) frequently cause the release or 'mobilisation' of nutrients within the ecosystem and this may result in an increased potential for nutrient loss or 'leakage' out of the system. A predictive understanding of the likely risks and levels of nutrient export from ecosystems and catchments associated with particular forest disturbances in the humid tropics is thus critical to the sustainable long-term management of both natural and plantation forests in these landscapes.

In this review we consider:

- the pathways of potential nutrient loss from tropical forest catchments;

- the features of disturbance events in natural and plantation forests that govern the extent of possible nutrient export, and;

- some of the methodological problems involved in measuring nutrient export from catchments.

The importance of integrating research in nutrient dynamics, hydrology and plant ecology to address issues of sustainable utilization of forest resources in the tropics is emphasised.

Transpiration of Trees and shrubs and hydrological balance in water limited environments under Xerothermo Mediterranean climate

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Studies were conducted in the late 60is and early 70is on the hydrological balance of areas of various vegetation types and cover, in Thermo-Mediterranean climatic conditions sensu Emberger et al. 1963. Interest in these studies resulted from concern about the hydrological balance of Israel's aquifers as influenced by large afforestation projects and reclamation of devastated natural oak scrub formations. The studies failed to produce accurate data due to calibration problems of the different methods used, and the extremely large spatial variabilityin site conditions, which prevented the determination of the water storage capacity of the bedrock-soil complex.

One of the ways to determine the water balance of forest areas is to use physiological parameters of the vegetation itself as an indicator of the bedrock-soil complex water availability. of the several parameters available, we selected the sap flow velocity, i.e., transpiration measured by the improved and calibrated heat pulse technique sensu Cohen et al. (1981, 1989) in the tree's trunk.

Sup flow, (i.e., transpiration) was measured continuously during several days on between 8 to 15 dates during a year in eight or 16 trees, whose diameter distribution represent the diameter distribution of all the trees growing in a plot situated either in *Pinus halepensis*, *Quercus calliprinos*, *Q. ithaburensis*, *Phillyrea latifolia* and *Tamarix aphylla* forests, (all native species); and in *Eucalyptus camaldulensis* plantations, a introduced species. Results of these measurements were used to scale up the single tree water use to stand water use at a given environment.

The relationshipe between water availability (rainfall), and the estimated amount of water used by the forest vegetation, should be regarded as a majore factor in forest management.

The hydrologic and growth response of eucalypt forests to soil salinity and waterlogging.

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The response of trees to salt in the soil is a vexed problem for land managers in much of southern Australia. Clearing native woodland for agriculture has resulted in dramatic increases in waterlogging and secondary salinisation which are arguably our two greatest land management issues. Over the last 10-15 years there has been a concerted effort by government, and private groups and individuals, to put trees back on the land, and to do this in a way which complements rather than replaces existing agricultural systems. This "greening" of agricultural areas is intended to ameliorate the hydrologic imbalance which has arisen from the forest clearing, and simultaneously provide an alternative crop for farmers.

However, there is considerable debate over the likely success of replanting much of the degraded land. Many of the commercial tree species are sensitive to salinity and waterlogging in their root zone. These sensitivities are compounded by the degradation of soil structure which has arisen from cultivation and from the rise in, often saline, watertables. The structure of the clayey subsoils has also been degraded by changes in the soil water electrolyte mix which accompanied the rising watertables.

Most of the native forest and woodland cleared in Australia grew in regions with mean annual rainfall from 300 to 1100 mm. The trees adapted, and flourished, in conditions where small scale salinity levels were very high, but the depth and extension of their root systems appeared to allow them to capture water where it was available. This strategy resulted in forests and woodlands which could survive drought periods, as well as locally concentrated salt. This ability to exploit the soil depended on macropores from old root channels and pedological structures, features which may well be hampered by the changes in soil structure. This paper reviews knowledge of how the native, largely *Eucalyptus*, forests of southern Australia respond to soil salinity, soil water deficit, and waterlogging conditions, and implications these have for integration of plantations with agriculture.

Task Force 6
Internet Resources

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Web-based information resources for forestry research on the Internet

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Keywords: bibliography; reference information; document type; public access; knowledge exchange; resource discovery; electronic publishing

Internet applications have evolved in many ways during recent years. One extraordinary development is the multiple use of World Wide Web features. This is especially true in the scientific context, but developments in e-commerce, web-based messaging, cyber-administration, distance learning or in the entertainment industry are also shaping interpersonal communication and business processes. These changes can be observed in the forestry and wood sector as well as in the field of forest sciences, e.g., electronic publications, directory information on the Web, archives of mailing lists, downloading of software, e-shop facilities, document repositories, modelling programmes.

In fact, facing the mass of data available by an Internet address (URL) on the Web the user is looking for support in locating, filtering, selecting or sorting relevant information. The retrieval process has become - in a paradoxical manner - simpler and more complex at the same time. New search engines may link very fast to a specific document or data set by their weighting mechanisms.

However, in other cases only the visit of an authoritative source on the net will allow to search for the information needed in a database stored "locally" .

A few examples will illustrate the current situation with respect to both fee-based services and publicly accessible data. As far as forestry research is concerned one can expect quite a broad range of bibliographic collections available through web interfaces: library catalogues / web-OPAC, publisher's price lists, table of contents or cited references produced by research institutions and scholarly associations, personal homepages, etc. Additionally one can find other types of reference information, i.e., current research descriptions, meta-data services, media collections (images, audio files, ...) or even basic data on patent literature. Terminological aids, classification schemes, virtual libraries and other tools which facilitate a high quality profile of interaction within the scientific community are increasingly in use on the Web.

IUFRO is also supporting these activities by its web site and special projects, namely the Task Force GFIS (Global Forest Information Service), the terminology clearinghouse SilvaVoc, its bibliographies/catalogue, search engine, and documents in PDF. The Task Force on Internet Resources has contributing in the past to setting up a basic information infrastructure in favour of the IUFRO research network.

Task Force 7
Global Forest Information Service

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The Role of Libraries and Information Centres in the Global Forest Information Service

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As the information society develops, traditional libraries and information providers are changing: moving from physical 'places' to digital 'spaces'. Electronic resources supplement and in part replace local holdings, and formerly stand-alone services are increasingly integrated into institution-wide, country-wide or regional facilities. Despite this, there remain huge distributed collections of printed material, not available in electronic format but still of high relevance to forest research; and even though electronic publishing is growing fast, so is print: every year sees a further rise in the numbers of printed scientific journals published. The provision of access to non-electronic material is thus a key element of the Global Forest Information Service and this paper examines the role of libraries in meeting that challenge.

Libraries have traditionally had both a curatorial and an educational role, which applies as much to electronic as to conventional resources. Digital material poses difficulties in organisation, long-term retention and preservation, just as other media do, and librarians have long experience in devising innovative solutions to these problems. The profession is devoted both to the preservation and dissemination of knowledge, working with educators and researchers to facilitate its creation, sharing and use. The computer, and the internet in particular, provide powerful tools in aiding this process, but human input is required in all three of its facets; machine based systems speed up its operation, but also create increasing demands for reliable, well-evaluated resources and high-quality education in their use.

Libraries within the GFIS subject envelope can help meet these demands by:
- locating, describing and classifying relevant resources in all formats
- guiding local and remote users in their most efficient use
- providing rapid access to requested material by traditional and electronic means
- identifying non-electronic resources for digitisation
- organising the creation and maintenance of digital archives
- providing local access to electronic resources which cannot be globally networked
- developing inter-connected catalogues hyperlinked directly to electronic resources
- encouraging IT literacy and the development of electronic publishing
- advising on copyright and other intellectual property issues
- publicising GFIS in conjunction with local and regional networks of all sorts
- offering a 'human face' for electronic systems, in a familiar context and local language

This paper reviews how far these and related activities have already progressed, what more can be implemented with current technology and which areas need further investment.

IUFRO Task Force Global Forest Information Service (GFIS) for improving access to information on forests

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Improving access to forest information was formally recognised as a priority by the United Nations Conference on Environment and Development in 1992 when it stated in Agenda 21, Chapter 40: "Countries and organisations should exploit various initiatives for electronic links to support information sharing, to provide access to databases and other information sources, to facilitate communication for meeting broader objectives, such as the implementation of Agenda 21.The Intergovernmental Panel on Forests in 1997 "emphasised the need to review and improve information systems. Attention should be given to world-wide access to information systems that would encourage effective implementation of national forest programmes, increased private-sector investment efficient development and transfer of appropriate technologies, and improved co-operation".

The aim of the Task Force on Global Forest Information Service is to develop a strategy for, and to implement an Internet-based meta-data service that will allow co-ordinated world-wide access to forest information. The resulting service will provide multiple benefits to information users and providers including: faster access to key information sources; and improved dissemination and quality of forest-related data and information.

The service will provide access to both digital and non-digital information on forest resources, forest policy, criteria and indicators for sustainable forest management, research activities, and other timely and relevant issues.

Technical & Design Options for Implementation

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The mission of the Task Force on Global Forest Information Service (GFIS) is to develop a strategy for, and to implement, an Internet-based catalogue service that will provide access to forest information world-wide. The resulting service will provide multiple benefits to information users and providers including faster access to information resources; and improved dissemination and quality of forest-related data and information. The service will provide access to both digital and non-digital information on forest resources, forest policy, criteria and indicators for sustainable forest management, research activities, and other timely and relevant topics.

This paper describes the technical options for implementation of GFIS. By definition, GFIS facilitates information dissemination between forest information providers and the user community using the Internet. Users should be able to find the information they require in a simple and logically consistent manner, and in such a way that ownership and attribution of the information is respected.

GFIS has predecessors in other disciplines than forestry, and there are many lessons to learn. Different design options are reviewed and one is proposed based on the model of a regional network of 'information servers' which, taken together, form a single distributed catalogue (known as a metadatabase). With such an arrangement, users may search for 'metainformation' held in diverse and disparate databases. Having located the information required, they can then access the information through appropriate hyperlinks. The information server concept enables peers to interact in a virtual community.

The language used by information specialists differs from that used in other disciplines, including forestry. This paper attempts to describe the implementation of GFIS in language that both communities can understand.

Mobilising and Disseminating Information on Forests to Promote Sustainable Management in Africa

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Keywords: Global Forest Information Service, Africa, Networking, Capacity building

Much of the groundwork for building capacity in African countries that are signatories to the Lomé Convention (ACP countries) has already been completed: contact has been made with the relevant international forest information providers, a prototype of the Global Forest Information Service (GFIS) has been launched on the Web, a Users' Needs Analysis has been carried out, and enthusiastic agreement in principle to the concept of the GFIS has been received from FAO, JRC, EFI, OFI, IUFRO, CIFOR and WFI. This Service will answer needs highlighted by the Convention on Biological Diversity, the Intergovernmental Panel on Forests, the Convention on Climate Change and the Forest Principles. Without access to good information on forests, policy-makers, forest managers, economic planners and researchers from many disciplines do not have a solid basis on which to operate. This is particularly important in tropical forest countries, where forest change is happening most rapidly. GFIS will serve the needs of a great variety of people, and ultimately lead to a better understanding of the world's forests and management impacts, both positive and negative.

With the approval of the 3 year project by the European Commission DG VIII "Mobilizing scientific information on forests to promote their sustainable management in ACP countries" the establishment of five nodes within Africa began. These nodes will facilitate access to and dissemination of scientific and technical information on forests and their utilization. The location of these nodes are Western Africa (Ghana and Senegal), Eastern Africa (Kenya), Southern Africa (Zimbabwe), and Island Africa (Madagascar).

GFIS and its regional nodes will be a valuable information resource for decision-makers in tropical forest countries, and others. in particular it will provide forest information and generating integrated information products. The use of the World Wide Web is rapidly increasing in the developing countries, and GFIS will give agencies in those countries an opportunity to use information that has up to now only been accessible through inter-library loans or after long searches through foreign institutional facilities.

Two project staff members will be located at FAO in Rome and will have responsibility for developing the interfaces for GFIS-AFRICA and for helping to set up equipment. Each node will be provided equipment, training, salary for an information specialist and operational costs for each of the five nodes. As the project is implemented many new partners will be included to help develop the network.

The objectives are: (1) to improve access to reliable scientifically based information on forests in ACP countries and their utilization, (2) to build capacity in selected regional research institutions to develop and manage internet-based systems to facilitate broad access to research information on forests in the ACP countries, (3) to share experience and good practice in information management between ACP countries, and (4) to enhance integration and comparability between national data on forests throughout the ACP countries.

Task Force 8
Science/Policy Interface

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How social values have affected forest policy

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Social values are difficult to define and measure. Social scientists define social values as desired end-states that go beyond self to address the concerns of the larger society; they are not necessarily values held by the majority of society. Two primary indicators of social values are public opinion and people's behavior. The American people associate a wide range of social values with our forests. Forest policies attempt to respond to and reflect a range of social values. The challenge facing foresters is the disconnect between public opinion which supports increased environmental protection and reduced forest commodity production (i.e., "what I say") and people's behavior which demands an increased amount of forest products and services (i.e., "what I do"). We suggest that public judgment, which goes beyond public opinion and addresses taking responsibility for the consequences of one's behavior, merits consideration. Foresters have an important role to play in facilitating public judgments about our forest resources.

Keywords: Social values, public opinion, behavior, public judgment, forest policy

Qualitative Comparative Analysis: Opening New Paths for Social Science Research in Forestry

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The internationalisation of the forestry dialogue and subsequent internationalisation of forest policy brings about new challenges for social science research in forestry. One evident need is to increase our understanding of similarities and differences between cases through comparative studies at both regional and global scale.

On the one hand, comprehensive social or policy research in forestry typically addresses a large number of economic, resource, social, policy and cultural aspects, not all of which are quantifiable so that they could be analysed with quantitative methodology. On the other hand, despite significant advances in qualitative analysis software, most qualitative methods are rarely used to do more than "pattern" analysis, that is discovering structural patterns (*e.g.* groupings) in the data. Accordingly, many policy researchers face the problem of having to compare extensive data, consisting of both qualitative and quantitative elements, in a large numbers of cases in a systematic way.

Qualitative Comparative Analysis (QCA) is a comparative tool which has been developed by Charles Ragin to bridge some of the gap between qualitative and quantitative analysis. The method uses Boolean algebra for a systematic analysis of similarities and differences across cases. It is gaining popularity in sociology and political science, and it is also taking its first steps in comparative forest policy research. Therefore, it is reasonable to ask what this new tool is like. Which type of applications have most potential for social science research in forestry, and why?

QCA is mostly associated with causal terminology and applications, which makes it unattractive to many qualitative researchers. in our view, the greatest problems related to QCA are not based on the technique of the method but on the limited ways in which it has been applied. Although not commonly recognised, the method has no in-built premises validating only causal applications.

This paper aims to provide an understanding of QCA that would encourage experimentation with the method in social science in forestry, regarding different kinds of research, data and questions asked. This is done by presenting an example of two different types of non-causal approaches to QCA in research that compares environmental forestry conflicts during 1984-95 in seven cases (Finland, Sweden, Norway, France, Germany, Minnesota and the Pacific Northwest region of the USA). The data for the research consists of a total of 210 focused interviews conducted within these countries.

At first, the data is analysed with the "empirical typology" approach to QCA. in this approach, the value, policy, market and resource aspects of environmental forestry conflicts are analysed separately, with the aim to organise and condense the data in a systematic way. The empirical typology approach is already known in literature but it has been used in very few applications with real data. Secondly, the "hermeneutic" approach to QCA is used to explore the interface and to discover interactions between value, policy, market and resource aspects of environmental conflicts. This application to QCA has been developed within research conducted by the authors of this paper.

These non-causal applications increase flexibility in the use of QCA and, thus, greatly extend the applicability of the method in comparative social research in forestry. It will also be demonstrated that when applying QCA, different types of applications may be combined in order to produce an understanding of the whole.

Changer de mode de régulation de l'utilisation des ressources forestiere Madagascar

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Madagascar s'est doté d'une nouvelle politique forestière depuis 1995 avec l'appui méthodologique des universitaires. Cette politique pour sa mise en œuvre préconise plusieurs types de moyens stratégiques dont celui de la gestion participative, le désengagement de l'Etat de la gestion opérationnelle et la réforme de l'administration forestière. Malgré que l'Etat et les bailleurs de fonds se sont engagés pour sa mise en œuvre, cette politique présente des difficultés d'ordre méthodologiques. En effet, la société malgache vit avec un ancrage culturel profond qui fait que les méthodologies découvertes ailleurs rencontrent des problèmes d'adaptation pour leur utilisation dans des projets forestiers Malgaches. Ainsi, la gestion participative qui constitue le moyen stratégique par excellence pour l'intégration des acteurs dans la préservation et l'exploitation de la ressource risque d'aboutir, dans le cas d'échec, à un résultat totalement contraire. C'est dans cette perspective que la recherche sur la formulation de méthodologie ayant rapport à l'élaboration de norme a été conduit depuis 1997 au niveau de la Division d'Enseignement et de Recherche en Economie et Politique forestières du Département Forêts de l'ESSA. Cette étude a pour but de mettre à disposition des forestiers de terrain une méthodologie pour la mise en œuvre d'une gestion participative d'une ressource forestière.

La recherche est conduite sur plusieurs sites malgache correspondant à une typologie écologique mais aussi culturelle notamment Mandraka et Ranomafana (forêt dense humide et une population d'agriculteur à niveau d'éducation élevé) sur la falaise orientale Malgache, Morondava (forêt dense sèche décidue et une population d'agriculteur-éleveur) sur la Côte Ouest et Tampolo (forêt dense humide littorale et population d'agriculteur itinérant).

L'approche utilisée a été celle systémique qui englobe à la fois l'analyse des pratiques forestière (produits ligneux et non ligneux, défrichement) et des systèmes de gestion de la ressource mais aussi l'analyse du système de production, celle du système de gestion publique et de la dynamique régionale ainsi que l'analyse du système de taxation forestière.

Au niveau des pratiques forestières les acteurs qui jouent les rôles les plus importants sont pour la plupart des citadins pour ce qui concerne les filières de produits ligneux. Ce sont ces dernières qui représentent la plus importante chiffre d'affaire en valeur monétaire. Pour les produits non ligneux les communautés riveraines des ressources maîtrisent la décision de coupe mais les filières ne représentent qu'un chiffre d'affaire monétaire minime. Au niveau de ces pratiques, et quels que soient les sites d'études, plus le chiffre d'affaire est important et plus le rôle des spéculateurs urbains devient prépondérant. Mais le système de gestion de la ressource bute aussi sur des problèmes de gestion technique proprement dit tant au niveau de l'exploitation (forte perte) qu'au niveau de la reconstitution de la ressource (manque de données).

Au niveau du système de gestion public les communautés sont assez différentes mais présentent des ressemblances notamment sur l'existence de deux types de pouvoir: celui légal qui est constamment contourné et celui coutumier qui est plus ou moins respectée. Les premières conclusions ont mis en évidence la nécessité de faire transiter par les droits coutumiers les règles de gestion.

Mais la durabilité de la gestion participative réside aussi dans la possibilité de répartir équitablement entre les acteurs la ressource monétaire mobilisable à partir des taxes forestières. En effet, les enjeux monétaires sont telles que les activités sources de revenus sont rapidement contrôlées par les acteurs dominants que sont les spéculateurs urbains. Le système actuel de taxation transitant par des circuits administratifs trop classiques ne peut que développer la pratique de la corruption et nécessite un besoin de réarrangement institutionnel qui devrait suivre le processus de la décentralisation du pouvoir à Madagascar.

Mots clés: Politique forestière, gestion communautaire, fiscalité forestière, dynamique régionale

Forestry in Transition

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Keywords: political changes, countries in transition, sustainable forestry, public awareness, climate change.

There are many changes and challenges for the mankind at the end of the 20th century. The world changed dramatically during the last hundred years while the population reached the 6 milliard peoples. There are substantial changes in natural, political and social environments and these components have a certain reaction one another. The political changes promote the natural awareness in the former socialist countries. These countries are the "countries in transition", because the centrally planned system is replaced by market economy conditions. Since 1990 also the Forestry is adapting to the market economy. Co-operative forests have been given back to their former private owners, and one part of the state forest have been privatised together with some technical services and wood processing plants. These changes are coinciding with the reorientation of the international environmental and forest policy. in accord with the increasing public awareness in environmental issues, the non-wood forest functions got higher priority, and the sustainable forest management are interpreted in a much wider context, where the conservation of biological diversity and sustainable development of the natural and human environment are equally important criteria. While the other part of the world the area of the forests decreases, in Europe increases. The multifunctional forestry appears important in this densely populated continent. The climatic and economic changes in the last decade arose the importance of forests, forest science and forest policy. The transition includes a large scale changes in ownership in course of privatisation in the eastern part of Europe. Some of these countries have a large agricultural potential, while they want to join into the European Union which has a great problem with his own agricultural policy. The changes in environment and society were the main elements which made the legislation to create new acts for forestry and environment protection in these transition countries. How can the forests serve the needs of the environment protection, rural development under the changing climate, economy and society? There will be the main questions for the forestry, forest policy and forest science in the beginning of the next century.

Foreign Direct Investments of Forest Industries in a Global Economy

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Even if forest industries have not been the forerunners in the globalization process, foreign direct investment (FDI) by forest companies has increased rapidly in the 1990s. A central question then is to what extent FDI and traditional trade in the forest sector are substitutes or complements to each other, for example, does FDI lead to increased or decreased exports from the home country in the long-run. This paper explores the dynamic relationship between foreign direct investment (FDI) and exports of forest industries with U.S., Finnish and Swedish data. Both short-term and long-term interrelationship between FDI and exports is studied, as well as the short-term and long-term effects of exchange rate movements and exchange rate variation.

The results show that for the U.S. forest industries, FDI generates more exports of forest products in the long-run. in the case of the Finnish and Swedish forest industries, it is the exports that seem to drive the investments abroad. The effects of exchange rate risk and movements on FDI were estimated to be low in the case of the U.S. and Finnish forest industries, and only moderate in the case of Swedish forest industries. The results suggest that initiatives toward freer trade may also spur increased FDI by forest industries.

Keywords: Globalization, trade, corporate strategies

INDEX

INTRODUCTION

This volume of Congress proceedings includes summaries of posters received by 31 May 2000. Minor changes may have occurred since that date. These proceedings are divided into three parts or sections:

Part 1 : Posters in the main poster hall

Part 2 : Posters presented in poster/panel and group sessions.

Part 3 : Posters displayed during sub-plenary sessions

Part 4 : Posters displayed in task forces

Special thanks to the authors for their contributions to the scientific programme of this Congress. Enjoy your stay in Malaysia.

Eric Teissier du Cros, chairman of the CSC

Note: The summaries have been published as received from the authors and reviewers, respectively, who have sole responsibility for their content.

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Posters in the main poster hall

Division 1
Silviculture

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1.00.00 Division 1 Meetings

Análisis de la composición florística y estructura para la vegetación del piso basal de la Zona Protectora La Cangreja, Mastatal de Puriscal

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El presente estudio consta de dos partes. Una primera orientada hacia el estudio de la composición florística y diversidad del bosque en el sector de la Zona Protectora La Cangreja y una segunda parte enfocada a estudiar la estructura del mismo y a la vez dejar establecido una red de parecelas permanentes de muestreo.

El área de estudio se ubica en las zonas de vida según la clasificación de Holdridge de bosque húmedo tropical y bosque muy húmedo tropical transición a premontano.

En el sitio se establecieron siete parcelas con un área total de 16 100 m^2, a través de éstas se logró determinar, que para el sitio estudiado el área basal es de 38,5 m^2/ha, la presencia de 591 áboles/ha en 148 especies/ha, un dosel que alcanza los 43,6 m de alto, para dar paso a un piso superior >29m de alto, un piso medio entre 14,5m y 29m, y el piso inferior con un altura < 14,5m.

El área mínima de muestreo obtenida es de 1 ha.

Por medio de los criterios de clases de frecuencia y el índice de Simpson (0,03) se determinó que el sitio es diverso, no así por los índices de Shannon (0,44) y riqueza (0,19) quienes lo catalogan como diversidad media. Esto es producto de las intervenciones del pasado, que han provocado la concentración del 86% del IVI en 10 especies en su mayoría heliófitas.

Con el inventario de flora se deteminaron 193 especies arbóreas distribuidas en 126 géneros y 56 familias, donde las familias más importantes por número de especies presentes son *Euphorbiaceae, Meliaceae, Lauraceae, Moraceae y Mimosaceae* con 8,11,13,16 y 17 especies respectivas.

El endemismo en el sitio es de un 7,25% a nivel arbóreo.

High Density Short Rotation System: A Potential Woodlot Technique for the Production of Fuelwood and Poles in Areas of Diminishing Forest Land Base

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High density short rotation woodlot technique has been used in many tropical countries to produce fuelwood and pulpwood. However, in the West Africa sub-regions, especially Ghana, adequate studies have not been conducted on the production of fuelwood and pulpwood with this technique. Therefore trials were established in the Sudan and Derived savannah areas of Ghana to determine the effect of planting density on the growth and dry matter production litterfall and decomposition, nutrient sequestration and nutrient use efficiency and soil chemical properties of *Gmelina arborea* harvested on very short rotations. The spacing treatments allotted were 0.6m^2, 1.2m^2, 1.8m^2 and 2.4m^2 per tree of growing space. Harvesting was done at 20, 3- and 4-years after planting. Weeds were adequately suppressed by manual weeding. At two, three and four years, the 0.6m^2 treatment gave significantly ($P<0.001$) dry matter production for all component fractions (leaves, bark, wood and branches) and also total dry matter for *Gmelina arborea*. With respect to nutrient concentration the differences within the cutting cycles in the different spacing were significantly different for all the species ($P<0.05$). The concentrations in the tree component were in the order leaf > stembark > branches stemwood. The sequestration (kg/ha) in these components were also significant ($P<0.05$) and in the order stemwood > branches > stembark > leaf. Monthly leaf litterfall (g m^{-2} month-1) for *Gmelin*a in the four spacing were 0.6m^2> 1.2m^2> 1.8m^2> 2.4m^2. Decomposition rate for *Gmelina* litterfall was faster than Teak. The rates in the various spacing were 0.6m^2>1.8m^2>1.2m^2>2.4m^2 and differences were significant ($P=0.001$). Tree stocking and cutting cycle effects on soil chemical properties also indicate that pH levels declined with increasing cuttings years. Available phosphorus levels increased with increasing tree stocking. Magnesium also declined at the higher tree stocking density. It is concluded after preliminary analysis of spacing/cutting cycle interactions that the 0.6m^2 treatment yielded the greatest dry matter in all species during the two, three and four yearly cutting cycles. Also in terms of perha the 0.6m^2 treatment was the best in terms of dry matter production. With regard to the impact of tree stocking on litterfall, decomposition, nutrient sequestration and soil chemical properties, the results were positively correlated and the $0.6m^2$ spacing at four-yearly cutting cycle was the best.

Keywords: *Gmelina arborea* high density, short rotation, woodlot, fuelwoods.

Effects of Fertilizer and Previous Land Use on the Pools of Carbon, Nitrogen, and Phosphorus in Soils *from Eucalyptus globulus* Labill. Plantations in Southwestern Australia

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The pools of carbon (C), nitrogen (N) and phosphorus (P) were measured in soils under *Eucalyptus globulus* plantations established on ex-pasture and ex-native forest sites. The *E. globulus* plantations were fertilized with N, P or N-and-P. The parameters measured in the plantation soils were compared with values obtained from adjacent pasture and native forest soils. Application of both N and P fertilizer significantly increased the pools of C, N, P, and C:N ratio in soil under the *E. globulus* plantation established on an ex-native forest site. The pools of N and P were also enhanced by N-and-P fertilization in soil from the ex-pasture plantation site, but fertilization had no effect on the amount of organic C or the C:N ratio. The results suggest that changes in the pools of C, N, and P were associated with previous land use. The native forest soil had higher levels of organic C, N and P than the ex-native forest plantation soil. However, both the native forest and ex-native forest plantation soils had high C:N ratios, reflecting the quality of the organic residue inputs entering these soils. The pasture soil had higher total organic C, total N and P concentrations than the ex-pasture plantation soil, but these two soils had similar C:N ratios. The results of this study suggest that fertilizer prescription for improving the growth of *E. globulus* plantations must consider past land use and fertilizer history.

Key words: Australia, Eucalyptus, plantations, sites, fertilizer.

Agroforestry Systems in Nepal: Lessons Learned and Challenges Ahead

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Nepal is a relatively small country, of about 14.7 million ha, between India and China. Based on altitude, it has been divided into five physiographic zones: High Himal; High Mountains; Middle Mountains; Siwaliks; and Terai. Most people (>19 million) depend on agriculture and related business for their livelihood.

The aim of developing agroforestry within Nepal is to meet the present and future requirement of fuelwood, fodder, small timber and to protect environmental degradation. The topic of "Agroforestry" has recently received considerable attention. This is largely due to the evidence that trees and agricultural crops could be managed simultaneously and guarantee the sustainability of agricultural system. The agroforestry systems practised by the Nepalese farmers vary according to the physiographic zones. And within a given physiographic zone, it varies with location.

Past studies carried out on the existing agroforestry system in Nepal point towards the need for a closer study of indigenous agroforestry practices. Based on these studies, future agroforestry models should be developed taking institutional capability, research needs, and training and extension opportunities into consideration. Considering the current weakness in research, extension, and training in the area of agriculture, livestock, forestry, and natural resource management, the challenge of promoting agroforestry is formidable.

In the Nepalese context agroforestry systems have their own limitations. Some are institutional and others are socio-economic. In general, farm size holdings are too small to produce large marketable quantities of timber and other non-timber products. In addition, poor infrastructure restricts flourishing markets particularly in the hills. Perhaps one of the major limitations to agroforestry development in Nepal is the sheer complexity of both the ethnic and agro-ecological conditions. This limitation as far as practicable, should be overcome. This paper examines the lessons learned and the challenges ahead in developing agroforestry systems in Nepal.

Irrigation Requirement for Establishing Forest Plantation in the Semi- arid Zone of Israel

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The need for afforestation, especially in semi-arid regions, is increasing rapidly world-wide due to the denudation of the land and the lack of wood and timber for fodder, fuel and construction. The success of those afforestation activities is directly related to the ability of forest seedling to establish under those unfavourable conditions. It is well accepted that the first dry season after planting is the most critical.

The aim of the present study was to test the possibility of ensure forest seedling survival and establishment by adding the minimum irrigation possible, during the first year after planting, for maximum survival. The experiments are done in the Northern Negev, latitude 31°25'N .

This area is characterized by rolling hills, 250-400 m above sea level. The soils are typical loess soils with low water infiltration capacity. The mean annual rainfall of the area is 250mm. The winters are relatively mild and the summers are hot and dry. Site preparation included contour mounding for water harvesting, and weed control by spraying simazine and outs. One year old seedling of *Eucalyptus turcuata*, *Prosopis* sp and *Acacia* sp. Were planted in within the furrow with distance of 6 m between seedlings. Watering was done manually I-4 times during the dry season. The study includes soil water content analysis using depth moisture gauge, plant grow measurements, and roots exposure. The most prominent result at the end of the first growing, season was that no significant differences in survival was found between seedlings that were watered only once (end of April) and seedlings that were watered 4 times. It seems the irrigation done at the dry season allow the roots to continue their penetration into the ground to more wet layers and thereby to ensure their survival. Different species showed different root morphology and different root growth rates.

Growth of *Eucalyptus grandis* in Response to Nutrients in the Western Ghats, Kerala, India

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Sixteen fertiliser combinations of N, P and K and nine silvicultural treatments comprising three each of pit sizes, spacing and skinning in factorial combination were applied to *Eucalyptus grandis* planted at Vallakkadavu in the Western Ghats, Kerala, India. Treatments were aimed to ensure that growth was not limited by lack of nutrients in plots of different silvicultural treatments during the first three years after planting. The fertilisers, Urea, Mussorie rock phosphate and Muriate of potash were applied for N, P and K respectively, at the time of planting in June 1992 in the planting pit and in furrows in October 92, June 93 and October 93, the latter two with double the dose of those applied in the first year. The furrows were 5-10cm deep, 15-25 cm away around the plant and then filled with soil. Fertiliser treatments had significantly and substantially increased growth in mean height during the study period, 36 months and basal area at 36th month after planting. There was no interaction between fertiliser combinations and silvicultural treatments.

The trees in the plots receiving the best nutrient combination, N2 P2 K1 i.e., 30g of N, 30g of P and 15g of K/plant, which is equivalent to 163kg of Urea, 375kg of Mussorie rock phosphate and 73kg of Muriate of potash/ha, were 1.2 times taller and had 1.5 times more basal area than those in unfertilised plots.

More detailed growth estimates showed fertiliser inputs had substantially increased the volume of trees. After 3 years, the best fertiliser treatment had increased the volume from 8.37 m^3 to 12.42 m^3/ha. Tree growth in unfertilised plots in this study was severely inhibited by low soil nutrient supply.

Seed Production and Seed Quality in Dry Dipterocarp and Mixed Deciduous Forest in Huai Kha Khaeng (Thailand)

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The present study was carried out in the frame of a research project funded by the European Union on "Ecology and sustainable semi-natural sylvicultural management of indigenous forest of Central South East Asia". The research deals with the understanding of early regeneration processes by focusing on seed ecology. General aim of the research is to contribute to the knowledge improvement on the regeneration ecology of the dominant species in natural dry forests in SEA to serve to outline semi-natural sylvicultural programs. Specific objectives are: to study the spatio-temporal features of seed production and dispersal; to observe the damage types on the seeds and relative frequencies during different phases of seed rain; to standardise a quantitative and qualitative classification of seeds in order to highlight morphological parameters, seedlot viability frequency, germination ability, damage type and severity (damage effects on seed viability and on germination success are also considered); to observe the early stages of germination per seed class.

The study was carried out in the Thung Yai- Huai Kha Khaeng Wildlife Sanctuary (central-western Thailand), the largest protected area in South East Asia. The survey area is located at an altitude ranging between 200 and 300 a.s.l. The climate is characterized by three seasons: hot and dry during the February-April period, hot and damp from May to October, cool and dry from November to January. The average yearly rainfall is 1448mm and it's variation ranges from 1105mm to 2003mm (extreme values recorded in 16 years at Khao Nang Rung weather station).

Average yearly temperature is 25.5°C (1980-1997). The monthly average of maximum temperatures varies between 30°C and 36°C, the monthly average of minimum temperatures instead varies between 12°C and 25°C. Seeds were collected a. on ground, b. directly from the tree crowns, c. by using seed traps, in order to evaluate the seed production both per individual trees and per canopy unit. The collection of seeds was taken out every 5 days for the recalcitrant seeds of *Shorea* and every 10 days for the other species. Seed dispersal was observed by seed traps and plots on ground, placed at increasing distances from the stem of isolated trees along the four cardinal directions.

Seed quality was evaluated by external observation. Four seed quality classes were detected, i.e. Healthy seed (Absence of visible damage); Insect damage (Entrance holes, presence of larvae inside the seed); Rodent damage (Evidence of rodent bites on seed); Fungi damage (Necrosis and withering of seed portions).

Seeds were examined one by one, attributed to one of the four classes and then counted. Seeds were classified on the basis of weight (all species), diameter and length of the main wing (only *Dipterocarpaceae*). Afterwards, such class-grouping system was used to extract samples by which proceed on with germination and viability tests. The species with recalcitrant seeds (*Shorea obtusa-Shorea siamensis*) disseminate at the beginning of rainy season, otherwise the other species observed (*Pterocarpus macrocarpus, Legerstroemia calyculata, Hymenodictyon excelsum, Vitex limonifolia*) do it during dry season. The rate of healthy and damaged seeds vary significantly during the period of seed production and remarkable differences can be observed between seeds collected directly from the tree crowns and on ground. The insect larvae are the main responsible of the damages found on the seeds. The germination is in general high for all species and even damaged seeds showed appreciable germination rate.

The Potential of Some Indigenous Dipterocarp Tree Species for large-scale Industrial Tree Plantations in Malaysia

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Keywords: Wood-based industry, dipterocarps, silviculture, stumpage value.

The wood-based industry in Peninsular Malaysia is facing a very challenging future arising from an acute shortage in the supply of quality timber raw material. The sharp decline in local log production from natural mixed dipterocarp forest during the past decade was due mainly to the tapering off in the opening of new forest areas for agriculture, stricter adherence to annual logging coups and curbs on illegal logging. Amongst the strategies adopted by the authorities concerned to stem any further deterioration of the industry include upgrading the management and quality of the remaining natural forests and the establishment of large-scale industrial plantation of "fast growing" tree species. Unfortunately, the currently on-going

Compensatory Forest Plantation project (CFPP) using fast growing exotic tree species is through to be inadequate and has yet to live up to its early promises. In view of this, there is an increasing trend now to look seriously into the potential of some prime and fast growing natural indigenous timber tree species (especially the Dipterocarps) which may provide the real answer to the raw material supply problem for our wood-based industry in the future. Already many misconceptions surrounding these indigenous tree species have been successfully dispelled through consistent R&D efforts conducted both in Malaysia and elsewhere and confidence in these species is increasing. The paper is based on a study of 15 selected dipterocarp tree species which are known to show great potential as candidates for large-scale industrial tree plantation. Amongst the factors considered in the analysis include their silviculture, nursery practices, growth rates as well as economics.

Nitrogen and Phosphorus Fertilization Effects on Forest Growth and Nutrient Cycling in Two Secondary Tropical Dry Forests in Mexico

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Tropical dry forests in the Yucatan Peninsula have been transformed at high rates into henequen plantations. The Mayan cultivated the henequen (sisal) *Agave fourcroydes*, a native agave, since the pre-Colombian period. Henequen was considered "green gold" and, by the 60s, 50% of the regional labour force was employed in its cultivation. In the 70s when synthetic fiber was introduced, henequen production was greatly reduced until its final collapse in 1992. Nowadays there is a mosaic landscape characterized by a coexistence of some henequen plantations and extensive areas of secondary tropical dry forests. The long-term henequen cultivation has reduced the nutrient pools in soils to levels that probably inhibit the natural forest succession.

The importance of the effects of low levels of nutrients on plant growth in tropical forest succession has been discussed more often than it has been exactly determined. In order to study the influence of nutrient limitation during the secondary succession in Yucatan dry forest, two forest sites of about 10 and 40-years old respectively, were fertilized with N, P, and nitrogen plus phosphorus. There were sixteen 12 x 12m plots per site, four plots per treatment and control. The secondary forests are located in the surroundings of Conkal village. In each of these forests, we measured tree trunk growth, litterfall production, nutrient fluxes from the aboveground vegetation and nutrient turnover in forest soil before and after fertilization.

Litterfall production showed a strong seasonal pattern. This production was similar in both sites without fertilization. However, forest soil carbon turnover was lower in 10-years site than in 40-years site. Litterfall production and nutrient turnover in forest soil were found to change after fertilization. Our preliminary results, after the first year of fertilization, strongly suggest that secondary forest production be limited by the availability of phosphorus.

Effect of a Gap-understory Gradient on Early Development of Scots Pine and Norway Spruce Seedlings

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Small-scale gap disturbance is an integral part of the natural dynamics of boreal forests. As such, it has been suggested that sustainable forest management should aim at reproducing the structural heterogeneity created by natural disturbances. Accordingly, and due to increased public concern about ecosystem diversity and sustainable forestry practices, foresters are turning to small-scale alternative silvicultural methods to manage forests. As a result, more regeneration area is in a gap-understory environment. Small-scale silviculture contributes to increase the amount of forest edges, which in turn affects the microenvironment for regeneration, especially light. Light influence seedling development and gives rise to different competition situations and survival strategies. Both size and morphology play an important role in determining succession dynamics after a disturbance, conferring a competitive advantage at the regeneration stage and promoting production.

We studied the early development of *Pinus sylvestris* L. and *Picea abies* (L.) Karst. seedlings growing along a gap-understory gradient in a boreal Norway spruce forest. The effects of radiation, seed pre-treatment by moist chilling and seedbed microsite soil preparation (inverted pyramids) on aboveground size and morphology of seedlings were described for the first two growing seasons. Shade intolerant *P. sylvestris* responded more to increased radiation than shade tolerant *P. abies*. Two-year-old *P. sylvestris* underwent a 7-fold increase in aboveground dry biomass from the understory to the centre of the gap, whereas *P. abies* experienced a 2.5-fold increase. Moist chilling and microsite preparation resulted in additional increases in aboveground dry biomass for both species. With increasing radiation, one- and two-year-old *P. sylvestris* allocated photosynthetic carbon such that they built up 46% and 56% more aboveground dry biomass in needles compared to stem, respectively. The biomass distribution for one-year-old *P. abies* changed from shade to sun, such that the proportion of biomass found in needles increased by 26%. For two-year-old seedlings, the pattern of biomass distribution was almost constant. With increasing radiation, the total leaf area of one- and two-year-old *P. sylvestris* underwent 8- and 13-fold increases, while *P. abies* showed 3- and 5-fold increases, respectively. The specific leaf area of one- and two-year-old *P. sylvestris* decreased by 15% and 30%, and mean needle length increased 1.9- and 3-fold with increasing radiation, respectively. On the contrary, radiation did not affect the specific leaf area and mean needle length of *P. abies*.

Although early development is important for later success, the results from this study cannot predict that *P. sylvestris* will outcompete *P. abies* in similar gap environments. This is because the subsequent development of seedlings is also affected by other factors, such as competition by ground vegetation and herbivory. This effect, as well as early seedling growth, is likely to be strongly dependent on within-gap position, since competition with mature trees retards the growth of ground vegetation in gap edges. It is possible that these contrasting factors affecting seedling growth and survival can lead to some type of within-gap partitioning between species. To verify this hypothesis would require tests of longer duration.

Aspen Forest Stands of the North-west of Russia are a Potential Base for Forest Stock Improvement

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In the 1930s and 1940s significant territories of coniferous forest stands in the north-western region of Russia with high site quality of locality underwent intensive clear cuttings. Today considerable areas of these territories are covered by aspen stands. This is due to the fact that no silvicultural activities favoring reforestation and growth of the coniferous species in the cutover areas were carried out. Because of its defects aspen (*Populus tremula* L.) timber has a limited market which leads to accumulation of mature and overmature forest stands. Aspen stands comprise some 20% of the area where harvestable forests grow, and occupy the most productive soils, which could have otherwise given plenty of sound wood if only conifers grew there. As aspen stands grow on the most productive soils, forestry incurs losses as a result of low output of merchantable wood from these areas. Considerable areas of aspen stands have an undergrowth under its canopy that includes coniferous species. If properly managed, these stands could be converted to higher value spruce and mixed-species stands. Today, it is therefore very important to develop systems for utilization and management of these stands for their transformation. We have conducted field research, which have shown that aspen stands vary distinctly and so should be treated differently. The type of forestry management in the aspen stands area is determined on the basis of the following criteria:

- age and condition of the young spruce growth, i.e., its growth potential after the cutting of the aspen canopy;
- its stand density and distribution within the site, which both determine the cutting technology to be selected;
- the amount of the broad-leaved canopy which can be removed safely without causing dramatic ecological changes within the site.

Ecology and Reproductive Biology of Pondberry (*Lindera Melissifolia* [Walt] Blume)

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Pondberry (*Lindera melissifolia*) is a shrub of the southern United States that grows in seasonally flooded wetlands and on the edges of sinks and ponds. It has been listed as an endangered species since 1986, and fewer than 50 populations are known. Many of the existing pondberry colonies are small and occupy only a portion of the apparently suitable habitat. The species has been affected by habitat destruction and alteration, especially timber cutting, clearing of land, and drainage or flooding of wetlands. In addition, stem dieback is a problem and sexual reproduction is sparse in some populations.

Pondberry is a stoloniferous, clonal shrub that grows to a maximum of 2 meters in height. It is a dioecious species with small yellow flowers that bloom in spring. Pondberry has always been a rare species, and knowledge of its ecology and reproductive biology is lacking. Male plants outnumber females; female clones are smaller than male clones, and are sometimes absent from stands. Seed production can be erratic.

We will report the results of three years of research on the ecology, seedling biology, and reproductive biology of the species. We studied pondberry populations in Mississippi and Arkansas and visited populations several other states. The most vigorous pondberry populations we observed occurred in locations with abundant light. Stem dieback appears to be widespread in populations. We have isolated three fungal pathogens from stems. Six insect species were found in association with pondberry, but do not appear to be a limiting factor for the plant. Fruit production can be abundant, but as in many other clonal species, few seedlings occur even when seed production is high.

Individual stems can be easily transplanted, and multiply rapidly. Opportunities for dispersal are very limited now due to land use of areas surrounding pondberry populations and to changes in hydrology. The hydrology of the pondberry habitat has changed, so areas that were suitable in the past are now less than ideal and some populations are not thriving. However potted plants in the greenhouse are flourishing, indicating that the plant grows well under the proper conditions. Many populations occur in small wooded areas that have not been cut and planted with crops only because they are slightly lower in elevation than the surrounding agricultural land, thus the plant's ability to spread or to migrate to more favorable habitats is limited. Because of the conditions in which it occurs, the survival of this species may depend on man’s intervention and introduction of the species to new areas or areas where populations existed in the past.

Bamboo (*Bambusa arundinacea* (Retz.) Willd.) Hedgerow Systems in Kerala, India: Root Distribution and Root Competition for Phosphorus with Adjacent Teak and Malabar White Pine Trees

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Root distribution of bamboo (*Bambusa arundinacea*) and root competition between bamboo and associated tree components in two mixed-species systems were evaluated using modified logarithmic spiral trenching and 32P soil injection techniques respectively.

To characterise the root distribution pattern, 18 boundary planted bamboo clumps were randomly selected. Based on diameter, the clumps were classified into small (1.0-2.5m), medium (2.5-4.0m) and large (>4.0m). Logarithmic spiral trenches were dug around the clumps (10m long). The number of severed roots exposed on both sides of the trench was assessed by placing 50 x 50m quadrats against the vertical sides of the trench at 1-m intervals.

For 32P soil injection, two binary associations (*Tectona grandis* L.f-bamboo and vateria *Vateria indica* Linn.-bamboo) were chosen. Thirty-six experimental units (eighteen each for teak-bamboo and vateria-bamboo) were selected considering the range of lateral distances between teak/vateria with the corresponding bamboo clump (grouped into 1 m or 1.5 m classes). 32P solution was applied at rate of 116.92 MBq per plant through eight equi-spaced PVC access tubes at 50 cm radial distance (either at 25 cm or 50 cm depth; randomised block design with three replications). The most recently matured leaves from the treated and neighbouring plants were radio-assayed at 15, 31 and 45 days after application of 32P following the Cerenkov counting technique.

Excavation studies indicate that root density declined with increasing depth and lateral distance. Clump size is a cardinal determinant of lateral spread of roots (with 83% of the large clump extending roots beyond 10 m while only 30% of the small clumps extended roots up to 10 m). Number of roots in small clumps ranged from 446 m^{-2} at 0-2 m distance (43% of total) to 36 roots m^{-2} at 8-10 m (3.5%). Medium clumps recorded 467 roots m^{-2}

(46%) at 2-4 m and 92 m^{-2} (9%) at 8 -10 m. The respective figures for large clumps were 386 roots m^{-2} (43%) at 2-4 m and 90 m^{-2} (10%) at 8-10 m. Nearly 85-90% of the roots excavated was less than 2mm in diameter. Linear regression linking root density with lateral distance for bamboo clumps gave reasonably good predictions (R2>0.53).

Significant differences in 32P absorption by treated teak and vateria as a function of lateral distance to bamboo clumps within the range of lateral distances tried (1.5 to 4.5 m in teak bamboo and 2 to 6.5 m in vateria bamboo combination) were not detected. Implicit in this is probably the non-discriminatory nature of bamboo clumps with respect to root proliferation in this zone. Absorption of 32P by neighbouring bamboo clumps also was not statistically significant except at 45 days after application (vateria-bamboo). Highest 32P counts were recorded by bamboo clumps in the 1-3 m lateral distance zone. Although there was a decreasing trend in 32P absorption as the lateral distance increased, no predictable pattern was discernible.

In general 32P absorption by bamboo was higher when the same was applied at 50-cm depth in vateria-bamboo combination. This would imply that even deep placement of the fertilisers may not ease competition from nearby (<6.5m) bamboo clumps. Inter-specific root competition with under-planted crops can, however, be avoided by planting 8-9m away from the base of the bamboo clumps.

The Use of Different Tree Species for the Afforestation of Problematic Sites

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In central Europe a change of forest management can be observed. One important objective of this management is to increase the portion of broad-leaved species on the total forest area. Beside a slow change of conifer stands into broad-leaved stands, the afforestation of free fields gives the possibility to reach the goal in a shorter time. Therefore a long-term investigation was established in a low mountain range area in northern Germany. In the Solling mountains, a highly loaded forest site with acid soil and harsh climatic conditions in 500 m over sea level was selected. There is an average annual input of 30 kg sulfur and 40 kg nitrogen per hectar. The growth of ten different tree species was investigated over a seven year period. The forest stand has been established on three differently treated sites:

- intensive site preparation, with deep ploughing and extreme amounts of fertilizer in order to create optimal site conditions
- liming with a common intensity (4 t/ha)
- untreated control site

Already during the first years after the stand establishment there are huge differences in the survival rate of the 10 tested tree species. Above all pioneer species like black alder and birch were able to grow in a normal way. Noble fir (*Abies procera*), Ash (*Fraxinus exelsior*) and Norway-maple *(Acer platanoides*) showed very high rates of mortality, the mortality of European beech (*Fagus sylvatica*) and Sycamore-maple (*Acer pseudoplatanus*) was lower. In addition to the lower mortality rate, the pioneer species were at least one meter higher than the other tree species. Furthermore the practice experiment show, that the tree species react in a very different way on supporting treatments. For European beech and Douglas fir (*Pseudotsuga menziesii*) already a normal liming treatment could improve the life conditions, whereas ash and both maple species showed a distinct improvement only after an extreme site preparation with deep plouging and big quanitities of fertilizer, that are not realistic for practical application on a grand scale. The natural regeneration of quick-beam *(Sorbus aucuparia*), Norway spruce (*Picea abies*) and birch (*Betula verruccosa*) was the better, the poorer the soil conditions was. Only willow (*Salix caprea*) had higher densities on soils with better nutrient conditions.

The differences of the nutrient content of leaves and needles were more determined by the species than by the site treatment. Compared to the control, only calcium and magnesium showed significant higher concentrations within the leaves on the limed sites.

Structural Elements of the Pedunculate Oak's Crown as an Important Factor in Forestry Management in Croatia

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The tree crowns and forest soils are the main factors for all life activities in the stand. The effect that the tree crown has on the stand is manifold. Of all the structural elements, the tree crown, as one of the most susceptible and most obvious indicators of the physiological state of the stand, presents an interesting medium for observation and research. In the broad sense of the word, the structure of the crown means the size and shape of the crown, its growth and development, its arrangement in space and time and its proportions in relation to the remainder of the tree's parts. During the past thirty years, as part of ecological-management research of forest types in Croatia, studying the crown's structure has held an important place. Issues include researching the intensity of growth and development of the crown both horizontally and vertically in relation to dbh and the age of the stand, the period of maximum growth of the crown and the laws that govern them. Subsequently, the crown's shape, its area and volume, the site index, the amount of crown and horizontal projections on the ground and the crown complex are researched as important conditional factors for natural regeneration.

Searching for laws between the variables, i.e. expressing empirical equations, is an important area of research for foresters. This aim can be attained if the following questions are answered: What type and how strong is the relationship (correlation) between certain elements of the crown's structure and the tree's diameter? Further, the interdependence of the researched variables with other parts of the tree has to be established and the most acceptable equation function has to be found, i.e. a regression model. Finally, a mean morphological shape of the pedunculate oak's and common hornbeam's crown structure has to be expressed. Researching the laws governing changes in the width, length and area of the crown with an increase in the trunk's diameter is of a linear character and its dependence can be expressed by a linear equation. The volume of the crown according to diameter classes changes its size whose laws change can be expressed by a non-linear regression in the form of an exponential function. The form quotient of the crown is 0.56. The relative development of the crown's length is 45% of the tree's height and the relative development of the crown's diameter (the relationship between the tree's diameter and the crown's diameter) is on average 17 fold. Growth in the crown's diameter in an average stand's tree has a maximum value of 15.69 cm, where the tree's diameter is 8 cm, its age 17 years and the soil's ground covering of the crown is 70%, and is a good prerequisite to natural regeneration. Interception is highest in middle-aged (21.9%) and lowest in young stands (2.3%). Precipitation flow down the tree per 1 m^2 in the crowns of young trees is 23.9 times greater than in mature trees. The obtained laws can be utilised to advise about correct and timely management, increase the amount of information available about the state of stands, solve current problems in the forestry profession and increase awareness about the role and significance of the crown in the forest’s development.

The Dynamics of the Vertical Development of Tree Crowns and Trunks in Homogeneous and Mixed Pedunculate Oak Stands in Croatia

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The crown length is an important indicator of developmental stand conditions. An increase in the crown length increases its volume, as well as its assimilatory mechanism and production of tree substances, while the relationship between the trunk and the crown changes in favour of the crown. The share of the crown to the tree's total height, in deciduous trees, is approximately 30% and is a good indicator of forestry management and a prerequisite of good natural renewal. Observing the crown development as one of the stand structural elements is a point of interest for all foresters, especially in determining the time, intensity and duration of the sylviculture, as well as its growth.

This paper shows the intensity of the vertical development of the tree crown and trunk in relation to the breast height diameter and the age of the stand, in addition to observing differences in the length of the tree crowns and trunks in homogeneous and mixed pedunculate oak stands. Research was undertaken in the associations of pedunculate oak and common hornbeam (*Carpino betuli-Quercetum roboris* Anic ex Raus 1969) and the pedunculate oak and great green weed (*Genisto elatae-Quercetum roboris* Ht. 1938). For both associations fifty sample plots were chosen for investigation. The age categories were between 20 and 120 (140) years. Data processing was done in the same manner for all plots. Correlative and regressive analyse was carried for tree crowns and trunks length. The aim was to find a mathematical expression that reflects the spreading and variability of the data.

Preliminary research that was carried out in homogeneous oak stands show that the share of crowns in the total tree length is uniform throughout all developmental stages, excluding regeneration, and is 45% of the tree height. Further more, the crown length increases as the diameter and the stand age increase up to the fertilisation period. Vertical development is most prominent in young stands, slower in middle aged stands and weak in old stands.

The length of the trunk, as well as the tree diameter, is one element that influences the share of useful tree volume. The development of the trunk length of young trees is very intensive, then decreases and with the formation of the permanent crown ceases. Once the permanent crown is formed only the diameter will increase.

Establishment of Seed Production Areas For Teak At Mata Ayer Forest Reserve, Perlis, Malaysia

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Establishment of seed stand or seed production areas (SPA) is an effective method of producing improved seed in a large quantity to meet the immediate demand such as teak. Five plots each covering about 0.5 ha were established on 20 years old stands at Mata Ayer Forest Reserve, Perlis, Malaysia and this activity has been given high priority with the seeds collected mainly used for forest plantation establishment in the country. The stands of trees that have been upgraded and managed for seed production are based on their frequency of superior phenotypes. Several criteria used in the selection activities and establishment technique are described. Progeny obtained from these SPA stands are also being tested and results obtained are promising.

Keywords: *Tectona grandis* phenotypes, selection, production area, progeny and stands.

Establishment Techniques and Early Growth Performance of Teak On Decking Site

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Teak, *Tectona grandis*, is one of the recommended forest plantation species and is widely planted in the country. However, due to the variation in various soil types and conditions these species does not strive well and at times failed. Often most forest plantations are established on sites which are known to be neglected, degraded or compact such as the decking area, water-logged, lateritic, sandy and heavily eroded sites which are poor in fertility and growth rate. Such sites required high management costs, good silvicultural practices and intensive labour.

Hence, this poster describes the appropriate three different planting methods via deep furrow, big hole and normal standard practices applied on a decking site which has been left idle was formerly a log yard. The growth performance of the two and a half years old teak are also being studied and early results obtained are promising with the proper planting technique used.

Keywords: Teak, Soil variation, degraded, decking, silvicultural practices.

Performance of Selected Mesophytic in the Raised Lands of the Sundarbans Mangrove Forest of Bangladesh

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Sundarbans, the largest single tract of natural mangrove forest of the world, is located at the southern extremity of the Ganges River Delta bordering the Bay of Bengal. It occupies an area of about 10,000 sq. km including both Bangladesh and Indian parts. The forest in Bangladesh territory covers an area of 6,017 sq. km and lies between 21°28`-22°30`North latitude and 89°-90° East longitude.

The forest is very rich in biotic diversity supporting 334 plant species, 400 species of fishes, 35 species of reptiles, 270 species of birds and 42 species of mammals. Unlike most other mangrove forests the tree vegetation of the Sundarbans is not dominated by the *Rhizophoraceae* family. *Heritiera fomes* (63.8%) and *Excoecaria agallocha* (17%) are the two most extensively occurring tree species.

The Sundarbans plays an important role in the national economy of the country by supplying a remarkable quantity of timber, fuelwood, thatching materials, raw materials for newsprint and hardboard mills, fishes, honey crabs, etc. It contributes about 40% to the total revenue income of the Forest Department.

The Sundarbans has been under scientific management for more than 100 years. Future stocking of the forest is dependent on the natural regeneration. The productivity of the forest is very low (1.12 m^3/ha/yr) in comparison to other mangrove forests of the world.

The reason for low productivity of the forest may be due to slow growth of the main species (*H. fomes*), poor regeneration in some parts of the forest, poor control on the management systems etc. Areas with poor regeneration are increasing day by day and these areas are covered with some non-commercial species which are called Non Commercial Cover (NCC). According to ODA inventory report (1985), about 2% of the area of the Sundarbans are NCC. NCC is found in two forms such as;

a) raised land where there is no or very little tidal inundation, specially found in the north and north eastern parts of the forest and

b) depressed land where there is a stagnation of water, found specially in the western parts of the forest.

Raised NCC lands are unsuitable for mangrove species as these areas are seldom inundated by tidal surges. Mangrove Silviculture Division of the Bangladesh Forest Research Institute has been trying to introduce commercially important mesophytic species to cover those areas. Since 1986 to 1992 experimental trial plantations were made with 19 mesophytic species in different locations. These species are *Lagerstremia speciosa*, *Samanea saman, Albizia procera, A. lebbeck, Acacia nilotica, A. catechu, Swietenia macrophyla, Cassia siamea, Dalbergia sissoo, Toona ciliata, Leucaena leucocephala, Melia azedarach, Aazadiracta indica, Calophyllum inophyllum, Tamarindus indica, Polyalthia longifolia, Anthocephallus cadamba, Diospyros perigrina* and *Caesalpinia pulchirrima*. Out of 19 species, 3 species namely *L. speciosa, S. saman* and *A. procera* were found promising and recommended for the pilot plantation trial. Accordingly plantations were raised with these 3 species at different locations in 1992, 1993 and 1994. Survival and growth performance data recorded in June, 1998 were analysed. The results show *L. speciosa* as the most suitable species for the plantation in the raised areas of the Sundarbans for its good survival (78%-91%) and growth (height growth 0.95–1.05 m/yr and diameter increment 4.02–4.53 cm/yr) in ever location.

Reaction Ability of Silver Fir and Norway Spruce in the Dynaric Region of Slovenia

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Keywords: silver fir, Norway spruce, reaction ability, ring width trends, understory trees.

The main objective of the study was to investigate the recent growth reaction ability (for sociological rank changes) of the understory silver fir and Norway spruce trees in natural and selectively managed Dynaric silver fir-beech (*Omphalodo-Fagetum*) and spruce-silver fir forest (*Ribeso alpini-Piceetum*). The results shall illuminate the ecological perspective of natural silver fir and Norway spruce and the perspective of selection forest management under current environmental conditions.

The study area is located in the south-eastern part of the Dynaric region in Slovenia. The interference climate with relatively intensive rainfalls (above 1600mm per year) and moderate annual average temperatures (between 5 and 8°C) are characteristic for this area. For the study 8 research plots (size from 0.25-2.0 ha) were chosen: four plots in the silver fir-beech forest (altitude 800-900m), two plots in silver fir-beech forest with natural Norway spruce (attitude the same, site-climate more cold and wet), and the last two plots in spruce-silver fir forest (altitude 1150-1300 m). One of the silver fir-beech plots was located in the protection belt of the virgin forest (Rajhenau), and one of the spruce-silver fir plots in natural forest (Goteniski Sneznik). On each plot, 45 to 75 trees were selected (randomly if not all of them). Besides usual dendrometrical and silvicultural variables also the developmental tendency, vitality/health condition and light/shade condition of trees were assessed. Two increment cores were taken (up to the pith) from each of the selected tree for dendrochronological analyses.

The main results of the study are:

1) The ages of the understory silver fir and Norway spruce trees are surprisingly high at both sites: up to >240 years for silver fir at the silver fir-beech site and up to >340 years for both tree species at the silver fir-beech site (with Norway spruce) and spruce-silver fir site. The maximum ages of understory trees does not differ very much between selection and virgin/ natural forest.

2) The recent growth response to light of the released (and not seriously damaged) understory trees is still very strong (the diameter and height increment are strongly increasing), irrespective of their high physiological age or long suppression period in the past. The understory silver fir and Norway spruce growth behaviour is very similar. Understory silver fir and spruce trees could therefore be very perspective for selection forest management.

3) Although the long-term ring width trends of the understory trees do not differ significantly between silver fir and Norway spruce, the recent ring width trends of dominant trees are generally different (last 30 or more years): declining for silver fir and increasing for Norway spruce. Comparison between stands of various development history suggests that the type and intensity of forest management is the primary factor responsible for different dominant silver fir and Norway spruce growth trends.

4) From ecological and environmental point of view the optimum silvicultural technique for this forest ecosystems would be the single tree selection ("Einzelplenterung") for silver fir and single to group-wise selection ("Gruppenplenterung") for Norway spruce also under current environmental conditions.

Development of *Triplochiton sclerexlyon* (Wawa K. Schum) as a Plantation Species by Cuttings

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Among the primary endemic species that contribute substantially to Ghana's timber export earnings is *Triplochiton scleroxilon* (K. Schum), (Wawa), accounting for about 22% of the total cubic volume of the major timber product exports. The exploitation of Wawa is due to its abundance in almost all the forest types in Ghana and West Africa is general. Though Wawa has multiplicity of uses, the species is well known to produce seeds irregularly, both on annual and seasonal basis, a major constraints to having enough seeds for replanting. Vegetative propagation techniques have been developed for the species to encourage reforestation efforts. This study describes the application of low technology propagation system using cuttings.

Two experiments were carried out: (i) testing of rooting performance from cuttings of 2 year old, 4 year old and 8 year old stockplants (banded and unbanded), and (ii) growth (height, diameter) performance of rooted cuttings on different mixtures of sand, loam, and sawdust. No rooting was observed in 8 year old cuttings. Blanching had no significant effect on rooting. Highest rooting percentage was in 2 year old cuttings.

Growth medium of 25% sand, 25% loam, 50% rotted sawdust produced significant growth (height and diameter) (P=0.05 ANOVA) and biomass accumulation (leaf, root).

The results indicate that the most suitable cutting material for vegetative propagation of *T. scleroxylon* is 2 year stock plants and rooted cuttings performed best on growth medium of 50% rotted sawdust. Use of juvenile stockplants and seedling growth medium rich in organic nutrients may be recommended for use in propagation of *T.scleroxylon* cuttings.

Keywords: Ghana, *Triplochiton scleroxylon*, cuttings, plantations

A Shelterwood System for Regeneration of *Picea abies* (L.) Karst in Sweden

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Regeneration of Norway spruce *Picea abies* [L]. Karst. under shelterwood is a silvicultural system that demands knowledge, activity and endurance. On an appropriate site and with a well planned silvicultural program the net income can be higher than from clear-cutting, scarifying and planting. This is mostly due to that the regeneration cost decrease more than the logging cost increase in the shelterwood system. However, incomplete regeneration, windthrow and damage done to the regeneration during felling of the shelterwood can result in a lower net income than from the clear-cutting system.

Some of the advantages with the shelterwood system compared with the clear-cutting system are: (i) reduced risk for frost damage on the seedlings; (ii) a less heightened ground-water level in the regeneration stage; (iii) suppression of the field vegetation, which facilitate seedling establishment and growth. The most feasible sites are usually moist and fertile and located in low parts of the terrain, i.e. where the above mentioned advantages are most clearly outspoken. In addition, a shelterwood induce less environmental changes compared to a clear-cut, e.g. for air humidity, shadow and wind speed. This is especially important in stands where species adopted to long forestry continuity are present. Many of these species are rare and are not likely to survive a clear-cut.

The logging operations included in the system are: Preparatory-, Seed-, Removal- and Final cutting. When the new generation of conifer plants is established the final cutting should be carried out at a suitable time in order to minimise physiological damage due to, e.g. changes in light and humidity, as well as logging-related damage to the regeneration. The final cutting can be done with both single- and two-grip harvester systems with an acceptable amount of damage in the regeneration. However, it is necessary that the logging is careful and that the stand is not too dense and the regeneration not too sparse. On average 40-60% of the original seedlings will be damaged or killed.

Windthrow usually occurs during the first five years after the logging operation and can be a severe problem. On an average, 10-20% of the shelterwood trees will be windthrown. In order to minimise the probability for windthrow, the seed-cut should not exceed 40% of the trees, corresponding to about 30% of the standing volume, when thinning from below. Preferably the highest trees with a long green-crown length should be left and trees with a short green-crown length should be cut.

Indigenous Woody Species in Grassland Areas of Northeastern Luzon, Philippines: An Alternative for Grassland Rehabilitation

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Five grassland sites in Northeastern Luzon, Philippines were studied to identify indigenous woody species and determine their potentials for rehabilitating degraded grassland. Sixty two (62) species belonging to fifty (50) genera and twenty nine (29) families were identified in the woody patches of grassland areas in five localities classified as 57 trees and 5 shrubs. Among these, three (3) are promising species for reforestation namely: *Afzelia rhomboidea* (*Leguminosa*e), *Pterocarpus indicus* (*Legurninosae*) and *Vitex parviflora* (*Verbenanceae*) while eleven (11) others have potential in grassland rehabilitation based on the following characteristics they possess: a) most of them have multiple usage capable of providing products and services in addition to fuelwood and timber; b) since all are native species, they adapt well to the site, establish easily and require little care; c) they are capable of growing in extreme environment such as infertile soils, low moisture and exposure to frequent grassland fires and strong typhoons; and d) some have the ability to fix atmospheric nitrogen, ability to coppice and fast growing. These are *Albizzia procera* (*Leguminasae*), *Alstonia scholaris* (*Apocynaceae*), *Erythrina orientalis* (*Leguminosae*), *Polyscias nodosa* (*Araliaceae*), *Trema orientalis* (*Ulmaceae*), *Antidesma ilocaman* (*Euphorbiaceae*), *Mallotus philippinensis* (*Euphorbiaceae*), *Bauhinia malabarica* (*Leguminosae*), *Canarium aspersum* (*Burseraceae*), *Diospyros pilosanthera* (*Ebenaceae*) and *Streblus asper* (*Moraceae*).

Productivity of Grasses in Relation to Site Quality in *Pinus roxburghii* Sargent Plantations

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The present study was conducted during the 1996 growing season (June-October), in Solan Forest Division of India's Himachal Pradesh. It is located between latitudes 30-31°N and longitudes 76-77°E and the region's climate is sub-tropical. Two sites were selected. Site I is a good site quality and site II is a poor site quality. Site quality was determined by the height intercept method. The aboveground biomass of the grasses was determined by the harvest method and belowground biomass was estimated by excavating a monolith of 25x25x30 cm, from each quadrat taken at a fortnightly interval starting on 15th June. The important grass species recorded in the study were *Themeda anathera, Chrysopogon montanus, Heteropogon contortus* and *Panicum maximum*.

The total aboveground biomass on sampling dates varied from 10,1 q/ha to 23,5 q/ha in site I and from 9,8 q/ha to 27,6 q/ha in site II. In both sites the peak biomass was recorded around mid-August. In site I the aboveground biomass showed a gradual increase until mid-August and in site II, except in mid-July, a similar pattern was noticed. At peak biomass stage *Chrysopogon montanus* contributed with 26,7 q/ha (96%) to the total aboveground biomass in site I and with 15 q/ha (54%) in site II. The percentual contribution of *Chrysopogon montanus*, *Heteropogon contortus* and *Panicum maximum* was 90, 40 and 3, respectively, in site I and 64, 27 and 9, respectively, in site II. During the study period, *Themeda anathera* aboveground biomass, was significantly different, on both sites, in mid-August, end-August and end-September but on the other dates it was equal. During the study period, *Chrysopogon montanus*, *Heteropogon contortus* and *Panicum maximum* aboveground biomass were significantly different on both sites.

The total below-ground biomass of grasses on different sampling dates varied from 9,6 q/ha to 17 q/ha on site I and 7,9 q/ha to 17,8 q/ha on site II. It was recorded that below-ground biomass increased gradually from June to mid-August after it showed an irregular trend. At peak biomassa stage, *Chrysopogon montanus* contributed with 16,6 q/ha (97%) to the total below-ground biomass on site I, whereas on site II besides *Chrysopogon montanus* (73%), *Panicum maximum* (14%) and *Heteropogon contortus* (12%) also contributed significantly to the total below-ground biomass.

Thus, it was found that the difference in site quality based on the tree characteristics had no influence in total above or below- ground grass biomass but had an influence on the biomass production of individual grasses and thereby their contribution to the total biomass of the community. An attempt was made to correlate the site quality and aboveground biomass with rainfall and basal area of the grasses. It was found that rainfall explained, in site I and in site II, respectively 25% and 34% of the aboveground biomass variation. Basal area of the grasses accounted, in site I and in site II, respectively for 49% and 30% of the above-ground biomass variation.

Natural Reproduction of *Quercus serrata* Coppice Forests by the Mother Tree Method

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Deciduous coppice forests dominated by *Quercus serrata* are widely distributed around cities and farm and mountain villages in Japan. In these areas the afforestation by conifers was made actively during 1950's to 1970's. But recently the new trend towards natural reproduction by making full use of native broad-leaved tree species have been growing among forestry experts and regional people. The mother tree method have a number of advantages; e.g. easily performed, enable to shorten the regeneration period and so on. Various fundamental studies and technical tests were carried out in order to examine applicability of the mother tree method for *Q. serrata*. The canopy trees produced good seed crop almost every two years, bumper seed crop at intervals of 6 or 8 years. Larger number of mature seeds were supplied at years when the trees bore more seeds. Most of seeds fell right under tree crowns or near around them and collected mainly at low spots on the ground surface. The seed fall was followed by leaf fall and the leaves also collected in the same manner to cover seeds. So seeds could avoid desiccation damage. Seedlings showed, already at current year stage, high photosynthetic ability in leaves, 60-70% of young trees, and the photoinhibition of photosynthesis was not observed. Daytime stomatal conductance of current year seedlings was kept relatively high even in non-rain fall periods in summer, probably due to marked development of their root system. At the following year weeds and shrubs started to grow thick and suppressed certain parts of the seedlings. It was, however, concluded that the regeneration of *Q. serrata* would succeed finally if the growth of bamboo grasses could be restricted artificially. The use of a backhoe was extremely effective for removing the under-ground system of bamboo grasses etc. Although soils were compacted by using such heavy machinery, the soil compaction did not strongly influence the photosynthetic performance and growth reaction of the seedlings.

Bosques tropicales secundarios en transición

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Este trabajo trata sobre la estructura y composición florística de vegetación boscosa secundaria submesotérmica en el Escudo Guayanés al Sudeste de Venezuela, y es parte del proyecto "Dinámica Bosque-Sabana" en la Gran Sabana, a fin de analizar los cambios en la vegetación boscosa. Bajo el clima húmedo regional no ocurre una cobertura continua de bosque siempreverde; más bien predomina un mosaico de bosques, sabanas y una vegetación transicional entre ambas formaciones. Se ha postulado que ese mosaico representa una etapa transitoria de un proceso dinámico de cambio de los bosques hacia sabanas, ocasionado principalmente por una combinación de fragilidad latente y baja capacidad de recuperación de la vegetación boscosa, en donde los incendios forestales durante los años extremadamente secos son los principales agentes desencadenadores. Los factores externos que usualmente perturban los bosques son los incendios no controlados y la agricultura migratoria. Los resultados sobre vegetación secundaria post-conuco confirman el habitual cambio en la estructura y la diversidad arbórea a través del tiempo, sin embargo se detectó una diferenciación de esas características en función de las condiciones de sitio así como del tipo y frecuencia de perturbaciones agrícolas. En cuanto a la vegetación secundaria post-incendio se puede diferenciar entre comunidades secundarias resultantes de eventos perturbadores singulares de incendios ocurridos durante sequías excepcionales y aquellas comunidades surgidas a partir de incendios reiterados en el límite bosque-sabana. Cabe señalar que en ambas variantes se ha podido constatar una tendencia hacia un proceso de degradación de la vegetación boscosa secundaria, en vez del habitual proceso de recuperación sucesional. En estos bosques no sólo es notoria la falta de especies pioneras especializadas, sino también la escasez de esciófitas. Más bien la mayor parte de las especies aparentan poseer un comportamiento poco especializado, o sea bastante flexible en lo que respecta a su tolerancia o necesidad de luz. Ello parece indicar una adaptación de las especies a ecosistemas forestales con un alto nivel de perturbación. La restringida estabilidad del sistema determina una fuerte dinámica, lo que implica una alta probabilidad de variación de las condiciones e incidencia de la luz, durante el lapso de la vida promedio de un árbol. Por lo tanto, una especialización estricta de especies como árbol esciófito bajo estas circunstancias sería muy desfavorable, mientras que un comportamiento como oportunista sería más viable para su supervivencia. La amplia distribución de la mayoría de las especies en los distintos tipos de bosques y la relativamente alta afinidad florística entre los distintos tipos de bosque indican una adaptación de gran parte de sus especies a diferentes condiciones de sitio. En vista de la carencia de suficiente información sobre requerimientos de agua, nutrientes y luz no se pudo distinguir realmente cuando el factor limitante para la ocurrencia de una especie es la incidencia de luz o las condiciones de sitio. Evidente parece ser sólo la ausencia de especies pioneras típicas, que normalmente son exigentes, no solamente con la luz, sino también en relación al suministro de nutrientes, como por ejemplo especies de los géneros: *Cecropia*, *Roupala* y *Schefflera*, que posiblemente sean excluidas, debido a los suelos extremadamente oligotróficos.

Taper Variation among Progenies of *Acacia mearnsii* de Wild and its Implication in the Tree Volume Estimation

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This paper aims to determine the taper variation among progenies of *Acacia mearnsii* De Wild. (black wattle) and to discuss its implications in the tree volume estimation. Black wattle is an important forest tree species in Rio Grande do Sul State, Brazil. The total area planted with this species is estimated in 120 thousand ha with an annual plantation rate of 13 thousand ha. 75% of the total plantation area is located in small farms, in varied agroforestry systems. These farmers plant agricultural crops (mainly cassava, corn, beans or watermelon) associated with black wattle trees in the first two years. When the trees are three or four years old, the grass regenerated understore is used to feed the cattle introduced in the forest. The main products of the black wattle forests are bark, demanded by the tannin industries, wood, used as an energy source by the local population, and chips, demanded by pulp industries. Estimation of tree volume during the rotation period is an important tool used by the foresters not only for experimental reasons, but also, to keep control of the forest stock for administrative purposes. The methodology most used to estimate the black wattle tree volume is based on the estimation of the cylindrical volume multiplied by an average taper value. However, measuring the black wattle tree height planted in a high density forest (2000 trees/ha) is a difficult task for trees taller than 9 m of height. This study was based on 135 trees of 46 open-pollinated black wattle families, planted in Piratini County, Rio Grande do Sul State, Brazil (31002' LS, 52057' LW and 220 m. a.s.l). The trees were four years of age and belonged to a replication of a progeny test planted in the randomized block design. The average taper values of the 135 trees measured was 0.517 with a coefficient of variation of 14.9%. There were statistically significant differences (95% of probability) among progenies in relation to the taper values. Regression analysis among the cubed volume and the volumes obtained by different methodologies emphasized the need to use an equation adjusted for these population. Based on the results of this study, it was concluded that the volume of black wattle trees estimated using equations based only on diameter values (DBH) was accurate (r^2=0,87) and less time consuming, therefore, should be adopted in the black wattle tree improvement program carried out in Southern Brazil.

Rehabilitation of Degraded Peat Swamp Forest

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Keywords: Peat swamp forest, rehabilitation, native species, nursery practice

Degradation of peat swamp forests has been closely associated with human activities especially uncontrolled logging. These degraded areas need to be rehabilitated to help restore productivity, improve peat swamp forest environments, and maintaining their role as sources of high quality timber. Adequate high quality planting material is currently a major constraint in rehabilitating degraded peat swamp forests, and research on appropriate planting techniques using suitable species is crucial. The study site was conducted in Compartment 101, Raja Musa Forest Reserve in Batang Berjuntai, Selangor. The area experiences fire on a regular basis and was occupied by grass, *mainly Imperata cylindrica* (lalang). Four different methods of planting and six different peat swamp forest species were used in this study. Growth (height and diameter), survival and mortality data of the seedlings, as well as foliage samples, were taken every three months during the course of the study. Planting materials were successfully raised using seeds and wildings. It was found that planting materials of peat swamp forest species can be raised using normal soil potting mixture in the nursery. Handling of these species in the nursery does not require special care, and their management in the nursery was similar to that for dryland species. Seedlings of peat swamp forest species had fewer problems with disease and fungus. The findings showed that these species can be raised with minimum care as long as we have sources of the plants (seeds and wildings).

Recycling of Wood Ash - Effects on Stem Growth in Swedish Coniferous Stands on Mineral Soils

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During the last decade, the interest in utilizing logging residues for bioenergy has increased in Sweden. The use of such residues for energy production generates large amounts of wood ash, which at present are being dumped. This dumping is not unproblematic. It is space-demanding, and involves the risk of strong bases and heavy metals being leached out contaminating the ground water.

A more intense harvesting results in an increased export of nutrients and soil acidification. To prevent, or reduce, the negative effects of intensive biomass harvesting, it would be of value to recirculate the nutrients contained in the wood ash. Wood ash has a high pH (ANC), and a major part of most macro- and micro nutrients (except for N) from the biomass is retained in an inorganic form.

With the object to study whether the stem-growth of coniferous trees is affected by applying wood ash, a series of field experiments was established in middle-aged Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea abies* (L.) Karst) stands on mineral soil. Stabilized wood ash in doses of 1, 3 and 6 tons ha-1, as well as a combined ash + N treatment, was studied.

Preliminary results indicate that the addition of wood ash increased stemwood growth on fertile sites in south Sweden and decreased growth on less fertile sites further north. The number of experiments is still small, but results agree well with experiences from liming.

Despite the anthropogenic input, N is still the growth-limiting nutrient for the vast majority of the Swedish forests, and the addition of wood ash probably influences the supply of inorganic nitrogen available for tree growth. The addition of wood ash on the fertile sites, with N-rich forest soil, such as moder/mull soils, probably resulted in an increased net mineralisation of N in the soil organic layer, while it in the more N-poor forest soils probably led to an increased N-immobilisation. The C:N ratio in humus seems to be a good measure from which to judge if a pH increase in the soil leads to an increased or decreased net mineralisation.

Reclamation of River-damaged Areas through Agro-forestry in Nepal

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Keywords: agroforestry, montane regions, Nepal, silvipastoral systems, rehabilitation, *Dalbergia sissoo*, *Acacia catechu*

Land degradation due to flooding has become a major threat to the foothills of middle mountainous region and Terai part of Nepal, leading to the deterioration of socio-economic conditions and of natural ecosystems. Agroforestry practices have been promoted in those areas with the twin objectives of countering land degradation problems and meeting the demands of local people for fuelwood, fodder, and small timber. The present study assessed the effectiveness of such practices in the riverside areas of the midhills region in reclaiming the degraded lands, considering vegetation establishment, land productivity and control of weed infestation (*Imperata cylindrica, Saccharum munja*) as the bases for evaluation. Data were gathered from the field measurements and observations. In addition, data pertaining to crop yields were collected using semi-structured questionnaires. Results of two years' study showed that *Dalbergia sissoo* could be successfully intercropped with *Zea mays, Solanum tuberosum, Cajanus cajan* and *Phaseolus vulgaris* in river affected areas. There was no significant difference in growth performance of *D. sissoo* planted in river-affected areas and unaffected areas. Yields of various crops have also been documented. Three treatments adopted to control infestation of

Imperata cylindrica and *Saccharum munja*: (1) land preparation using power tiller, (2) dense plantation of riverine tree species at 1 x 1 m spacing, and (3) silvipastural management (i.e., protection of existing grasslands from excess grazing and planting *D. sissoo* and *Acacia Catechu* at 4 x 4 m spacing). Of these treatments, the dense tree plantation was most appropriate from both the economic as well as ecological standpoints. Species composition was found to have changed in the silvipasture plots. Land preparation using power tiller was found to be an effective approach to eradicate *Imperata cylindrica* and *Saccharum munja*, although it was not economically feasible and transportation of the power tiller was also difficult in remote areas.

Stand Structure and Spatial Pattern of Commercial Species in Logged and Unlogged Venezuelan Forest

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The impact of logging on the stand structure and spatial pattern of commercial species was studied along a chronosequence of 5-19yr old logged stands in the Forest Reserve of Caparo, Venezuela. For comparison, a mature forest stand was surveyed. A systematic sampling design was applied. On average, 10.2 trees/ha with a bole volume of 66.5 m^3/ha were removed. Up to the mid 1980s, covered by this study, only *Bombacopsis quinata, Swietenia macrophylla, Cedrela odorata and Cordia apurensis* were logged. The 5-yr, 8-yr and 19-yr old logged stands showed a mean basal area of 17.8 m^2/ha, 21.3 m^2/ha and 22.2 m^2/ha, respectively, whereas 33.2 m^2/ha were measured in the mature forest. The share of undamaged trees in the basal area increased from 30.8% in the 5-yr old logged stand to 43.9% in the oldest logged stand. The number of emergent trees (>3m height) was considerably reduced by logging; even 19 years after logging only 8 stems/ha were found in this height class comparing to 51 stems/ha in the mature forest. *B. quinata*, the most important timber species in the study area, occurred with only two heavily deformed individuals in the logged stands. Juveniles of *B. quinata* were rare (< 10 stems/ha) in both logged and unlogged stands. A similar situation was found in *C. odorata* and *S. macrophylla*. In contrast, *C. apurensis* was well represented in small size classes in logged and unlogged areas. A second cutting cycle will be based on a variety of medium- and small-sized shade-tolerant and light-demanding species which were regularly distributed in the unlogged and logged area. However, the spatial patterns of seedlings and saplings of these species did not show any clear trend. Nineteen years after logging, only one third (61.3m^3/ha) of the commercial bole volume of the mature forest (185.3m^3/ha) was attained.

Stand Characteristics and Natural Regeneration of *Kalopanax septemlobus* Growing at Kangwon Province, Korea

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Kalopanax septemlobus is a deciduous tree whose height and diameter at breast height (DBH) sometimes exceed 30m and 1.8, respectively. The importance of *K. septemlobus* in Korea has been recognized these days due to several reasons. Timber quality is better than any other woody species of which reason makes this tree species expensive in timber market. In addition, *K. septemlobus* produces saponin, one of the second metabolic products that could be effective for several medicinal and edible uses. Although *K. septemlobus* deserves many good things for human life, there has been no previous research on its ecological characters. The objective of this study was to understand the characteristics of stand distribution and factors affecting natural regeneration of *K. septemlobus* growing with other hardwoods in Kangwon Province, Korea. We have researched the seed quality by X-ray photography and site characteristics, which are altitude, slope, aspect, elevation, moisture and nutrient content of soil. The plot was established by 20 X 20m and all individual trees > 2.0cm in DBH were measured for the vegetation composition, and compare to the topographical and soil characteristics. *K. septemlobus* was spottily distributed at the high elevation and in good nutrient soil conditions mixed with *Quercus, Acer, Betula* and *Carpinus* species. Its distribution patterns were clustered at the early stage, but, the mature trees were randomly distributed only in one or two individuals. The seedling grew fast under good light conditions, and showed shade tolerance at the early stage. The growth of *K. septemlobus* continued from April till August when measured for girth band at Mt. Kyebang. The dominant tree grew by 6.1mm per year whereas suppressed one under other trees showed almost no growth. The natural regeneration of *K. septemlobus* in natural hardwood forests was very difficult because of its low seed viability and its germination. The seed viability of *K. septemlobus* was 34.5% under good light condition in forests, whereas 19.6% inside forests. The height growth of *K. septemlobus* seedlings showed a reverse-J shaped curve, which might induce high mortality. Such mortality was resulted from severely competing herbs or seedlings of other species and also browsing by wild animals.

Economic Analysis of Forestry Plantations on Degraded Sites

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The present paper studies economics of forestry plantations in three degraded sites viz. eroded soils, water-logged soils and alkaline & saline soils. Such plantations were maintained by the farmers on their farm lands in order to meet various household and agriculture needs. The study is based on the survey and interviews with the farmers of the area under consideration. Plantations in all the degraded sites under study being sparce, the estimations were done per 100 trees, rather than area basis. In order to assess profitability of the plantations, Net Present Worth (NPW) and Benefit-Cost Ratio (B-C Ratio) were determined at 12 % rate of returns, as the farmers of the area are getting long term agricultural loans at 12% interest per annum.

Eroded sites are characterised by low soil depth, oftenly exposed hard rock and nutrient deficit landmass. Special site specific benefit-cost studies for such plantations were conducted in Suan river catchment area of Una district in Himachal Pradesh, India, for the plantations of *Dalbergia sissoo*, *Albizzia lebbeck*, *Toona ciliata* and *Grewia optiva*. Plantations of all the species under consideration in eroded soils were profitable. *Grewia optiva* being very popular and useful fodder species of the area, yielded the highest NPW (US$ 240) followed by the *Dalbergia sissoo* (US$ 112), *Toona ciliata* (US$ 122.73) and *Albizzia lebbeck* (US$ 79.8). However, the B-C ratio was found to be the highest for *Dalbergia sissoo* (2.59) followed by *Toona ciliata* (2.58), *Grewia optiva* (2.35) and *Albizzia lebbeck* (1.97).

The water-logged soils of Una district in Himachal Pradesh, India, have existing plantations of *Dalbergia sissoo*, *Acacia arabica*, *Populus* and *Eucalyptus* spp. The plantations of all the four species under reference were profitable. *Populus* spp. and *Eucalyptus* spp. being short duration (8 years) crops yielded significantly higher NPW (US $ 318.2 and US $ 228.3, respectively) and B-C ratio (4.18 and 6.18, respectively) as compared to long rotation (25 years) *Dalbergia sissoo* and *Acacia arabica*. The total undiscounted benefits of *Dalbergia sissoo* (US$ 1788) and *Acacia arabica* (US$ 1798) were, however, considerably higher than *Populus* spp. (US$ 919) and *Eucalyptus* spp. (US$ 597.8).

Alkaline and saline soils pose a great problem for cultivation of many crops in many parts of India. Growth as well as survival of forestry plantations in such lands is adversely affected. This study was done in one of the districts largely affected by this type of soils (Karnal, Haryana, India). Plantations of different species studied were *Eucalyptus* spp., *Acacia nilotica*, *Zyzyphus* spp. *Morus alba*, *Dalbergia sissoo*, *Sesbania aegyptica* and *Prosopis* spp. The plantations of all the seven species under study were not profitable to grow under alkaline and saline soils. NPW and B-C Ratio criteria of economic analysis indicate the plantations of *Eucalyptus* spp. *Acacia nilotica*, *Zyzyphus* spp. *Dalbergia sissoo* and *Prosopis* spp. were profitable while *Morus alba* and *Sesbania aegyptica* were non-profitable. *Eucalyptus* had the highest NPW (US$ 448.80) while *Morus alba* had the lowest NPW (US$ -30.83). On the other hand the B-C ratio was the highest for *Eucalyptus* (4.97) and the lowest (0.74) for *Sesbania aegyptica*. *Eucalyptus* was found to be the highly profitable species due to its fast growth and reduced supply of wood in present days. The economic analysis of these site specific plantations related to marketed benefits provided information on profitability of various local tree species. However, many non-marketed benefits of these plantations will further increase profitability of such plantations.

1 US $ = Rs. 42.00 (Rs. = Indian Rupees)

Rehabilitation of Degraded Tropical Forest Ecosystems

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1. Background and Justification

Tropical forests are decreasing at the rate of 16.9 million ha/yr due mainly to clearing for agriculture and shifting cultivation. Moreover, timber harvesting results in more than 5 million ha of tropical forest becoming secondary forests every year without any adequate management. The decrease and degradation of the tropical forests affect not only the production of timber but also global environments.

Many environmental changes are initiated by forest harvesting including site degradation, reduced water supply, soil loss and greenhouse gas emission. What is needed at the present time is the assessment of harvesting impacts which significantly influence rehabilitation methods. A growth in population and rapid economic expansion have resulted an escalation in demand for wood products. Increased supply of wood from plantation forests has the potential to reduce pressure on natural forest resources as well as contributing to environmental care and economic advancement for landholders in the tropics. Short-rotation plantations will show changes in nutrient storage and cycling processes. The clarified scientific information enables managers to devise silvicultural systems which enhance soil properties important to sustainable production and minimise deleterious effects associated with short rotation. Therefore, "Rehabilitation of Degraded Tropical Forest Ecosystems" as the CIFOR research project was proposed and started in 1996.

2. Research Activities

Following research activities have been proposed and started in 1997 collaborated with seven institutions such as UNMUL-Indonesia, FCFUM-Argentina, PNGFRI-Papua New Guinea, INIA-Peru, UPM-Malaysia, KUFF-Thailand, and EMBRAPA-Brazil.

(1) Evaluation of forest harvesting impacts on the forest ecosystems: (i) evaluate logging and yarding methods on disturbance of forest ecosystems, (ii) analyse the demography of regenerated tree population, (iii) model a/de-gradation processes in forest ecosystems.

(2) Development of methods to rehabilitate logged-over forests and degraded forest lands: (i) treatments accelerating natural regeneration, (ii) development of enrichment planting methods.

(3) Development of silvicultural techniques on degraded forest lands: (i) development of species-site matching methods, (ii) management options for sustained productivity, (iii) social and economic acceptability of management options.

3. Experimental Site related with Activities

UNMUL is carrying out the study of two different harvesting intensities + forest fire at Lowland mixed Dipterocarp forest -9 ha in Bukit Soeharto, East Kalimantan, Indonesia. FCFUM is studying two different harvesting intensities with bamboo at YABOTI Sub-tropical forest -72 ha in Guarani Forest Reserve, Misiones, Argentina. PNGFRI is carrying out the study of three different refining intensities + enrichment planting at Logged over lowland mixed evergreen forest -150 ha in Oomsis and Bulolo, Papua New Guinea. INIA initiates the study of mixed species plantation at the abandoned agriculture and pasture grasslands and secondary forests (purmas) in Campo Verde and Nueva Requena, Pucallpa, Peru. UPM is studying the three Gap plantings and three line plantings + mixed planting at logged over mixed Dipterocarp forest -12 ha in Pasoh, Malaysia. EMBRAPA is carrying out the study of clearcutting + 7 site preparation: site management + organic residue and litter treatments, undergrowth treatment, tillage, fertilisation at 7 year old *Eucalyptus grandis* –16 ha in Sao Miguel and Mogi Guacu, Sao Paulo, Brazil. KUFF is studying tree different thinning intensities and one clear cutting + intercropping at 17 year old Teak -4.32 ha in Thong Pha Phun, Kancganaburi, Thailand.

4. Final Outputs

Rehabilitation is aimed to improve biological diversity, increasing commercial value for the timber production, increasing non-timber products, increasing forest functions, improve fertility and improve soil physical properties etc. Technical developments are expected for reducing logging impacts, sustainable forest management, accelerating natural regeneration, species selection – site matching, enrichment, sustainable site management and catalytic plantation. Socioeconomical developments are also expected that rehabilitated production forest and environmental forest, local community participation and socio-economic acceptability.

The Management Problems in Planting of *Haloxylon* spp. in Iran

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Haloxylon spp. are very important for erosion control in sandy hills and deserts. Over the past 16 years in Iran, one of the major problems that has arisen is the weakening (yellowing) of these trees, especially during the summer season, in trees between 12-16 years of age. Ecological, ecophysiological and physiogenetic research conducted between 1993 and 1998 has sought answers to causes of this problem. Our research included initial studies of natural and artificial habitats of *Haloxylon* in which ecological parameters were measured, including climatic, edaphic and geographic parameters as well as plant community composition. Research plots (with area 5000 m2) were selected for physiological studies. Parameters such as height, diameter, healthy conditions and natural regeneration were studied in all of trees in each plot. At least one soil profile was described in each of the plots. In each of the plots, four green, four yellow and four green-yellow trees were selected at end of summer. One and two-year-old branches were sampled for studying alteration of cations, anions and enzymes in each season. Further sampling was done from 1- and 2-year-old branches of green and yellow trees for genetics studies at the end of summer. Genetics studies were done by analysis of peroxidase and esterase enzymes. Results showed problems of management including: 1- Monoculture of *Haloxylon*; 2- Unsuitable distance in planting; 3- Intraspecies competition; 4- Use of unsuitable seeds for planting; 5- Uncontrolled grazing by camel in natural *Haloxylon* habitat.

Testing the Effects of Fertilization and Liming for the Restoration of Forest Stands in Air-polluted Regions

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The present condition of Norway spruce stands in air-polluted regions of the Czech Republic is not satisfactory. The pollution manifests itself in the increased defoliation and frequent occurrence of symptoms characterizing the direct effect of air pollution. Yellowing of stands due to the long-term effects of acid depositions and the following decrease of bases in soil are very evident. Based on the reasons it is clear that inevitable revitalization measures will be necessary in the future.

The aim of the study was to test the application of PHOTOMAG+ (pure solution of magnesium monohydrogencarbonate Mg (HCO3) and dolomitic limestone for improving the condition of forest stands in selected areas. Aerial application of PHOTOMAG+ and liming were carried out in three spruce stands 78-98 years old situated at 1000-1200 m altitude of the Jeseníky Mts.and 30-50 yr old stands at 700-800 m in the Krusne hory Mts. (Erzgebirge). The stands exhibited marked symptoms of yellowing (Mg deficit) and a relatively high degree of defoliation before application. The proportion of trees showing yellowing and the proportion of yellowing needles were recorded in particular. Yellowing intensity was highest in older needle year-classes (≥ 3rd-4th needle year-class). In a short time after its application (4 months), PHOTOMAG+ significantly increased the value of efficiency of primary photochemistry of photosystem 2, induced increased reparation of damage of the inner photosynthetic apparatus of needles and markedly stimulated photosynthetic assimilation of CO_2 (particularly due to the increased ability to utilize lower values of radiation). The preparation did not significantly affect the structural components of the photochemical apparatus and this fact manifested itself in small changes of values in the rate of transport of electrons. Some 15 months after PHOTOMAG+ application, a perceptible but not significantly positive effect of improved photosynthesis was recorded as well as an evident tendency in ceasing its effects.

PHOTOMAG+ application caused a significant increase in Mg and Ca content in needles and im-proved balance in nutrition. With respect to the considerable deficit of these elements, however, the dose used was not able to replenish the elements to the level necessary for sufficient nutrition. As for micro-elements, the level of Zn and partly also Cu nutrition was improved.

PHOTOMAG+ application caused increase in the content of total and available (Mehlich II) Mg and Ca in soil and a positive change in soil pH occurred to a more acceptable level from the viewpoint of requirements for the uptake of nutrients by forest trees and for decomposition processes in soil.

Significantly positive effects of Photomag application were found of previous applications of dolomite limestone. In spite of the fact that the application of dolomite limestone was carried out in 1992, its effects were significant in the higher content of Ca and Mg both in needles and soil, in the better bal-ance of nutrition and in the lower occurrence of yellowing symptoms. The effect of the application of dolomitic limestone in the Krusne hory Mts., with respect to a short period which elapsed from the time of liming, manifests itself in the decrease of acidity in the upper layer of soil being negligible as for mineral nutrition improvement. It is possible to conclude that revitalization measures in Norway spruce stands in the region are highly substantiated. The results show that PHOTOMAG+ and crushed dolomite lime-stone application can improve health conditions of stands in air-polluted regions. PHOTOMAG+ applica-tion can be recommended for increasing the resistance of young stands, where the initial symptoms of Mg deficiency are observed or where it is necessary to delay the dieback of stands fulfilling the protection role in the course of their regeneration.

Structural Development and Silvicultural System *of Pinus densiflora* Stands in Kyushu, Southern Japan

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This study describes the stand structure and individual tree growth of *Pinus densiflora* (Pd) secondary stands, on 6 sites in the *Abies firma* (Af) and *Tsuga sieboldii* (Ts) forest zone between cool and warm temperate zone. The study objectives are to clarify quantitatively the structural development pattern and to design an extensive silvicultural system of Pd stands.

The stands has high basal area of Pd, Ts and Af but few broadleave trees. Stands stratification is as follows: Pd in the uper layer; Ts, Af and tall broadleave trees in the intermediate layer; Ts, Af, tall broadleave trees and shrubs in the understory. Pd didn't exist in intermediate and understory layers, because it is a intolerant species. Age differences between sample trees of different heights, from each Pd, Ts and Af single cohort stand, is less than 10 years.

At stand starting stage, Pd upper layer trees has the greatest height and dbh growth rates. Af, Ts and broadleave intermediate trees has lower growth rates. Differences in height and dbh among Pd, Ts and Af increases with stand development. However, height growth rates for Pd, Ts and Af became about the same after Pd reaches 40 years.

At stem exclusion stage, above 40 years, species dominance status changes with stand development. Pd decreases, and Ts, Af and tall broadleave trees increases. Size dbh hierarchy and height distribution for Pd populations simplifies, but for Ts and Af populations developes with stand development. Differences in dbh among Pd, Ts and Af increases, but differences in height are steady and decreases with stand development. In the future, Pd stands shifts to Ts and Af stands, because the height difference among Pd, Ts and Af decreases with stand development and Pd is supressed by Ts and Af under interspecific competition for light at ages above 80 years.

An extensive silvicultural system was designed for Pd stands. Target Pd timber production is as follows: log diameter bigger than 40 cm and log length greater than 4 m. The target Pd population is as follows: rotation age, 150 years; mean dbh, 57 cm; mean height, 26 m; stand density, 150 trees/ha; stand volume, 437 m^3/ha. The silvicultural type is the clear cut spatially dispersed and natural seeding regeneration. The tending operations, weeding, cutting of woody vines and cleaning are conducted at stand starting stage. Population density is controlled through natural thinning at stem exclusion stage. When stand is 80 years old or stand density is close to target density, Ts and Af trees higher than 12 m are cut to prevent decreasing Pd stand density following competition for light among Pd, Ts and Af. When the stand age is 150 years, Pd stands are clear cut and new Pd stands are created by natural seeding regeneration. This makes it possible to conduct Pd sustainable timber production.

Mast Fruiting as a Dynamical Feature of Flowering and Subsequent Survival to Mature Acorns, in a Japanese Deciduous Oak, *Quercus mongolica* var. *grosseserrata*

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Keywords: Mast fruiting; Acorn; Fruit set, Oak

In order to understand the proximate causing of mast fruiting, I studied mast fruiting pattern for *Quercus mongolica* var. *grosseserrata*, a major canopy tree in cool-temperate forests in Japan, with special reference to flowering and subsequent flower survival to acorn maturation. I observed flower and acorn production on shoots, and survival of flowers to mature acorn, at crown surface of trees growing a natural deciduous broad-leaved forest in northern Japan from 1990 to 1996. I also estimated pollen production in the stand using litter traps, as the indicator of pollen supply under natural condition. To detect the effects of pollination success on acorn production, I also conducted artificial pollination experiments.

Female flowers were produced every year although showed yearly fluctuation. Pollen production followed same trend of female flowers. Acorn production, however, was intermittent and restricted in some years, such as 1992 and 1994. Annual acorn production was correlated with survivorship of flowers to mature acorns (hereafter; Fruit set), not with flower abundance. Fruit set varied annually, and higher in mast years compared to non-mast years. Key factor analysis revealed the importance of early stage survival as the determinant of the annual acorn production. In non-mast years, artificial pollen supply increased survival of flowers in early stage, not acorn production. In mast year, however, higher early stage survival under natural condition as well as that on under artificial pollen supply, resulted large acorn production.

These facts suggest that pollination failure is the important cause of non-mast years because of severe flower abscission. Because pollination failure was irrespective of pollen production, external factors especially weather conditions at the pollination must be considered as the determinant of pollination success. It was implied that initial acorn crop which was determined by pollination success might affect the Fruit set. Success of pollination, and high fruit set after pollination, which was related high pollination success, can be required for mast years.

Patterns of Putative Ectomycorrhizal Basidiome Production in a Lowland Rain Forest in Peninsular Malaysia

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Keywords: Ectomycorrhizas, basidiome production, rain forest, tropics, Peninsular Malaysia

The rain forests of Peninsular Malaysia are dominated by the ectomycorrhizal *Dipterocarpaceae*, one of the most important families of timber trees in South East Asia. As with other host plants ectomycorrhizal fungi have been demonstrated to enhance uptake of phosphorus and improve seedling growth of some dipterocarp species. In the northern hemisphere ectomycorrhizal fungi are also known to play important roles as indicators of ecosystem health and monitors of soil disturbance.

The main groups of ectomycorrhizal fungi involved in the symbiotic association with dipterocarps are members of the *Amanitales*, *Boletales*, *Cantharellales*, *Russulales* and several hypogeous taxa, all members of the *Basidiomycot*a. Between 1992 and 1997 collections of putative ectomycorrhizal fungi were made in Pasoh Forest Reserve, a lowland dipterocarp forest located approximately 140 km south-east of Kuala Lumpur, the capital of Malaysia under the auspices of various joint collaborative projects. The main aim of these collections was to examine the frequency of basidiomes of putative ectomycorrhizal fungi in logged and unlogged lowland rain forest. Collections were made during March in each year and additionally in early September 1995 and late August 1996, coinciding with the two predicted annual rainy seasons of February-March and July-August. During each visit of about three days duration, collections were made along the Main Trail, Nature Trail, around Ecological Plot 1 and the Arboretum. Beginning from 1995, collections were extended to the newly established regeneration plots, A-E.

A total of 290 species, distributed in 19 families were recorded with many of the collections being new to science. For the purposes of comparing basidiome fruiting patterns in this presentation, collections made from the regeneration plots are excluded. Although collections were made at approximately the same time(s) each year, the number of species collected each year varied considerably from a low of 45 species in 1993 to a high of 107 in 1995. While the higher number of species encountered in 1995 may be attributed to two collections that year, this did not hold true for the following year when only 53 species were recorded despite collections being made in March and late August. In fact, the number of species found in just one short visit in 1992 (87 species) far exceeded the numbers recorded in 1996. As in Europe and North America, erratic fruiting appears to be a feature of the Malaysian lowland rain forest. It is unclear as to why this occurs. The following are possible reasons for this phenomenon: the frequency and abundance of fruiting may be influenced by seasonal or local weather patterns and/or host-fungus relationships; the fungal mycelia could require a certain length of time for accumulation of sufficient energy for basidiome production; grazing or feeding intensity by animals could influence fruiting. Members of the *Russulaceae* were always the most numerous in each year's collections with the exception of 1997 when surprisingly only 4 species of this family were collected. Much work remains to be conducted on the taxonomy of the Malaysian *Russulaceae* as many of the collections have distinctive differences in morphology and life-strategies from the temperate and West African taxa. Members of the *Boletaceae* and the *Amanitaceae* were the next most frequently collected species followed by members of the *Cantharellaceae* and *Cortinariaceae.* Members of the other families were less frequently encountered and often only single specimens were found. Several hypogeous fungi were also recorded, refuting the claim that such fungi are absent from tropical rain forest. Ideally a much longer period of study than that available to the present researchers is required to obtain more meaningful results.

Nitrogen Supply Effects of Seabuckthorn *(Hippophae rhamnoides* L.) in Poplar Plantations in Dry Subhumid Area of China

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Poplar is a fast-growing and high-yielding tree species in dry subhumid area of China, but its growth is affected by nutrient and water stresses. This species is being managed over successive rotations with continuous cropping. Introduction of the seabuckthorn into pure poplar plantations may lead to significant changes in organic matter decomposition and nutrient recycling, and hence to an increase in tree growth and biomass production. The objectives of the study were: to determine responses of soil nutrient availability and nutrient cycling processes of poplar plantations mixed with seabuckthorn; and how these responses vary with mixing patterns or poplar varieties.

Nitrogen supply effects of seabuckthorn in poplar plantations in a dry subhumid area of China were examined over 3 years in different poplar varieties (*Populus* 'Xiaohei', *P.* 'Zaoling06' and *P. euramericane* cv. 'N3061'), and in two different mixing designs (individual- or strip-mixing patterns). The positive effect of seabuckthorn on tree growth was found in the poplar plantations, irrespective of poplar variety or mixing pattern. The aboveground net primary productivity were significantly larger (27% to 113%) in the mixed stands than in the pure stands, regardless of poplar variety or mixing pattern. The increases was due largely to the contribution of the mixed seabuckthorn plants, accounting for 20% to 41% of the total above-ground net productivity. The concentrations of N, P and K were found to be significantly higher in the seabuckthorn leaves than in the poplar leaves. Nutrient concentrations in poplar tissues were frequently larger in the mixed stands than in the pure stands, but the nutrient concentrations varied with elements and varieties. The concentrations of soil total N and available N were 86-164% and 19-36% higher in the mixed stands than in the pure stands. The enhanced growth was not always correlated with foliar N concentration, but related to the increased annual amount of N uptake. The annual nutrient returns in the poplar mixed stands were enhanced, as the ratios of annual nutrient return to uptake were higher in mixed stands than in pure stands. This implied that there was a large amount of nutrients involving in the nutrient recycling processes in the poplar stands when mixed with seabuckthorn.

In conclusion, a growth response to the occurrence of seabuckthorn was possible in poplar plantations under the nutrient-deficient and seasonal drought stress in the dry subhumid climate of China. The growth enhancement of poplar tree was largely attributed to the increased availability of soil nutrients, especially N. The increased N availability was the result of one or more of the followings: the increased N inputs into the soil through N -fixation by root nodule, good-quality litter fall, and rapid nutrient recycling. Seabuckthorn acts as an N pump and plays an important role in maintaining sufficiently stable N availability in concert with rapid poplar growth. Seabuckthorn was characterized by its high ratio of leaf to stem, relatively rapid turnover, and high tissue nutrient concentrations, as well as its important function of N-fixation. The importance of seabuckthorn in modifying soil chemical processes and elemental cycling would be signified in view of long-term site productivity and sustainable productivity in poplar plantations, in particular, under successive rotations with continuous cropping on the same sites.

Influence du Pâturage, par Trois Ruminants Domestiques, sur la Dynamique de la Végétation du Nord de la Côte d'Ivoire

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Mots-clés: savanes soudano-guineennes, pâturage, bovins, ovins, caprins, vegetation herbacée et ligneuse, Côte d'Ivoire

Dans le Nord de la Côte d'Ivoire, les troupeaux sont dirigés vers des espaces boisées et quelques jachères eges qui sont les principales ressources fourragères actuelles en raison de l'extension des superficies cultivées. Ces espaces étaient source de bois d'oeuvre, de l'énergie, des ressources alimentaires, de la pharmacopée, etc. car ils servaient de biotope et de nombreuses espèces animales et végétales. Il est urgent d’aménager durablement ces espaces menaceés pour garantir l'avenir des formations boisées et la perennité des produits que les hommes en retirent. Pour cet aménagement durable, la connaissance de l'impact du betail sur la végétation est essentiel.

L'étude a été menée dans les environs de Korhogo. Le climat y est de type soudanais humide. L'unique saison des pluies, de mai à octobre, apporte 1.200mm d'eau. Les regimes alimentaires des bovins, ovins et caprins ont ete étudies dans un dispositif experimental récent (1995) par la methode des "coups de dents" décrite par Guerin en 1988. L'impact de deux troupeaux, l'un exclusivement bovin l'autre mixte: bovins + ovins + caprins, sur la végétation herbacée et ligneuse est analysé comparativement et une mise en defens. La registration des arbres a, tout particulierement, etait suivie par comptages, mesures et cartographie sur des parcelles unitaires de un are (5 pour chaque troupeau + 10 mises en défens). Apres trois anneés, il est possible d'estimer l'effet du pâturage sur la régénération des especes, et s'il y a un risque de modification irreversible du milieu.

Les bovins consomment préférentiellement, 90% les graminées, les ovins mangent 80% d'herbacées et les caprins 80% de ligneux et subligneux.

Apres trois ans, le développement de la végétation ligneuse est fortement reduit par le troupeau mixte. L'abroutissement, par les caprins essentiellement, des branches basses et l'écorage plus ou moins important des troncs, ralentissent la croissance des arbustes. La consommation des jeunes semis, sauf pour quelques rares especes particulières, empêche la reconstitution de la strate arbustive.

Au contraire, l'espace est récolonie par les ligneux dans les parcelles bovines exclusifs. Le houppier des plants dejà installes se développe sans contrainte. Pourtant, la régénération des ligneux ne peut pousser et le tapis herbacé est fortement degradé par la surconsommation des graminés les plus appetées. La mise en defens favorise la croissance, lente, des régénérations des ligneux.

Afzelia africana: une Essence Précieuse et Plastique

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Afzelia africana est un grand arbre de la famille des Césalpiniacées dont le bois, de grande qualité, est recherché par les industriels du bois sous le nom de “lingué” ou parfois de “doussié”. Son fût, généralement droit et cylindrique, est court en zone de savane et long et parfaitement élagué en zone forestière. De plus, c’est une espèce à usages multiples au feuillage fourrager, aux graines oléagineuses fréquemment utilisées en médecine traditionnelle.

L'aire naturelle d'*Afzelia africana*, en Afrique occidentale et centrale, est vaste. C’est une des rares espèces arborées dont l'aire de répartition va des zones sèches (précipitations de 900mm/an) jusqu'à la forêt dense semi-décidue. Ce n’est pas une essence grégaire. Les arbres sont généralement disséminés, très rarement en bouquets. En milieu naturel, cette espèce ectomycorhizienne montre une grande plasticité vis-à-vis des conditions pédologiques. Néanmoins, plus le climat est sec, plus elle recherche des sols profonds, bien draînés et approvisionnés en eau.
Cependant, *Afzelia africana* risque de disparaître car cette espèce est très sensible aux feux qui empêchent sa régénération naturelle.

L’élevage en pépinière est aisé et court (plants en pots) si un prétraitement adéquat est appliqué aux graines. Des essais en plantation en plein, sans ombrage, ont été réalisés en Côte d’Ivoire, aussi bien en zone de savane, de forêt dense semi-décidue que de forêt dense sempervirente. En zone de savane, la croissance initiale est lente (2,6 m de hauteur en moyenne à 8 ans) mais fortement influencée par les conditions de sol : elle peut atteindre 1 cm par an en diamètre sur termitière où les sols sont les plus fertiles. En zone de forêt dense semi-décidue, la hauteur moyenne est de 16 m à 17 ans avec une croissance de 0,7 cm par an sur le diamètre. En forêt sempervirente, elle atteint 19 m de hauteur au même âge. Dans les deux derniers cas, en zone forestière, le fût libre, droit et cylindrique, peut atteindre 10 m.
On peut escompter une utilisation industrielle de qualité des bois issus de plantations. Bien que sa croissance soit assez modeste, la valeur du bois et son aptitude à croître en peuplements mono-spécifiques, font de *Afzelia africana* une bonne essence de reboisement économiquement intéressante en milieu favorable.

Mots-clés: *Afzelia africana*, bois, plantation, croissance.

Isoberlinia doka: une Essence Méconnue et Abondante pour une Production Durable de Bois d'Oeuvre en Forêts Claires Soudano-Guinéennes

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Isoberlinia doka Craib & Stapf. est un grand arbre de la famille des Césalpiniacées qui peut dépasser 23 mètres de hauteur et 70 cm de diamètre. C’est un arbre des forêts claires soudano-guinéennes

d'Afrique de l'Ouest, où il domine fréquemment au sein des forêts denses sèches dégradées par le passage répété des feux.

Le fût est généralement droit et cylindrique. Le bois parfait, brun rosé, présente des veines gris violacé d'un bel effet esthétique. Le rendement au sciage sous écorce est de 52% avec aubier et de 31% pour le bois parfait seul. C'est un bois mi-lourd, mi-dur et moyennement nerveux mais cassant. Il est utilisable pour les panneaux, la menuiserie et l'ébénisterie. Néanmoins, il est peu utilisé faute d'unités de transformation et de valorisation dans son aire naturelle.

Cette essence est délicate à élever en pépinière et sa croissance est particulièrement lente en plantation : en moyenne moins de 2 mètres à six ans au sein de parcelles de recherche bien entretenues.

En forêt naturelle au Nord de la Côte d'Ivoire, celle de Badénou par exemple, *Isoberlinia doka* est l'essence dominante tant en nombre d'individus à l'hectare qu'en volume sur pied. Cependant, le peuplement d'*Isoberlinia* est déséquilibré par une régénération réduite du fait de passages très fréquents du feu. Cette insuffisance de régénération ne permet pas de garantir l'avenir de cette espèce.

Il est impératif de supprimer les feux pour permettre à *Isoberlinia* de se régénérer. Après exploitation à blanc-étoc de la forêt et trois années de protection, on observe une forte régénération de *Isoberlinia*, aussi bien par rejets et drageons que par semis. Par contre, dans la savane boisée non exploitée, sous le couvert des arbres, les semis naturels et les drageons sont rares ; les rejets proviennent essentiellement de souches régulièrement endommagées par les feux.

Ainsi, dans les espaces régulièrement parcourus par les feux de brousse, l'espèce reste néanmoins abondante dans la strate de régénération car les souches résistent aux feux courants. Par contre, ces souches et les jeunes plants traumatisés ne donneront jamais de bois d'oeuvre même si les feux sont arrêtés. Les déformations subies dans le jeune âge semblent rédhibitoires et se concrétisent à l'âge adulte par une pourriture humide du bois de coeur, parfois sur deux ou trois mètres de haut.

Mots-clés: *Isoberlinia doka*, bois, croissance, régénération, aménagement.

Mixed Stands Silviculture and Management in Portugal - Preliminary Results

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In Europe there is a renewed interest in the mixed-species stands creation and, when the sites permit, in the steady change from pure to mixed-species stands, of softwood with broadleaves. This interest is due to the knowledge that mixed-species stands are, in general, ecologicaly more stable and less susceptible to the risks of natural catastrophes (wind, fire), provide a better quality A-horizon soils, improve the natural stand regeneration conditions and, guarantee the benefits from associate forest products.

In Portugal, three research studies are being developed whose results will allow a definition of mixed stands silvicultural and management models, providing an important contribution for the social, economic and aesthetical valuation of the rural landscape. A set of six research plots, organized in a randomized block design with two replications, were measured in Rossas, Bragança (northeastern Portugal). These plots are designed to analyse the *Castanea sativa* productivity under different species composition and management alternatives: control; selective removal of *Pinus pinaster*, selection and tending of *Castanea sativa* crop trees; removal of *Pinus pinaster*, selection and tending of *Castanea sativa* crop trees. *Pinus pinaster* top height (15m) at plot installation age (24yrs) places the study location in a medium-high site class (20m at 50yrs). The basal area increment (95-98), for the control plots, is 0.9 m^2/ha for *Castanea sativa* and 1.6 m^2/ha for *Pinus pinaster*.

A set of twenty one research plots, organized in a replacement series of a substitutive randomized block design, with seven types of mixtures and three replications, were measured in Bemlhevai, Bragança (northeastern Portugal). These plots are designed to analyse the growth and potential productivity of *Castanea sativa* and *Pseudotsuga menziesii* mixed stands and the long-term individual performance of *Castanea sativa* component. *Castanea sativa* top height values range from 3.1 to 9.1 m, in monoculture, and from 2.6 to 9.4 m in mixture. For *Pseudotsuga menziesii*, these values range from 3.2-11.7m in monoculture, and from 2.8-12.9m in mixture. A clear benefit on both species productivity is steadly increasing with time in mixtures 1, 2 and 3, in which the interspecific competition effect is

present, corresponding to relative yield total values greater than 1,0. From the economic point of view, the most productive mixtures (1 and 2) are also very competitive when compared with the traditional solution of *Castanea sativa* monocultures in most mountain regions.

A set of three research plots were installed and measured in Lousã mountain (central Portugal), covered with *Pinus pinaster*, *Castanea sativa* and *Quercus* spp. These plots were designed to analyse species composition changes under different thinning alternatives: control; 30% removal of crown cover; 50% removal of crown cover, providing mixed compositions, ecologicaly and environmental more balanced, in the scope of a modern multifunctional silviculture that harmonizes the wood production with other social forest benefits. *Pinus pinaster* is dominant in all the plots, with an average of 90% in basal area and ranging from 44 to 71% in number of trees, but only with an average of 37% in crown cover. The crown cover removal under the different thinning alternatives requires an accurate selection criteria, using plots crown charts, in order to mantain a dynamic balance in the species composition.

Present Status of Cropland Agroforestry Systems of the Northern Bangladesh

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Keywords: Cropland, Bangladesh, component, arrangement pattern, interaction, rotation

An exploratory survey to assess the present status of cropland agroforestry systems of the Northern Bangladesh with respect to component, arrangement pattern, tree density, interactions of the components and management interventions adopted by the farmers were carried out over a period of one year (1999). From the 26 districts of the Northern Bangladesh, one district (Jhenidah) was picked randomly followed by the random selection of a village (Sabek Binni) within it. The village Sabek Binni shares important environmental, farming system and socioeconomic characteristics widely found in Jhenidah district. A complete list of the farmers with cropland agroforestry of Sabek Binni was made and 30 farmers were selected randomly from this list for detailed study. A species inventory followed by PRA techniques involving combination of semi-structured interview, participatory observation, and group discussions were adopted to collect the data.

The 30 crop fields surveyed varied in size from 0.24-0.85 ha with a mean of 0.58 ha (sd±m=3.89). Farmers grew different varieties of rice, wheat, and seasonal vegetables (e.g., *Phaseolus spp., Dolichos lablab, Ipomoea batatus, Colocasia antiquorum,* and *Cucumis sativus*) in their crop fields, either in mixture with trees or in patches, all primarily for household consumption and for sale in case of any remaining surplus. *Mangifera indica, Phoenix sylvestris, Acacia nilotica* and *Dalbergia sissoo* were deliberately retained in the crop fields, and recorded from all the farms surveyed. Apparently, these were the species preferred by the farmers for multiple outputs and commercial values in the region. Three types of arrangement patterns of trees in the crop fields were identified: alley cropping, scattered planting and border planting. The arrangement patterns depended on the types of the trees grown and size of the lands. Fruit trees were usually grown in larger sized lands (≥0.4 ha in size) in alleys with regular spacing (2.7 m x 13.5 m for *Phoenix sylvestris* and 4.5m x 13.5m for *Mangifera indica*). Timber species were grown in smaller sized lands (<0.4 ha) with scattered distribution. In both cases, a minimum of 9m patch surrounding the plot from the aisle was retained for growing agricultural crops. Border planting was restricted only in the common aisle of two successive lands owned by the same landlord and both fruit and timber trees were grown in mixture with a tree to tree distance of 4.5-9m in line. Mean tree density ha^{-1} varied from 61-102, 40-52, and 50-70 for the arrangement patterns alley cropping, scattered planting, and border planting respectively. Farmers were well aware about the competitive interactions between the components. Farmers opined that with the augmentation of tree canopy and root system, crop losses became significant after 3-5 years of tree planting due to competition for light and nutrients. Farmers maintained a regular pruning schedule to keep competition for light and nutrients between trees and crops to a minimum. Moreover, different tree based products (e.g. fruits, molasses, raw materials of handicrafts, fuel, timber etc.) which were becoming available at that stage compensated their crop losses even many folds. Farmers maintained rotations of 12-15 years for *Acacia nilotica* and *Dalbergia sissoo*; 20-25 years for *Phoenix sylvestris*; and 40-45 years for *Mangifera indica* in the crop fields.

Evaluation of Thinning Effects on the Productivity and Regeneration in Conifer Plantations, Using the Canopy Dynamic Model

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Keywords: thinning, canopy structure, conifer plantation, gap

The thinning makes changes on the stand structure, productivity and microclimate in the stand through the changes of the canopy structure, like the creation of the artificial canopy gaps. The author constructed the canopy dynamic model for simulating the changes of foliage distribution, stem volume increments and spatial distribution of photosynthetic photon flux density (PPFD) in the stand during the closure of thinning gaps. The aim of the model is to evaluate the efficiency of different sorts of thinning in the plantations of conifer species, mainly *Cryptomeria japonica* or *Chamaecyparis obtusa*.

The model was composed of following four integrative parts.

1) The three-dimensional shape of canopy surface was simulated from the three-dimensional positions of the tree apex and the crown form, which was represented by the simple formula.

2) The plot was divided into small (0.2m x 0.2m x 0.2m) cubes. The foliage-mass density within the small cube in the canopy was determined from the location of the cube (the vertical distance from crown surface and the horizontal distance from the stem), and the tree size. Hence, the foliage distribution within the individual crown or within the stand could be estimated from the location of the stem base, the tree height, and Dbh of individual tree.

3) The stem volume increments and the stability of the crowns, which may relate with the resistance to the wind damages or heavy snow damages, were determined from the foliage distribution in individual trees.

4) The spatial distribution of PPFD in the stand was simulated from the estimated hemispheric diagram based on the spatial distribution of foliage and stems, and the topology of the ground.

The verification of this model suggested its availability as follows.

1) The simulated reduction of canopy gap ratio after thinning showed similar pattern and the speed to the actual reduction, which were reported previously.

2) The simulated foliage mass, stem volume increments and production diagram of individual trees corresponded to the measured values.

3) The PPFD in the stand was simulated well in daily totals. The model also predicted a frequency pattern of PPFD with sufficient accuracy for evaluating the thinning effects on light availability. Consequently, it is possible to predict the foliage distribution, the stem volume increments, and the light availability in the stand, although the model requires only the three-dimensional position of the bases and initial heights of individual trees as the individual data. The practical information for thinning effects on the productivity of stem volume, the stability of crowns, and the light availability at the forest floor was obtained by running the simulation model with different thinning intensities or types, as follows.

1) The increment of stem volume increased with thinning intensity. The line thinning showed less effect on the foliage weight that other thinning type did.

2) The shifting upward of foliage distribution accompanying with tree-height-growth was reduced with an increasing in the thinning intensity.

3) The line thinning enlarged the eccentricity of crowns more than other thinning type did, showing the tendency to lose the horizontal stability of crowns.

4) Spatial variance of the assimilation rate of seedlings was estimated in the plantation which was thinned by line thinning. The gap size influenced on the assimilation rate of seedlings beneath the canopy gap, while around the gap, it had a little influence on the changing pattern of the assimilation rates with the distance from gap edge.

Effet du Délianage sur la Régénération Naturelle en Forêt Dense Humide Soumise à un Traitement d'Éclaircie

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Mots-clés: forêt dense humide, régénération naturelle, pérennisation, délianage, eclaircie, Côte d'Ivoire.

La régénération naturelle est l'élément principal de la pérennisation d'une forêt. Les processus de régénération apparaissent dans des conditions naturelles (chutes d'arbres) ou suite aux interventions humaines (exploitation forestière). Cette étude, débutée en 1993, a pour but d'apprécier l'impact du délianage sur la régénération naturelle en forêt dense sempervirente. Elle entre dans le cadre des recherches visant à offrir des conditions favorables optimales à la régénération naturelle.

Quatre années après la mise en place de ce dispositif, les résultats partiels obtenus sont les suivants: (1) on observe une disparition progressive des lianes quel que soit le traitement (éclaircie ou témoins non éclaircie); (2) le délianage favorise une régénération naturelle des essences principales dans les parcelles éclaircies avec un taux d'augmentation de 2%. Cette régénération est plus importante dans les parcelles éclaircies que dans les parcelles témoins non éclaircies. C'est l'inverse en ce qui concerne les essences secondaires; (3) le délianage semble favoriser l'apparition de nouvelles essences principales telles *que Pycnanthus angolensis* (Ilomba), *Piptadeniastrum africanum* (Dabema), *Lovoa trichilioïdes* (Dibetou), *Canarium schweinfurthii* (Aiélé) et *Eribrema oblonga* (Bi).

Rehabilitation Techniques for Degraded Mixed Dipterocarp Forest in Consideration of Ecological Process

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Secondary forests have been spreading by mechanized logging, illegal logging and slush-and-burn agriculture in mixed dipterocarp forests. Proper methods of rehabilitation technique are needed to prevent degradation of these secondary forests. Objective of this research is to study effects of several rehabilitation methods on different types of degraded vegetation by means of, particularly, enhancing natural regeneration and application of enrichment planting in collaboration with Gadjah Mada University. The research station was in Jambi province, central Sumatra, Indonesia.

Tree vegetation around the research station is roughly classified into residual forest after logging, secondary forests after abandonment of slush-and-burn agriculture, rubber plantation, *Imperata cylindrica* grassland, etc. Methods of reforestation should be adapted to the degraded conditions of vegetations and their aims at reforestation. Some methods have been considered like an enrichment planting of dominant species, a mix-planting of dipterocarps with fast-growing species, an underplanting by natural pioneer trees, etc. 1) Releasing trees for creating artificial gaps enhance the growth of natural dipterocarp saplings, however the population structure may not become steady. 2) Enrichment planting exceeds the natural sapling growth under the forest. The species and releasing intensity should be best in moderate light intensity. 3) Mixed planting of dipterocarp seedlings with fast-growing trees or rubber trees. Both of the above methods are applicable to rehabilitate the logged-over forest as a practical method. Combination should be more considered on silvicultural system between the enhancement of natural saplings and the enrichment plantings. Further, our project has effectively combine seedling production of dipterocarps by practical inoculation method of ectomycorrhizal fungi.

The important thing is how to integrate these ecological techniques to the actual reforestation and rehabilitation projects in consideration of cost-performance. These problems also shall be discussed using some cases.

Regeneration of *Cryptomeria japonica* on Stumps in Natural *C. japonica* Forest in Northern East Region of Japan

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It is well known that fallen logs and stumps are often important regeneration sites for conifer species. To clarify the mechanism of regeneration of *Cryptomeria japonica* on stumps, a research plot (1.05 ha) was established in Sado natural forest reserve in Akita pref., Japan. Elevation of this plot is 950m a.s.l. and average annual temperature is 5.3°C. Snow depth in winter is about 4m.

DBHs (diameter at breast height) and heights of trees (DBH > 5 cm) were measured in 1992. In this forest, many *C. japonica* were seen on stumps. The regeneration sites were divided into 3 categories; forest floor, fallen logs and stumps. The size of all stumps and logs was measured. The density of trees of *C. japonica* and other species in each regeneration site was compared. Main species in this plot were *C. japonica* and *Fagus crenata*. *C. japonica* occupied 28% of population and 70% of relative basal area. Though the area of stumps is 3% of this plot, 45% of *C. japonica* trees grew on stumps. The density of *C. japonica* trees is 26 times as much as that on the forest floor. The area of fallen logs is 3% of this plot and only one *C. japonica* tree was seen there. Only one tree of *F. crenata* grew on stumps and no trees were seen on logs. So in this forest, stumps are used mostly by *C.*

japonica but neither the forest floor nor fallen logs are suitable regeneration sites for *C. japonica*.

Stumps were classified in 3 types according to vegetation on them: stumps on which *C. japonica* grew, stumps where broad leaved trees grew, and stumps on which no trees grew. The mean diameter and mean height of 3 types of stumps was compared.

Though we could not see any significant difference of mean diameter of stumps in these three classes, the mean height of stumps on which *C. japonica* grew was significantly higher than that of the other two stump classes. It is suggested that the height of stumps is an important factor whether *C. japonica* trees regenerate on them or not.

Seed fall and the dynamics of current seedlings of *C. japonica* have been researched in 32 quadrats (2 x 2 m) on the ground and 14 stumps for 4 years. In winter, under the snow cover, 60% of current seedlings were killed on the ground, though the rate was 20% on stumps.

Survival rate of *C. japonica* seedlings in 3 years is 2% on ground and 20% on stumps. These results confirm our findings regarding the importance of stumps, and stump height, on the regeneration patterns of *C. japonica* in this study.

Underlying Causes of Tropical Deforestation by Modeling Stock and Change Variables at Subnational Level

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Underlying causes of tropical deforestation were examined in this study. Empirical analysis was based on FORIS Database by FAO and on National Bureau of Economic Research data of Harvard University. FAO data included original random year observations from 1953 to 1991 on forest areas at subnational level. At the largest data set case, 477 observations were used. This is 5-6 times more than we have seen used in other similar deforestation modeling.

Both stock variables (forest area, forest cover, nonforest area, nonforest cover) and change variables (forest area and forest cover changes) were used as dependent variables in the modeling. Reliable change variables are in limited supply. We used 54 subnational observations from 13 Asian and Latin American countries. Independent stock variables included sizes of national and subnational population, national income (GDP) levels, sizes of ecological zones, data reliability estimates plus geographic dummies. Whereas in change modeling we applied only national and subnational population and national GDP as independent variables.

We used multiple regression analysis with ordinary least squares (OLS). All the variables were transformed into natural logarithms. In the stock variable modeling we used first only stock variables and then respectively only their ratio-variables. Regular statistical tests with residual analysis were carried out. In order to rank the independent variables in the order of causality we computed standardized regression coefficients for the independent stock variables.

Our results show that increasing population and GDP expand deforestation at low income levels. This result comes out both from our stock and change variable modeling. This is our prime finding which has global relevance, because other studies have not produced convincing results in this front so far. This causal relationship has been under debate both in the Intergovernmental Panel on Forests and in the Intergovernmental Forum on Forests in the United Nations. We, however maintain a hypothesis, that after a certain per capita income level threshold point, increasing income will start slowing down deforestation and expanding forest area (environmental Kuznets-curve).

Furthermore, the results suggest that ecological conditions as well as the quality of data play decisive roles in deforestation. Ecological conditions are linked to economic accessibility of forests, while the quality of forest data may be linked to the general information infrastructure of a region and hence reflects risks inherent to economic agents in the deforestation processes. One specific value of our modeling is that we experimented with twelve different independent variables. A major debate in deforestation modeling has concerned the relevant choice of the dependent variable. Our six variants of valid deforestation variables proved operational. The respective change variables of population and GDP supported our hypothesis of these relationships. We learned from the stock variable modeling, that when we can identify the factors which control the variation of forest area or relative forest cover at the subnational level, we can also understand better the underlying causes of deforestation. After all deforestation is defined as a decrease in forest area.

Testing Afforestation Methods with *Pinus halepensis* in a Semiarid Mediterranean Site

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A factorial field experiment was conducted in a degraded semiarid site of SE Spain, during 6 years, to test the effectiveness of mycorrhization and several soil preparation techniques on afforestation with *Pinus halepensis*. The mycorrhizal treatments tested were nursery inoculation with *Pisolithus arhizus* and forest soil addition to the planting holes. The soil preparation treatments were terracing (mechanical and manual) and addition of organic amendment (Urban Solid Residues).

One year after planting, the study revealed significant differences in mycorrhization levels, frequency of mycorrhizal species, fine root production and growth between the inoculated seedlings and the non-inoculated controls. Inoculation with *P. arhizus* gave better pine growth and mycorrhization rates than the addition of forest soil. Both mycorrhization treatments were particularly effective in combination with mechanical terracing. The pines survival rate was significantly higher in the subsoiled mechanical terraces than in the manual terraces, due to the much greater efficiency of the former to increase the water availability into the soil profile.

The addition of the organic amendment, corrected many of the negative effects that mechanical terracing usually exerts on the physical and chemical properties of soils and fostered the hydrological benefit associated with this land preparation method. The organic amendment had no apparent negative influence on the seedlings mycorrhization level and significantly improved pine growth. Six years after plantation, the *Pinus halepensis* seedlings showed a maximum development in the mechanical terraces with USR, where fertility levels were the highest, soil physical properties were the most favourable and soil moisture availability was the greatest among the land preparation methods tested. The seedlings growth increase with the treatments can be due to the change in soil conditions (increased fertility and soil aireation) and probably to a mycorrhization effect upon water relations, although this has not been clearly demonstrated. The results obtained show that both the survival and the growth of *Pinus halepensis* seedlings can be improved, assuring the success of afforestations even under such harsh drought conditions as those recorded in the experimental area during the 1994, 1995 and 1998 seasons.

Seed and Seedlings Management for Sustainable Dipterocarp Plantations

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Dipterocarps, the rainforest tree species of South and Southeast Asia, are of great economic importance because of their timber. In Bangladesh *Shorea robusta* and *Dipterocarpus turbinatus* are the prime species of *Dipterocarpaceae*. These species are generally propagated by seeds, which are difficult to germinate and lose their viability within a few days. We devised a method for large scale production of plantlets and their propagation all the year round. Seed of *S. robusta* and *D turbinatus* were collected at full maturity. They were kept on the soil at a shady place. Within two days seeds were found to have germinated. Each germinating seed was then placed on the polythylene bag containing alluvial soil and compost (4:1). After six months when the plantlets wer 40-50 cm in height, they were transferred to another place. In an open place soil was dug out upto 25 cm depth. A thick black polyethylene sheet was spread on the pit. Polybags containing plants were kept on it at a distance of 15 cm from each other and filled up with alluvial soil and compost (4:1). After one year the plants were 125-150 cm in height and the roots, instead of penetratig the soil, spead on the plyethylene sheet. The technique was convenient since when the plants were uprooted from the bed for transplanting in the field, practically no injury occurred and 95-100% plants survived. The technique is quite applicable to obtain large scale high quality seedlings and feasible in sustainable management for plantations.

The Urban Forest of Tomorrow - Pre-commercial Thinning Adapted for Use in Urban Areas in Sweden

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The Swedish urban forests originate mainly from the old production forests and are characterised by the forestry in practise at the time of urbanisation. Forests in the central parts of older urban areas are therefore generally old and senile, while forests situated in newly urbanised suburbs are relatively younger, with proportionally more young stands. In many instances, the areas of young growth in urban green areas of Sweden are in urgent need of management. The aim of this study is to demonstrate the creation of multi-functional urban forests by means of silvicultural thinning techniques to enhance the biodiversity of a regenerating mixed young forest. Twelve different small forest compartments were identified on 2.1 ha of 20-year old forest, all of which were subjected to their first silvicultural thinning. Every forest type services a specific function. The twelve compartments consists of the Rowan Forest, The Children's Forest, the Glade, the High Forest-like Pine Forest, the Untended Forest, the Mixed Forest, the "Walk the Dog" Forest, the Birch Forest, the Ever Juvenile Forest, the Willow Forest, the Multilayered Spruce Forest and the Aspen Forest. For each forest type silvicultural prescriptions are recommended to achieve and sustain the amenity requirements of an urban forest. A variety of silvicultural treatments are suggested for all of these categories in order to create and maintain forest structures adapted to the actual functional use of the forest.

A Soil Seed Bank in a Mature Conifer Plantation in Japan and its Development after Logging

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Keywords: Soil seed bank; Conifer plantation; Secondary succession

We conducted a study on the composition of buried viable seeds and their development after logging in a mature conifer plantation in order to understand the mechanism of secondary succession. The study site is located in a 76-year-old (in 1998) *Cryptomeria japonica*-*Chamaecyparis obtusa* mixed plantation. Canopy trees were felled on December 1997 and harvested on April 1998. Study sites were established both in the logged area and the reserved control area on March 1998. Integrated insolation in the reserved site was ca. 7% of that in the logged site. For seed bank analyses, soil samples (0.06 m^2 x 5cm in depth) were collected (n=35 for the reserved site and n=30 for the logged site). Each sample was put into a planter and incubated at the nursery for 120 days. Germinated seeds were identified and then removed. Quadrats (1 m^2) were established for seedling census both in the logged site (8 quadrats) and the reserved site (12 quadrats). Emerged seedlings of all woody species and large herbaceous species were tagged once on a monthly basis from May to October in 1998 and their numbers and the heights were recorded. We regarded the number of the emerged seedlings in the planter as the number of buried viable seeds in the field.

The density of buried viable seeds was 1.075 m^{-2} (62 species) for the reserved site and 1.792 m^{-2} (57 sp.) for the logged site. The dominant species of both sites was *Hydrangea luteo-venosa*. Several herbaceous species and *Rubus* spp. were also dominant. The large difference on species composition between soil seed bank and actual vegetation was observed. The soil seed bank was composed of 62 species in the reserved site, while actual vegetation on forest floor was composed of 87 species. There were thirty species common both in the soil seed bank and in the actual vegetation. However, 18 species out of those 30 common species produced no seeds in 1998. It implies the buried viable seeds of many species would be dispersed from the exterior of the study site or possibly dispersed in the interior of the study site when plantation were established or when thinning was carried out.

The density of current-year seedlings was 12.4 m^{-2} (18 species) for the reserved site and 33.4 m^{-2} (28 species) for the logged site. *Abies firma* (8.0 seedling m^{-2}) was dominant in the reserved site, although several pioneer species such as *Macleaya cordata* (4.0 seedling m^{-2}), *Mollotus japonicus* (3.8 seedling m^{-2}) and *Rhus javanica* (2.8 seedling m^{-2}) were dominant in the logged site. The percentage of emerged seedlings to the population of the buried viable seed was 7.7% for the logged site and 1.7% for the reserved site. In spite of the high density of buried viable seeds, most of them did not emerge even in the logged site.

In the logged site, current-year seedlings showed rapid height growth. Two exotic species, *Crassocephaium crepidioides* (mean height=94.3cm) and *Erechtites hieracifolia* (H=126.0cm), were abundant among them, although the densities of seedlings were small. *Mollotus japonicus* (H=25.5cm), *Macleaya cordata* (H=16.8cm) and *Rhus javanica* (H=15.8cm) followed them. In contrast, no seedlings grow over 10cm in height in the reserved site. It is suggested that dominant species after logging is not correlated closely with the density of their buried viable seeds.

Growth and Propagation of Selected Species of *Nepenthes*

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Keywords: *Nepenthes,* growth performance, vegetative propagation, micro-propagation

Nepenthes (commonly known as pitcher plants) of which there are 17 species recorded in Sarawak, thrive on the marginal soil along the roadside and secondary forests. Although they have been gazetted as "protected species" in Sarawak, they are nonetheless harvested extensively for use in traditional medicine and for sale as ornamentals. Preliminary studies were carried out to examine the growth performance of *Nepenthes ampullaria* Jack and *N. mirabilis* (Lour) under low light intensities (shade) and the potential of producing the plants through vegetative propagation by tissue culture and rooting of cuttings. The results showed that *Nepenthes* could survive under low light intensities (85% shade) with no significant reduction in photosynthesis rate and its growth. In fact, the plants grown under low light intensities produced more and larger leaves as well as more and longer pitcher compared to those grown under direct sun light. Vegetative propagation using nodal cuttings showed great potential as an alternative to propagate the species with 42.5% overall rooting success for *N. mirabilis*, 22.5% for *N. ampullaria* and 19.2% for *N. rafflesiana* with the application of industrial rooting hormones. *Nepenthes mirabilis* produced the best results with over 60% cuttings treated with Seradix-1R rooted, followed by *N. rafflesiana* (60% using Seradix-2 R). Experiment on micro-propagation through seeds managed to get 25% of the seed germinated on ½ MS with 6% sucrose media and these seedling were either grew into single seedling or form callus (+ 5.0/L, 2,4-D). The major problem encountered during in vitro germination was the high contamination of seeds by fungi and bacteria although the seeds were surfaced sterilized by soaking the seeds in 30% Chlorox R for 20 minutes. Once the seeds germinated there was no more contamination. Each callus seed produced 150-300 shoots and they were subcultured on ½ MS + 2mg/l IBA.0 5mg/l BAP. After four subcultures it is possible to generate about 150,000 new plantlets in 48 weeks.

Role of Tree Stands in the Rehabilitation of Degraded Lands of Auroville, India

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Agricultural development in the country has converted vast areas of forestland to meet demands on food production. Large chunks of such converted lands were mismanaged in the past without recourse to scientific methods of soil and water conservation. This brought degradation of these lands to the level of abandonment. Protection forestry is now extended to such agrarian regions through planting of fast growing exotics and other indigenous tree species supported by meaningful soil conservation strategies for the past two to three decades. The result of such endeavor against severe odds is the successful greening of wastelands of Auroville, Tamilnadu, India. Investigations were undertaken to assess the long-term effect of these tree planting activities on the amelioration of the highly degraded lands. The study was carried out in 20-year-old mixed stand dominated by *Entrerolobium cyclocarpum* and in the adjacent open area which has not yet been afforested. The objectives of this study were to observe the possible changes, if any, in the microclimatic conditions and the status of microbial proliferation. The productivity of this stand was estimated using biometrical observations made on the trees existing in the demarcated sample plots. Soil temperature was recorded periodically at two different depths (at 5 and 10 cm depths) both under tree stands and in the open site. Similarly soil moisture was estimated gravimetrically both under tree stand and in the open at the two different soil depths. Air temperature was also recorded in these two study sites. Soil samples were collected at two different depths both under tree stand and in the open for enumerating the population of bacteria, actinoomycetes and fungi adopting standard procedure (Parkinson et al. 1971). Tree stand registered mean height of 16.4 m and basal area of 330 m^2/ha. The net primary productivity of this tree stand was 21.2 t/ha/yr. Besides this productivity, the tree stands ameliorated the microclimatic conditions of the site which in turn supported proliferation of microbial population. While the mean monthly soil temperature in the barren site reached 42.3°C. The fluctuation of soil temperature (the difference in the soil temperature recorded at 8 and 12 hrs.) on an average was highest (12.8°C) in the treeless open ground and was only 2.6°C. under the tree canopies at 5 cm depth. Further, the tree stand restricted the fluctuation of air temperature from 6.6 to 9.0°C.

Tree stand enhanced the soil moisture content to 2.8% from that of in the open site (0.7%). This ameliorative effect of tree stands caused proliferation of soil microflora, which serve as an index of site enhancement Increased bacterial population were noticeable under tree stands (5.3 x 106 per gm. of soil) as compared to the barren soil (1.8 x 106 per g soil). In general the treeless site supported low population (12 x 105 per g soil) of actinomycetes compared to the afforested site (21 x 105 per g soil). Similarly, the soils under tree stand harboured more fungal population (21.3 x 104 per g soil) than the barren soil (13.7 x 104 per g soil).

Biomass Production in an Age Series of *Bambusa bambos* Plantations

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Keywords: Biomass, age series, *Bambusa bambos*. Plantations mean periodic increment, net primary production.

Bamboo is one of the most useful plants known to mankind and approximately 2.5 billion people, mostly the poor in developing counties, depend on it for a wide range of uses and livelihoods. Sustained availability can be ensured only by raising extensive bomboo plantations. The growth and biomass production in age series (1-10 years) of *Bambusa bambos* plantations were studied and compared with its growth in natural and plantation stands. Culm recruitment was monsoon dependent and was enhanced by light rains preceding the onset of monsoon. The average daily height growth was 30 cm and independent of monsoon rainfall.

In order to estimate the total biomass in relation to organic productivity, 15 culms were randomly selected from each age group. For reasons of economy the rhizome was excavated only from three in each age group. After felling, the total height of each culm, diameter at breast height (DBH), basal area and number of nodes were measured and subdivided into leaves, branches, culm and rhizome. Fresh weight of components was estimated in the field and sub-samples from each component was brought to the laboratory in plastic bags. The sub-samples were then oven dried at 103 + 2°C at constant weight. From the oven dry weight of the samples the total standing biomass of each age group was calculated by multiplying the total number of the bamboos of different ages with the average dry weight of the sample.

There was linear increase of the total biomass of all compartments with the age of the plantations. Biomass was distributed between culms (81%), branches (14%), leaves (1%) and rhizome (4%). The total biomass ranges from 2.3 t/ha (1 year) to 297,9 t/ha (6 years) and then decreased to 15,6 t/ha (10 years). The number of culms produced per clump its height and DBH was found increased up to 6 year, later it found decreased. Ultimately the accumulation of biomass also decreased after 6 years. The mean annual biomass production was 49,6 t/ha/year over the 6 period. The mean periodic increment and net primary production was highest in the 5 year, during which a peak of 124 t/ha/year in net primary production was obtained.

Changes in Plant Species Diversity in a Restoration Sequence of *Quercus variabilis* Forest Stands in Baotianman Mountain

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Changes in plant species diversity in a restoration sequence of *Quercus variabilis* forest stands in Baotianman Mountain were studied. The result show that species richness and species diversity indices of different layers in forest stands with different restoration time are as follows: herb layer>shrub layer>tree layer. Most differences between species diversity of tree layer, shrub layer and herb layer in the forest stands were not significant. Only differences between species richness of tree layer and herb layer and that of shrub layer and herb layer were significant. Differences of tree species diversity among the forest stands were more significant, differences of shrub species diversity were significant, and differences of herb species diversity were not significant.

Seedling Survival and Growth of Canopy Trees Across Openings of a Sri Lankan Rain Forest.

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The basis for the management of native forests is an understanding of the micro-site requirements necessary for satisfactory regeneration establishment of late-serial canopy trees. This study examines the performance of planted seedlings for the development of enrichment planting guidelines, and for constructing treatments to test natural regeneration methods in mixed-dipterocarp forests of the hill region of southwest Sri Lanka. Four canopy tree species were planted in mixture in five micro-sites that represented the understorey-gap continuum. This was replicated across three canopy openings that were located in different parts of the rain forest topography (ridge, middle-slope, valley). We selected two species of *Mesua* (*M. thwaitesii, M. ferrea*) and two species of *Dipterocarpus* (*D. hispidus, D. zeylanicus*). Micro-sites were located in the forest understorey on the southern side of the canopy opening; on the outside southern edge of the canopy opening; the opening center; on the outside northern edge; and the northern understorey adjacent to the canopy opening. Seedlings were planted and monitored for growth and survival over a two year period after which a sub-sample was taken for estimation of dry mass and proportional allocation to root, leaves and stem. The remaining seedlings were monitored for growth and survival for a further two years. Results demonstrate clear differences in survival and growth among species in relation to micro-site. Both *Dipterocarpus* spp. had low survival in the forest understorey as compared to *Mesua* spp. Trends in understorey mortality were most pronounced on the ridge site for all species, except *M. ferrea*, and least pronounced in the valley site. *M. ferrea* had greatest growth and mass, with greater allocation to roots, in the ridge understorey micro-sites as compared to the other species. *D. zeylanicus* exhibited the greatest height growth (after 2 and 4 years) and dry mass of all species, but this was restricted to the centers of the canopy openings on the valley and middle-slope sites. *M. thwiatesii* had greater growth than the other species in understorey sites of the valley. Results suggest *Dipterocarpus* spp. to be intermediate in shade-tolerance, with over 90% of the seedlings dying after 4 years beneath the forest canopy. Higher rates of mortality were recorded in those circumstances for *D. hispidus* than *D. zeylanicus*. Both *Mesua* spp. were more shade-tolerant, but *M. ferrea* was the most tolerant of dry sites in the forest understorey, as compared to the other species tested. Differences among species are discussed in relation to their known site affinities within the forest. Finally enrichment planting guidelines are suggested.

Factors Influencing the Degradation of Natural Forests and Conservation Programmes in Karnataka State, India

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Karnataka state is situated in the South -West of the Indian peninsula with an area of 192000 sq. kms. (19.2 million ha) and a population of about 44.8 million (1991). With an average growth rate of 2.066 percent per annum during 1981-91, Karnataka is one of the fastest growing states in India. The population projections are 49.18 million for 1996 and 53.73 million for 2001. It was estimated that an area of 38324 sq. kms. is under the control of Karnataka forest department, more than 50 percent of the area of forests is highly degraded because of the overexploitation. In Karnataka only 10 % of the total geographical area is under good tree cover. The majority of the rural population are entirely depending on the forests for fuel wood and other basic needs. The poster comprehensively reports on the reason for forest degradation in the state and the measures taken by the government, and the national and international non-governmental organisations (NGO's) to protect the natural resources. The strategies for conservation and sustainable management of forests in Karnataka are discussed in detail.

Agrosilvicultural Models for Small Farmers in the Coastal Region of Paraná State, Brazil

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Keywords: Brazil, agroforestry, farm models, sustainable forest management

The aim of the study was to develop agroforestry models for low income small farm owners in the coastal region of Paraná state. The analysis determined the best combination of forestry and traditional agricultural crops, with the level of technology available to low income small farm owners. Incomes improve when the forestry activity is focused on the market for medicinal usage of the tree, excluding traditional wood products. Sustained yield management of native wood species with characters adequate for medicinal utilization opens up a gateway for a harmonic life between man and nature.

The study examined the economic returns from a base model reflecting the current system, and three distinct agroforestry models. The base model included income from agriculture, traditional forestry extraction and wage income, for a property with 16 ha, of which 2.6 ha was in legal forest reserve. Gross monthly per capita income was R$51.26. The first agroforestry model included agricultural income, wage labor and forestry income from extraction of medicinal plants; monthly per capita income was calculated to be R$74.85.The second agroforestry model included agricultural income, wage labor and a more sustainable agroforestry model of medicinal plant production and extraction; this provided income of R$116.42. Finally, the third agroforestry model included agricultural income, wage income, sustainable medicinal plant production, and forest enrichment; income was still higher, at R$187.02, leaving ample income available for other household investment purposes.

The authors drew several conclusions from this study about the opportunities for agroforestry in the Parana economic and biophysical environment:

1. The inclusion of medicinal products in small farm profits significantly changes household income level, making possible greater investment and growth in productive activities.

2. Participation in the medicinal product markets creates a strong incentive for conservation and presernvation of natural resources in the biome.

3. The current situation forces households to seek off-farm employment, which is contributing to impoverishment, marginalization and rural exodus towards the urban centres.

4. The current methods of protection do not offer viable alternatives for economic survival of the native population of these protected areas. The situation of conflict between humans and nature continues.

Storage of Dipterocarp Seedlings at a Slow Growth Phase as Planting Stock for Plantation Programmes

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Most of the dipterocarp species that are economically important produce recalcitrant seeds where storage of these seeds is almost impossible. Storage of the seedlings of these species at a slow growth phase has yet to be an alternative for the continuous supply of planting material for plantation and reforestation purposes. Factors that are of main concerns for storage of seedlings are the quality of such seedlings during storage and the potential of the stored seedlings to resume rapid growth on return to normal growth condition. Field studies are also necessary to determine the ultimate quality of such stored seedlings as planting stock.

Many recalcitrant-seeded species are shade tolerators. Seedlings of shade tolerators have the capacity to acclimatize to dense shade where they grow very slowly. Germinated dipterocarp seeds of *Dryobalanops aromatica, Hopea odorata*, *Shorea assamica* and *Shorea leprosula* were found to develop into seedlings when sown on the forest floor and remain at a slow growth phase for periods ranging from one to two years under relative light intensities ranging from 10% to 15%. It is similar to the wildings developed from seeds dispersed from the mother trees. These seedlings were able to retain above 80% survival rates and resume normal growth when transferred into polybags and placed in the nursery for recovery. *Shorea ovalis* seedlings, however, showed suspended growth under such condition. In spite of the excellent medium for the growth of seedlings, storage of seedlings on the forest floor was not practical as high mortality rate of above 20% was recorded due to damage by animals and fungal infestation. It is suggested to simulate the same low radiation growth environment in shade houses. This approach should allow sunlight to penetrate in the form of sunflecks and avoid excessive water vapour around the seedlings. Hundreds of seedlings can be maintained within a metre square area in root trainers depending on the size of the seedlings.

Cold storage of seedlings, on the other hand, is an established practice for many forest and ornamental species in the temperate countries where environmental conditions and seedling dormancy are major constraints to lifting and planting operations. In the tropical region, preliminary work found that the dipterocarp seedlings could not tolerate temperatures below 10°C. Further research showed that cold storage incorporated with light is even more beneficial to the seedlings. Above 80% of the seedlings of *Dipterocarpus cortunus, H. odorata, Shorea curtisii, S. leprosula*, *Shorea longisperma* and *S. ovalis* could be maintained at a suspended growth state for periods ranging from three to six months in a growth chamber of 16°C under low radiation of approximately 5 $\mu mol/m^2/s$ provided by a daylight lamp. When the cotyledons shed, these seedlings suffered from starvation. Survival rates ranging from 60% to 95% were obtained depending on the species following retrieval of these seedlings from storage condition for recovery in the nursery. For the sustainable growth of seedlings, it is necessary to grow the seedlings in the cold chamber at above their lowest safe temperatures and light compensation points for a positive carbon (C) balance. The photoperiod, however, should be held in several sessions daily if necessary to reduce the heating up in the growth chamber.

The growth of the dipterocarp seedlings in the polybags placed in the nursery can also be controlled by some growth inhibitors to avoid root bound seedlings. Seedlings of *H. odorata* could be maintained as slow growing seedlings by means of up to two applications of paclobutrazol at rates of 0.5 and 1 g/l done at an interval of three months from the age of four-month old and upwards. They could fully recover from the slow growth phase within a period of three months when application of the growth regulator was ceased and fertilizer was applied to enhance the seedling growth. The seedlings following the third application of this growth retardant showed persistent growth inhibition even after the studied recovery period. Application of gibberellic acid may be necessary to facilitate the recovery of these seedlings from the persistent growth inhibition.

Biomass Production and Nutrient Dynamics Under High Density Short Rotation Energy Plantations in North Western Hill Region of India

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Short rotation forestry is an old silvicultural practice but its commercial use in the Indian sub-continent is recent. During the last two decades fast growing tree species, especially fuelwood species, have been grown to meet the energy needs of the fast increasing human population. The two distinct objectives of energy plantations are: i) increased biomass production in a short period and ii) amelioration of marginal lands. Total aboveground biomass production and nutrient dynamics under high density plantations raised at two different locations viz.; submontane subtropical low hills (upto 914 m. a.msl) and sub temperate sub humid mid hills (915-1523 m. a.msl) were evaluated. At location 1 in low hills *Eucalyptus tereticornis* (Smith); *Melia azedarach* L. and *Leucaena Leucocephala* (Lam.) de Wit were grown each at four densities: 5000, 10,000, 15,000, and 20,000 plants ha^{-1} for nine years. At location 2 in mid hills, only *Eucalyptus tercticornis* was grown at three densities: 27,777, 12,345 and 6,944 plants ha^{-1} for six and half years.

Aboveground biomass computed on per tree as well as per ha basis differ significantly with the species and density both. *Leucaena* accumulated more biomass per tree than *Eucalyptus* and *Melia*. The contribution of stem to above ground biomass irrespective of species and plant density ranged between 60.8-81.3%. Total aboveground biomass on per ha. basis was highest in leucaena (186.63 MT) which was 153% higher than *Eucalyptus* and 328% than *Melia*. Nutrient concentration (N, P, K, Ca, Mg) and their accumulation were significantly higher in leucaena. Soil pH, EC, organic carbon, available N, P, K, exchangeable Ca, and Mg were more in planted than unplanted plots.

At location 2 in mid-hills *Eucalyptus* biomass per tree decreased significantly with the increase in density. Biomass per ha, however, increased. Total biomass at maximum density was 2.5 times higher than the lowest and 1.75 times than the intermediate. The average productivity expressed as ton ha^{-1} yr^{-1} was 18.15, 10.12 and 7.07 as the density decreased from maximum to minimum. Soil organic carbon content increased with the increase in plant density, whereas N, P, K, Ca & Mg content in soil decreased. Depthwise distribution of soil organic carbon, N, P, K, Ca and Mg decreased with the increase in soil depth irrespective of plant density however, pH decreased. Relationship between biomass production and the available nutrient elements in soils have indicated that *Eucalyptus* absorbed more of the N from 0-30 and 30-60 cm soil depths and did not show specific preference to any of the soil depth for P, K and Ca . The correlation coefficient values yet , were high for the above two depths than 60-90cm. The correlation coefficient values between leaf nutrient concentration and the available nutrients in soils at different depths have also shown that trees absorbed more N, P and K from 0-30 and 30-60cm soil depths. Nutrient cycling studies i.e. retention, release and uptake have established that retention increased linearly as the plant density increased. The different tree components retained larger amount of nutrients and the release through leaf and non-leaf litter was negligible. In case of the total amount released through leaf and non-leaf litter was just 6% of the total uptake.

Species Introduction of *Monocalyptus* to Southwestern China

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Monocalyptus is the second largest subgenus in the genus *Eucalyptus* L'Heritier. It includes 134 species and 9 subspecies. Most of them are important species in the Australian forests for timber production, such as *E. regnan*s F. Muell., the highest angiosperm plant on the Earth and *Eucalyptus obliqua* L' Herit. The high economical value and high productivity of many *Monocalyptus* species have attracted a lot of interests in planting the species in many other countries outside Australia. However, examples of successful introduction of *Monocalyptus* species are only a few. Up to date, a few countries in the Southern Hemisphere like South Africa and New Zealand have shown limited success in planting *Monocalyptu*s. Therefore, species transfer of *Monocalyptus* is of great implication in ecophytogeography.

A species screening trial was established in Yipinglang Forest Farm in the central part of Yunnan Province, China with 11 species of *Monocalyptus*. The climate at the experiment site is mild with annual mean temperature of 18 centigrade degree, mean temperature of July, the hottest month, of 21-27 centigrade degree, mean temperature of January, the coldest month, of 8-10 centigrade degree and 250 days of frost free. The four seasons are not clearly distinguished with prolonged dry period from November to April. The trail set was located at the lower part of the slope, and previously occupied by natural forest vegetation that was dominated by *Pinus yunnanensis* Franch. in association with oaks and other hardwoods. The soil was yellowish red and well drained with a pH value of 5.5-6.0. 7-year results showed that *E. regnans, E. obliqua, E. delegatensis, E. elata, E. fraxinoides, E. triflora, E. fastigata, E. dendromorpha* and *E. muelleriana* were adapted to the local environments. The growth performance of these species is very promising in comparison with *E. globulus*, a landrace planted at adjacent plots at the same time. *E. fraxinoides* displayed the best growth performance and tree form, with an average annual height increment of 2 m and an average annual diameter increment of more than 3 cm. Species with average annual height increment of about 2 m are *E. fastigata*, *E. delegatensis*, *E. muelleriana* and *E. regnans*. The annual height increment of some individuals of these species was as high as 3 m. Several factors affecting growing *Monocalyptus* species in China were discussed. Site condition and microenvironment were identified as the critical factors that constraint planting of *Monocalyptus* species. Site selection would be essential part for a successful planting program with *Monocalyptus*. Temperature may be a factor more critical than precipitation for the species transfer of *Monocalyptus*. An expanded multi-site species/provenance trial of *Monocalyptus* species was recommended for further study.

The Forest Restoration and Sustainable Forest Management in the Three Gorge Reservoir Region in China

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Seriously disturbed by human beings, the forest vegetation and the degradation of the ecological environment in the Three-Gorge Reservoir Region in China are analyzed. Based on the diversity of the regional climate, the geomorphology and topography and the forest biology, the strategies for the sustainable forest management are discussed. (1) The forest vegetation distribution patterns are shown. Seriously disturbed by human beings, the vegetation in the Region is sparse and uneven with an unclear vertical distribution. Little forest vegetation distributes below the elevation of 800m. 17.5% of the land on the slop above 25 degrees are cultivated. *Pinus massoniana* and *Biota orientalis*, also the main forest species in the sparse forest grown by aero-sow and artificial planting, take the largest areas in the region. The species diversity is decreasing seriously. (2) The environmental problems, mainly the land degradation, the decrease of land productivity and the water and soil erosion caused by the disturbance of human activities such as the irrational land use and forest cutting, are analyzed and assessed. The soil erosion volume is up to 290 million tons per year. (3) Based on the forest shelter engineering in the middle-up stream of the Yangtze river, the strategies for the regional forest restoration and sustainable management mainly including closing the mountain and raising forest, returning the cultivated land on the slops above 25 degrees to forest, developing the firewood for energy and building the forestry management system with the multiple functions and mixed management models are discussed and assessed.

Effects of Land Use Change on Water Quantity and Quality in Penang State , Malaysia

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Penang is one of the most rapidly development and urbanising states in Malaysia. Land use changes have been rapid, largely from the forest to agriculture at the turn of the 19th century. After independence, however, rapid urbanisation, housing and commercial and industrial developments have further accelerated land use change from forest and agriculture. These changes have significant effects on the water resources of the states, both in terms of quantity and quality. Since the 1930s, rainfall in the catchment areas in the late hills has gradually declined from an average of about nearly 4,000mm to bout 2,500mm in the late 1990s. in the urban centres such as Georgetown, however, greater air population has slightly increased rainfall amounts but the rainfall over the urban areas are of no use in terms of water resources as the majority of rainfall in urban catchments are not trapped and retained but run off as overland flow. The rainfall- evaporation analysis also revealed that the amount of effective rainfall is often much lower than the total gauged rainfall. Furthermore, water quality has also declined considerably since the middle of the 19th century. Almost all rivers near the foothills (which are urbanised) consist of water that are too polluted to be of any use for water supply purposes. Hence, the major water catchments on the island have intakes on hill slopes before the rivers enter the foothills and the coastal plains. Coupled with the fact that Penang has very few water catchments, the state is faced with a "water insecurity" situation as it currently draws about 80% of its water demand from the Muda River which has its origins in Kedah. Despite the completion of the Teluk Behang Dam in the year 2000, the dam is expected to meet only about 45% of the water needs of the island, and Penang will still be insecure in terms of water. Penang's insecure water situation was laid bare during the prolonged dry spell of the 1997/98 El Niño, resulting in severe water stress. Hence, Penang is extremely susceptible to water stress. While urban areas cannot be reafforested, the authorities must take steps to reafforest farmed areas, illegality development and other deforested catchment land. Given the large area of catchment land under private ownership, the state should consider acquiring such land to stop illegal developments. Greater monitoring and enforcement of all developments on catchment land is necessary. Comprehensive river basin catchment management should be practised, ideally led by the Perbadanan Bekalan Air Pulau Pinang. More significantly, all catchment land should be gazetted immediately to prevent further destruction. Local plans such as the Penang Hill Local Plan may be used as a for of land use control. The water authorities must now revise the conventional strategy of Supply Management (increasing supply) to one of Demand Management (reducing demand and wastage). Finally, Penang should also consider looking at the option of inter-state water transfer with its water rich neighbours.

Eco-physiological Characteristics of *Sabina vulgaris* in Mu-Us Desert, China.

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Eco-pyshiological aspects of *Sabina vulgaris (Juniperus, Cupressaceae)*, evergreen coniferous shrub, were measured in Mu-Us desert to analyze the characteristics of trees for the revegetation in semi-arid region. Mu-Us desert is located in the south of Ordos plateau and the north of loess highland. Annual precipitation is 350mm and monthly mean temperature ranges from 21.8° in July to -11.4° in January. Even in such cold semi-arid region, *S.vulgaris* constructs dense and compact patches on fixed sand dune. Although the maximum height of trees is less than 2m, their branches are creeping on the ground and can stabilize the sand surface against strong wind in early spring. However, most of *S.vulgaris* communities in Mu-Us desert were destroyed by the reclamation initiated after the independence of China. Now only 10% of Mu-Us desert is covered by *S.vulgaris*. In 1988, a permanent experimental plot (200m * 400m) was established on fixed sand dune in Mu-Us desert to study the dynamics of *S. vulgaris* community and some eco-physiological characteristics of xerophytes plants, such *as S. vulgaris* and *Artemisia ordosica*, growing in semi-arid condition.

The topographic map of the plot and the distribution map of *S. vulgaris* patches in the plot were made. Twenty four sample patches were selected in the plot for intimate experiments. Four wooden stakes were paled at the periphery of each sample patch and the growth rate of creeping shoots to four directions (north, south, east and west) were measured from these stakes at once a year. To reveal the effects of long-term water stress on *S. vulgaris*, 72 seedlings were planted in gravel culture medium and the osmotic potential of Hoergland culture solution was controlled by the content of polyethyleneglycol (PEG).

Competing with *A. ordosica*, all sample patches enlarged continuously for ten years. The mean radial growth rate was about 11 cm/yr. The density of branches in the center part of patch begin to decrease after the patch radius exceeds about 8m. It means that most of the patches begin to deteriorate in 70 to 80 years after the establishment of seedling. The distance of the ground level of each patch from the groundwater level was ranged from 20cm to 5m according to the undulation of the fix sand dune surface. By the measurement of vertical root distribution and the analysis of ^{13}C in needles of several patches growing on different ground levels from the groundwater, it seems that patches growing on the lower part of fix sand dune are supported by the groundwater and others on the higher level are growing by only rainwater. Seedlings growing under chronic water stress for several years in a greenhouse showed a remarkable drought adaptation in both the stomatal and the cuticle transpiration rates.

Growing Shelter Belt Forest System-An Effective Way to Combating Desertification

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Chifeng municipality of Inner Mongolia, The People's Republic of China, is located at the interface section of Hunshandandake Desert and Kerqin sands where sand dunes and loess hills are integrated forming huge scale landscapes of desertification. Soil and water erosion imposes a constant severe threat to the overall development of the whole region. Within the territory of Chifeng Municipality, desert takes up 2,420,000 ha, nearly 62% of its total. Desertification proccess in Chifeng used to be accelerated at an alarming speed due to the long time effects of population growth, extensive cultivation, overgrazing, clearance of forest for wood and fuel consumption and many other irreversible damage to the natural vegetation. Hazards of desertification, such as persistant drought, heavy sand storms, devastating floods, and all other kinds of harmful events, intensify as the time increase. It is not a rare occurrence that farmfield being destroyed over night by heavy sandstorms, rangeland degraded or even completely covered with moving sand dunes. In some places the endless advancing sands destroy major transportation facilities and water projects, forcing numerous local inhabitants abandon their homes. It is estimated that 231 kms of major highway, 3891 country houses 1768 ha farmfield, 390,000 ha of rangeland were lost during 1958-1988 in only four counties in Kerqin desert region. It is very clear that people in desertification-pron area are facing a deteriorating situation with the actively advancing sands. Serious soil and and water erosion as the leading factor contributes to desertification in Chifeng protecture for its low and scarce vegetation, strong wind and heavy dust in spring and rainstorms in the summer. There are about 964,000 ha of land suffering extremely severe erosion. It is observed that there is 0.3 to 10 cm depth of earth washed away from hills and rolling land each year, that equals 12000 tons of soil loss per km^2. Based on the principle of taking suitable measures to site-specific condition, afforestation on loess hills for desert control had been conducted in a systematic way, planning and designing coordinately and tackling local problem comprehensively, in order to change the bold landscape into a new ecosystem characterized by thriving both forestry and livestock production. From the standpoint of all-inclusive agriculture, a new way of land arrangement was designed to replace the tradition of reclamation abandonment, a plundering way of land usage. By the new way, hills and gentle slopes are reorganized in utilization which roughly results in balance among agriculture, forestry and animal husbandry. In afforestation, three types of arrangements, shelter belt network shelter belt, and block stand, are basically taken from the consideration of making shelter belts play full function in run-off obstruction, controlling water and siol erosion, and making belts store up as much water as possible. These measures are expected to be favourable to forest growth and the rational utilization of of cultivated hillsides as well.

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2.00.00 Division 2 Meetings

Influence of Potassium on the Growth and Root Characteristics of Three Timber Seedlings Grown in Soil Containing VA- Mycorrhizae

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Acacia saligna, *Casaurina glauca* and *Cupressus sempervirens* seedlings, grown in soil containing the vesicular arbuscular mycorrhizal fungus *Acaulospora trappei*, were used to study the effect of potassium levels (0, 20, 40, 80 and 160 mg K/l) on seedling growth and root characteristics. Treatment with 20 mg K/l added to the soil (containing 1.2 meq K/l) gave the highest dry weight of leaves, stems and total dry weight. The root volume, root length and root surface area of *A. saligna* seedlings were highest with a potassium level of 20 mg/l. Increasing K levels up to 160 mg/l reduced these root characteristics. The root volume, root length and root surface area of *C. glauca* seedlings were highest with the 80 mg K/l treatment. However, the alternative K treatments did not significantly affect the other growth characteristics of *C. glauca*. For *C. sempervirens*, the highest height and dry weight of stems were obtained with the 80 mg K/l treatment. Root length and root surface area were highest with a treatment of 20 mg K/l), whereas the weight of roots, volume and radius were highest with the treatment of 80 mg K/l. However, these characteristics were significantly larger than the control for increasing K additions up to 160 mg/l. We conclude that addition of K fertilizer as potassium sulphate to newly reclaimed soils, containing *Acaulospora trappei*, would improve growth of fast growing tree seedlings by increasing root growth characteristics.

The Reasons for Earlywood and Latewood Formation

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Wood quality is determined by the proportion of earlywood and latewood tracheids, as well as by the morphological attributes of these cells. Morphogenesis of both kinds of tracheids is similar with the growth of primary walls in the radial expansion zone and deposition of secondary wall substances in the zone of secondary wall thickening. However, the terminal characteristics of earlywood and latewood tracheids differ considerably. The reasons of these distinctions were analyzed from measurements of cell development during wood formation in *Pinus sylvestris* L. and *Larix sibirica* Ldb. These two conifers are dominant species in the forests of Middle Siberia.

Observations were obtained on 10-12 trees with estimated ages of 50 to 60 years based on external and internal development. The mean numbers of cells within each of the two previous annual rings of each tree were similar and had a normal distribution. The durations and rates of xylem cell formation, primary wall growth and secondary wall thickening of earlywood and latewood tracheids were measured during the seasonal period of wood formation. The effects of air temperature and precipitation on each process were also studied. Radial diameter growth of earlywood tracheids in both pine and larch occurs mainly during June, with latewood tracheid development occurring in July. Secondary wall thickening of earlywood cells occurs in June-July, and in latewood cells such thickening occurs during August and the first half of September.

Hydrothermal conditions during xylem cell growth can considerably influence the morphological characteristics of tracheids. Each of the processes determining wood formation has its own optimum temperature range outside of which the process rate decreases. The developments of radial diameter and wall thickness have different air temperature maxima. The favorable mean daily temperature for radial diameter development in both pine and larch is 21-22°C, whereas, maximum thickness of tracheids is reached at temperatures of 15-16°C. The effects of day and night temperature on radial diameter and wall thickness differed. Distinctions in the temperature and moisture requirements for primary and secondary cell wall development appear to be related to differences in endogenous events leading to these developments. Radial diameters, as well as wall thicknesses of both kinds of tracheids, are larger in larch than for pine tracheids. The transition from earlywood to latewood cell formation is induced by internal water deficit of the cambial tissue and by changes in the linkage between cellulose microfibrills and xyloglucans. Internal water stress results in latewood tracheids having smaller radial diameters and greater length than earlywood cells.

Growth Responses of Palasan Seedlings, *Calamus merrillii* Becc., to Different Light Intensities and Watering Regimes

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The growth responses of palasan (*Calamus merrillii* Becc.) under different light intensities and watering regimes were studied under nursery conditions. Three light intensities of high light (100% sunlight), medium light (80-90% sunlight) and low light (50-60% sunlight) were imposed on palasan seedlings. Among the treatments, low light resulted in high biomass gain. This was attained because of large leaflet areas developed, more leaves produced and high chlorophyll content.

Biochemical and anatomical parameters were also determined. Photosynthetic responses were obtained with a LICOR 6200 closed-photosynthesis system. Photosynthetically active radiation, stomatal conductance, internal CO_2, relative humidity, leaf and air temperatures, and maximum net photosynthetic rate were measured. The results showed positive photosynthetic responses of palasan under low light intensity. Data from measurements were statistically analyzed by the analysis of variance method. Correlation and regression analyses were used to elucidate relationships among variables.

The light requirements for favorable seedling growth were shown to be at about 50-60% of sunlight. A 2-day watering interval favored growth as determined from biomass, height increment and root collar diameter measurements. Frequent watering gave high net assimilation rates and low starch and sugar contents in palasan leaflets. The plant relative water content did not vary under the different watering regimes, reflecting an efficient balancing of moisture in the test plant perhaps induced by stomatal closure. Likewise, moisture conservation may have been favored by the waxy surfaces of leaflets, a morphological feature of palasan. The cultural requirements for favorable growth of palasan in the nursery include low light intensity and watering at 2-day intervals instead of the usual daily watering used in the past.

Coupling a Diffusion Resistance Type Short Time Step Model With Structural Forest Growth Model

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While structurally explicit growth models are enhancing the realism of three-dimensional descriptions of tree growth, their computational complexity makes it difficult to maintain a full range of complexity for all physiological processes. Also, some feedback mechanisms cannot be adequately described on a short time basis.

LIGNUM is a spatially explicit three-dimensional tree growth model based on functional balance and pipe model theory. The model was originally developed for Scots pine in Finland with long time steps. Subsequent applications to pruned *Gliricidia sepium* in Guadeloupe, West Indies required shortened time steps and the explicit introduction of post-pruning nitrogen fixation and labile carbohydrate reserve dynamics. The LIGNUM model describes the flow of labile carbon and nitrogen between a shoot and a root compartment. All growth processes depend on sugar and nitrogen concentrations in the compartments. Depending on the labile carbohydrate concentrations the reserve compartments are either filled or emptied.

The coupling of a diffusion resistance model for net carbon uptake by foliage with short time steps with the slower pipe model requires the combination of different processes that run at different time steps. Allocation between different aboveground biomass parts is controlled by allocation keys derived from the pipe model theory in LIGNUM. The long time step model keeps track of pipe length, the three-dimensional architecture and runs a light interception model at regular intervals. Application of the model to *Gliricidia sepium* after coppicing is demonstrated.

Effects of Climate Change on the Seed Production of *Gliricidia sepium* (Jacq.) Walp. Germplasm Collection in VISCA and its Implication for Genetic Improvement: A Preliminary Study

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Gliricidia sepium grows well even in very inproverished soil condition. However, planting them directly using either seeds or cuttings in the field resulted in higher mortality rate. Thus, it is ideal to raise seedling in the nursery to ensure high survival rate. In the establishment of the germplasm collection of *Gliricidia sepium* (Jacq.) Walp. in the Visayas State College of Agriculture (VISCA), Philippines, mature seeds and branches of *G. Sepium* were collected from representative populations in different localities and abroad. Accessions were planted in CRD design with no replication. The seeds and cutting collection were raised in the nursery for 40 days and then hardened before transplanting in the field at a distance of 1m x 1m. Data on percentage survival of seedlings and cuttings were recorded two weeks after transplanting. Plant height and stem diameter was measured after outplanting and every three (3) months thereafter, and every six (6) months after the trees had reached one (1) year of age. Observation of each accession was made by taking note of morphological characteristics of the *G. sepium* germplasm collection. The experiments were conducted in 1990. Visual observation showed that most of the local accessions collected were bushy, shrubby and short-stuttered much so with those propagated through cuttings. On the other hand, foreign accessions performed well in terms of growth and were noted for their arboreal characteristics with lesser side branching. The leaf characteristics among local accessions were usually broad and oblong in shape compared to foreign accessions, which were small to large in size and elliptically shaped. Number of leaflets per rachis varies from branch to branch and tree to tree. In terms of plant growth and biomass production, the different accessions showed promising result. Prominent among the accessions propagated through seeds were Gs6 and Gs14 having a total plant height of 15.18m, a DBH of 11.80 cm and a biomass production of 0.1660 cubic meter, respectively at 72 months of growth. On the other hand, foremost among those accessions propagated through cuttings was Gc26, having a total plant height of 13.22 m, a DBH of 10.2 cm and a biomass production of 0.1088 cubic meter at 72 month of growth. Like other tree species, *Gliricidia sepium* succumbed to the attack of some pests and diseases. Among the insect pests identified were aphids, mealy bugs and ground termites while the identified diseases were stem canker and leaf spots. These infestations and infection affected the growth of the different trees in the germplasm collection.

Effects of ECM and AM, Alone or in Competition, on Root Colonization and Growth of *Eucalyptus globulus* and *E. urophylla*

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A glasshouse experiment examined the effects of competition between ectomycorrhizal (ECM) and arbuscular mycorrhizal (AM) fungi on root colonization and growth of *Eucalyptus globulus* and *E. urophylla*. *Eucalyptus* seedlings were inoculated with spores of the ECM fungus *Laccaria lateritia* alone, or in combination with pot culture inoculum of one of 3 AM fungi (*Glomus, Acaulospora* and *Scutellospora* isolates). In addition, soils from a new plantation site were used as inoculum for comparison as their relative importance at inoculum level is uncertain. Both ECM and AM fungi effectively formed associations with seedlings, though mycorrhizal root lengths varied considerably with plant age up to 16 weeks. AM fungi were initially able to colonize roots more rapidly from pot culture inoculum than the ECM fungus *Laccaria* could from spores. However, once established *Laccaria* became a more aggressive colonizer of new roots than any of the AM fungi. When both types of fungi were present, ECM root colonization levels increased substantially after 8 weeks, as the proportion of roots with AM declined. The relative susceptibility of *Eucalyptus* roots to these two associations apparently also changed as seedlings became older. AM colonization levels declined in the absence of ECM fungi after seedlings were 8 weeks old. The soil P levels, corresponding to a growth response curve for eucalypts in that soil, were used and relatively substantial growth responses to mycorrhizas at the lowest P level were obtained. All inoculated treatments, whether alone or in combination, stimulated plant growth relative to controls at the low P level. Plants inoculated with *Laccaria* alone or in combination with AM fungi gave the largest growth response. AM fungi alone also resulted in some growth promotion, especially for *E. urophylla*. Ectomycorrhizal fungi had a major impact on root system form - substantially reducing the proportion of fine roots (specific root length), but this did not occur when only AM fungi were present.

Estimating Genetic Parameters for Half-sib Progenies in Five Populations of Erva-mate (*Ilex paraguariensis* St. Hill) in Juvenile Age for the Trait Plant Height

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This trial is part of a project done in partnership between EMBRAPA/CNPF and the Genetics Department of the UFPR. The aim is to estimate genetic parameters for phenotypic characteristics from five populations of "erva-mate"-*Ilex paraguariensis* St. Hil. and develop other studies considered important for the culture. The populations were collected among different sites in the States of Paraná and Rio Grande do Sul, and were set up at the UFPR farm of Canguiri. The trial design was an 8x8 balanced lattice, with 9 repetitions, 6 plants per plot, and a total of 3,456 plants (64 half-sib progenies). The traits evaluated were mortality at the age of 4 and 12 months, and plant height at 12 months, from the date the trial was set up. Preliminary evaluations of the chemical properties of the soil where the trial was carried out were also performed. The results showed that plant height was not affected by the chemical properties of the soil. The mortality rate at 4 months was not affected by progenies nor by populations. At twelve months, strong differences in mortality rate was observed among populations. The populations from Barão de Cotegipe, State of Rio Grande do Sul, showed the lowest mortality rate. Significant effects for plant height were detected among populations and also among the progenies within them. Barão de Cotegipe showed the highest individual narrow sense heritability and average for plant height. Therefore at least the Barão de Cotegipe site deserves more attention since information from another source also reported the plant height trait having a positive and significant correlation with biomass in more advanced ages.

Continuous Diagnosis and Design of Agroforest Systems in Two Micro-Watersheds of Araponga, Zona da Mata, Minas Gerais, Brazil

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The study area for this work encompasses the rural communities of Araponga Municipality in the watersheds of two streams, the São Joaquim and the Boné, in the Serra do Brigadeiro of Minas Gerais state, Brazil. The Serra do Brigadeiro is part of the Zona da Mata, which itself is part of the Atlantic Forest of southeastern Brazil. These areas are also part of current activity of the Center for Alternative Technology of the Zona da Mata (CTA/ZM) in conjunction with the Araponga Rural Workers Syndicate (STR). The selected sites are representative of the general conditions of the Araponga Municipality.

Our method of diagnosis and design of agroforest systems was adapted from the Rural Participatory Diagnosis Systems, the Diagnosis and Design of the International Council of Research in Agroforestry (ICRAF), and other approaches that utilize participatory techniques in the collection of data and related information. The geographically referenced data obtained for diagnosis were stored and analyzed using a Geographic Information System (GIS) that delineated two small watersheds into locally specific and environmentally appropriate agroforest systems. The GIS system (IDRISI 4.1) operates on personal microcomputers with minimal sophistication.

The participatory diagnosis methodology retained information from the local farmers, facilitating understanding of their systems of production, their principal problems and causes of those problems, as well as furnishing aids for planning and implementing agroforest systems. The farmers participated in all stages of the diagnosis and design process.

Agroforest systems have great potential in both ecological and socio-economic terms to resolve diverse challenges in the study region that are acceptable and adoptable by the farmers. For these reasons, it is necessary to have a systematic focus involving the participation of the farmers in the entire process and emphasizing the importance of trees in the production system.

Although this work conforms to the design and implementation features of some agroforest systems currently being monitored by the CTA/ZM, the STR, and the Federal University of Vicosa, we expect that these systems can be modified and improved. Evaluations of diagnosis and design of our agroforest systems will be on-going by virtue of this work's dynamic nature. Thus, the present work will have continuity along with possible extensions into other studies.

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Physiological Studies of Biomass Production in Fuel-wood Tree Species under Agro-climatic Conditions of Palampur in Northwest Himalaya

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The rapid depletion in forests and the need for fossil fuel alternatives have focused attention on renewable energy sources such as plant biomass. The growth and biomass production of a few local as well as exotic fuel-wood species were studied in short rotation, high-density plantations at Palampur (elevation of 1300 m msl, at 32.06 N and 78.18 E) in the northwestern Himalaya.

Meteorological data for the five years, 1993-1997, show an average annual rainfall of 1737mm, and the mean monthly temperatures recorded in January and June were 5.8 and 29.1°C, respectively. Average relative humidity was 55% and the average solar insulation is 6.8 hr/day. The environmental conditions of this region are a very important determinant of growth and biomass production of tree species.

A Split Plot Design experiment with 10 tree species as the main treatment, spacing (1x1m and 1x0.71m) as a sub-treatment, 4 fertilizer levels of N:P:K as a sub-sub treatment, and with three replicates was established. *Populus deltoides*, known for its fast growth, was taken as the standard for comparison. Growth parameters and physiological observations were recorded up to three years under various environmental conditions such as low and high light intensities and cloudy weather during the course of the study. The trees were harvested after three years, and fresh and dry weights were measured. Significant differences in photosynthesis rate, transpiration rate, stomatal conductance and water potential were obtained between various treatments.

From April to June, vertical and radial growth increased by 20% to 50%, whereas, in the months of July-August, growth was 225% higher than during the initial period in spite of decreasing period of bright sunlight. During September to October, growth was low at 10-15%. In deciduous species, growth did not occur during the winter months of October to March. If winter extended beyond March, growth was reduced in all tree species.

Biomass production in *Salix tetrasperma* was appreciably lower than for the other species. Species with narrow leaves such as *Melia*, *Eucalyptus*, *Robinia* and *Albizia* showed 25% to 50% higher photosynthesis rates than plant species with wide leaves such as *Trewia nudiflora, Populus deltoides and Morus alba*. Plant growth is a reflection of net photosynthesis rate integrated over time. However, in spite of a lower photosynthesis rate, *Grevillea robusta* showed excellent aerial growth, which may be due to a "sun fleck" effect. After 36 months of growth, *Eucalyptus* gave the significantly highest dry weight of about 160 tons/ha.

Indian Forest Gene Resources - Need for Integration of Emerging Conservation research

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The Indian region is endowed with a diversity of approximately 45,000 species of plants, which approximately constitutes 12 percent of the global plant diversity. India's forest cover occupies an area of 64 million ha and includes 16 distinct major forest groups, each of which is divided into as many as 250 sub-types. Indian forests contain approximately 600 arborescent taxa representing 75 families with 260 genera important to commercial forestry. These taxa represent a mixture of Indo-Malayan, European, Sino-Japanese, Mediterranean, and African elements. Through cross pollinations, these taxa have produced enormous variability contributing to India's biodiversity and forest gene resources. A vast range of morphological variation occurs in important commercial species, e.g., *Cedrus deodara, Acacia catechu*, and *Tectona grandis*.

Forestry research to widen the gene base of commercially important species, while subsequently conserving genetic resources has been limited. Recent advances in forestry-related sciences have not been applied and integrated to commercial forestry programs. In order to sustain, manage, and conserve Indian forest tree genetic resources the following steps are important: (I) characterization of significant centers of forest gene resources by using remote sensors and integrating a geographic information system; (ii) quantitative assessment of the conservation status of species, and identification of critical index species and their sensitive parameters; (iii) biochemical characterization of population structure; (iv) multiplication and restoration of critically threatened taxa using recent trends in biotechnology; and (v) development of seed-gene, pollen and tissue culture gene banks for conservation. There is a need for inter-institutional support and networking among the international institutions working on common objectives toward the management and conservation of Indian forest gene resources.

Changes in Population Structure and Genetic Diversity of *Shorea curtisii* Dyer ex King due to Selective Logging

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Effects of a single selective logging event on the genetic diversity of *Shorea curtisii* at different age cohorts viz. seedlings, saplings, poles and adult trees, were determined using six simple sequence repeats (SSRs) loci. A total of 67 samples of *S. curtisii* were collected from compartment 48 (2-year old logged stand) and 27 samples from compartment 40 (unlogged stand) in the Serting Tambahan Forest Reserve, Negeri Sembilan, Malaysia. The reduction in basal area of trees above 1 cm diameter at breast height (dbh) after logging was about 42.3% compared to the unlogged stand. The mean basal area and tree density for seedlings and saplings (< 5 cm dbh) in the logged stand increased by 79.2% and 39.5%, respectively, over the unlogged stand, indicating that logging practices favour the regeneration process in the logged stand.

Genetic diversity increased by 28.8% in the seedlings after a single selective logging event while a reduction of 8.6-13.2% occurred in other age cohorts. Hypothetical multilocus gametic diversity was reduced by about 42% in adult trees after selective logging. Latent genetic adaptive potential of the adult trees decreased to about 63%, suggesting that the ability of this gene pool to adapt to changing environmental conditions may have been compromised. In contrast, the hypothetical multilocus gametic diversity and latent genetic adaptive potential increased in the seedlings by about 77% and 84%, respectively. This suggests that seedlings have the potential to produce genetically diverse gametes with the capability for colonisation or adaptation to long-term changed environments. About 66% of the genotypes detected in seedlings and saplings in the logged stand most probably originated from adult trees in the nearby unlogged or logged stands within the forest reserve.

Changes in genetic diversity of this species due to selective logging imply that gene pools of naturally regenerated progeny stands may be quite different from the original parental stands. Therefore, it is prudent to revise the current silvicultural decision-making process early to ensure minimal decline in productivity and genetic diversity in the regenerating stands.

Keywords: selective logging, regeneration, population structure, genetic diversity, microsatellites

Identification of Gibberellin in the Female Flowers, Male Flowers and Needles of *Cryptomeria japonica*

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Cryptomeria japonica (sugi) is a monoecious tree species that forms unisexual flowers at different periods: male flowers from late June to early July and female flowers from late July to early August. Flower bud formation of both male and female is promoted by gibberellin (GA) treatment. GA treatment promotes the formation of male flowers from early June to early July changing to promotion of female flowers from early August to early September. These observations suggest that

flower formation of *C. japonica* is possibly regulated by endogenous GAs, and that the physiological conditions of trees is closely connected with the development of male or female flower responses to GAs. Since both male and female flowers develop in needle tips, endogenous GAs in needles may affect the sexual differentiation of flowers.

Several research groups have surveyed the endogenous GAs in conifers, and various GAs have been identified in the early-non-hydroxylation biosynthetic pathway. However, rather few GAs have been identified in the early-13-hydroxylation biosynthetic pathway of conifers. We obtained similar findings in a survey of endogenous GAs in the pollen of *C. japonica*. Detection of GA9, GA12 and GA15 was obtained with a combination of dwarf rice assay (Tan-ginbozu), Enzyme-Linked Immunosorbent Assay (ELISA) and GC/MS, whereas, GA1 and GA3 were detected by ELISA alone. We analyzed endogenous GAs in the male flowers, female flowers and needles of *C. japonica*. The occurrence of GA1, GA3, GA5 and GA20 in the female flowers, GA1, GA3, GA4, GA5, GA9, GA12, GA15 and GA20 in the male flowers and GA1, GA3, GA4, GA5 and GA20 in the needles were suggested by dwarf rice assay (Tan-ginbozu) and/or ELISA. These GAs were confirmed by GC/MS or GC/SIM.

The early-13-hydroxylation biosynthetic pathway is predominant in vegetative tissue and female flowers, whereas, both the early-13-hydroxylation biosynthetic and the early-non-hydroxylation biosynthetic pathways are predominant in male flowers. The occurrence of GA1 and GA3 as the major GAs in vegetative tissues and female flowers suggests the organ specificity of GA biosynthesis as is found in rice. GA3 increased in needles during the periods of male and female flower formation. This result suggests that formation of male and female flowers is promoted by endogenous GA3 as well as by the exogenous GA treatment. GA1 increased in needles during shoot elongation suggesting that GA1 promotes vegetative growth in *C. japonica*, whereas, GA3 promotes reproductive growth.

Effect of *Acacia nilotica* Leachates on Germination and Initial Growth of Field Crops

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The bioassay studies were conducted in the Department of Forestry, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The extracts of leaf, flower, pod, root and mixed of *Acacia nilotica* (Var. *indica*) were prepared with five concentrations . The per cent germination of all the crops was observed more than the control (0% concentration) at 25 and 50% concentrations in root and flower extracts. However, among extracts, the poor germination of all the crops was recorded at 25 and .. [abstract incomplete]

Effect of Lime on Growth. Nodulation and Biomass Producton of *Leucaena leucocephala* Seedlings in the Nursery

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The effects of applications of different amounts of lime on the growth, nodulation and biomass production of *Leucaena leucocephala* seedlings were investigated in a nursery experiment. L. leucocephala, a multipurpose tree species is known to be very sensitive to the acid soils of the hilly areas of Bangladesh. Lime was applied at rates of 0 (T0-control), 10 (T1), 20 (T2), 30 (T3) and 40 t/ha (T4). Application of lime considerably increased soil pH from 5.5 in the control treatment to the highest recorded value of 6.9 in the T4 treatment. Application of lime also significantly improved the growth, nodulation and biomass production of the seedlings. The highest values for stem height (89.7 cm) and root length (76.9 cm) were recorded in T2 after 10 weeks of seedling growth. Collar diameter was highest (83mm) in treatments T1 and T3, and root diameter was highest (7.7 cm) in the T0 treatment. Nodule number was highest (20) in treatment T1 followed by T2 (19). Similarly, dry weight of stem (8.9 g) , root (7.9 g) and total dry weight of the seedlings (23.4 g) were highest in treatment T1. Leaf dry weight (6.9 g) was highest in the T2 treatment. Root-Shoot ratio (2.3) was highest in treatment T3, with Quality Index (1.916) being highest in the T1 treatment. Height

increment per week (7.85 cm) was greatest in the T2 treatment. It is concluded that a lime application of 10-20 t/ha to soils with pH values of approximately 5.5 significantly increases soil pH and enhances the growth performance of *L. leucocephala* seedlings.

Water use by some forest plantations species in the tropics

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Criticism of water use by forest plantations has been made by several environmental groups. Exotic plantations, like eucalypts, have been criticised for their excessive water use in the tropics. A detailed study on the water consumption of *Eucalyptus tereticornis*, *E. grandis*, *Acacia auriculiformis*, *Anacardium occidentale* and *Tectona grandis* has been conducted in the State of Kerala. Some of the above species are exotics and others are natives. Plantation water consumption was estimated with the Penman-Monteith model. Some of the salient results from the study are the following:

1. *Eucalyptus tereticornis* is an excessive water consumer with very little stomatal regulation during the dry season.
2. *Eucalyptus grandis* has a good stomatal control mechanism that reduces excessive loss of water.
3. *Acacia auriculiformis* has well-developed stomatal control mechanisms that reduce water loss during the dry season. However, the species transpires actively under high soil water availability conditions.
4. *Anacardium occidentale* has a stomatal mechanism similar to *Eucalyptus tereticornis*.
5. *Tectona grandis* conserves water by its deciduous habit in the dry season. However, it consumes excessive water during the post monsoon season.
6. Plantation water use in tropical areas with seasonal rainfall may only be a critical issue in the dry season.
7. It is important to choose suitable exotic species for plantations in the tropics if excessive water consumption needs to be avoided.

An extension of this study showed that the eucalypt roots invaded the water table of the study area, explaining the high water consumption by the eucalypts during the dry season. Excessive water consumption can be reduced to some extent by increasing tree spacing in plantations. *Eucalyptus urophylla* has higher water use efficiency in comparison to some of the other eucalypt species currently grown in plantations in India.

Early Selection of Sitka Spruce Using Farm-Field Site Technique

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Early selection is used to identify the superior genotypes long before they have reached the rotation age. It increases the genetic gain through shortening the generation interval and cost of progeny testing programme. However, co-ancestry problem associated with the quick turn-over of generation is the subject of major concern among the tree breeders.

Data collected by the Tree Improvement Branch of the British Forestry Commission's Northern Research Station were analysed. In retrospective progeny test 32 open pollinated families were planted in fertile and uniform farm-field site using intensive site preparation and close spacing. The same families had previously out-planted in two forest based sites. Farm-field plantations were of four years and forest based plantations were of eight years.

The most important parameters required for reliable early selection are high heritability and strong juvenile-mature correlation. Analysis of study showed low heritability and weak juvenile-mature correlation for all measured traits. Families with best performance at younger farm-field site were not consistently good performers at older forest based sites. A high genotype environment interaction was observed between farm-field sites and forest based sites.

Both farm-field sites and forest based sites were far from ideal. The poor site selection is possibly the main reason for the disappointing results. However, the results of this study do not undermine the possibility of future research on successful early selection of Sitka spruce (*Picea sitchensis*) in Britain.

Interactions in the Mycorrhizosphere of an Altimontane Norway Spruce Forest Undergoing Natural Regeneration

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Natural regeneration of Norway spruce has been studied in an altimontane autochtonous Norway spruce stand on permanent forest research plots in the east Julian Alps in west Slovenia. Sampling plots (0.5 x 0.5 m) were distributed in wind-rose directions (N, E, S, W) at every 2 m in three developmental phases (old growth-F, young regeneration center-D, clear-cut-G). In 45 soil samples (274 ml, 0-18 cm deep) 61,000 root tips were counted, 1 to 3% of which were nonmycorrhizal. Old unidentifiable ectomycorrhizal types were observed on 52% (F), 70% (D) and 81% (G) of all root tips. From the other, i.e. vital types of ectomycorrhizae, 20 (F), 10 (D) and 5 (G) types were identified on each of the plots. Most ectomycorrhizae are undescribed types for which the identity of the fungal partner is not known. The number of roots and diversity indices were correlated with the presence of natural spruce seedlings and their survival. Data and correlations are compared with the influences of the relative direct irradiance and winter dessication on the plots. Possible biodiversity impacts on plant production and processes in the forest ecosystem will be discussed.

Growth, Nutrition and Photosynthesis ofEectomycorrhizal (EM) and Arbuscular Mycorrhizal (AM) Tropical Tree Seedlings

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The objective of this work is to gather information on the autecology of the EM tree species to integrate them into rehabilitation programmes for degraded land. These species mainly grow on very poor soils in nature and thus seem to be suitable for reforestation of strongly devastated sites. Answers to the following questions are of unique importance: What are the light and nutrient demands of seedlings in their juvenile stages? Is there any difference in shade tolerance between ectomycorrhizal and endomycorrhizal species? What are the effects of fertiliser treatments and of mycorrhizal infection on the ecophysiological behaviour of these species? Are there any differences in the adaptability of the investigated tree species for different light intensities?

The investigation of different growth parameters shows clear differences between the tree species with VA- and EM-mycorrhiza, however also great differences in each group. All parameters show a great impact of irradiance on plant development. The seedlings of the VA-tree species are better shade-adapted than those of the EM-tree species. *O. alata* has an intermediate behaviour between the groups.

The seedlings of all VA-tree species have relatively high demands on the supply with basic cations. This holds also true for the EM-tree species *M. bisulcata*, but not for *T. moreliana*. The demand to single elements are distinctly different between the species. Evidently especially nitrogen is the growth - limiting nutrient in the discussed experiments. The phosphorus contents in the leaves are particular high in the MYK treatment due to enhanced P- absorption and/or partly to P accumulation as a consequence of reduced growth and biomass production in the MYK treatment.

The VA-tree species have higher demands on water supply as the EM-tree species. *M. bisulcata* shows a particular high adaptability to dry conditions. EM hyphae and mantle improve water storage and supply, which could be responsible for the high specific leaf area of M. bisulcata and the low water use efficiency values of all three investigated tree species in the MYK treatment, compared with the COM treatment, which in its turn is typical for moist sites. On the other hand the improved water supply can enable the EM- species to grow on very dry soils.

The VA-tree species are distinguished by a high productivity, which is conform with the high nutrient and water demands. High mycorrhizal infection rates produce high carbon sinks. Therefore dry weight, leaf area and photosynthetic capacity of *M. bisulcata* and of *O. alata* are reduced in the MYK treatment. Possibly improved biomass data for *T. moreliana* in this treatment are an effect of an extreme positive benefit/cost ratio of EM- symbiosis of this species.

Distribution and Genetic Diversity the Case *of Terminalia Paniculata* (*Combretaceae*)

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The Western Ghats Forests in India are considered as one of the biggest Biodiversity hot sports in the world. The past management during colonial era and subsequent management interventions has caused disturbance of the Western Ghats Forest ecosystems, resulting in the change in the loss of genetic diversity and vegetation structure. At present, in the semi-evergreen forest and moist deciduous forest of Western Ghats Forest, the *Terminalia paniculata* is a dominant species. However the fire and grazing in the Western Ghats Forest has contributed for the loss of genetic diversity of many species. To estimate the loss of genetic diversity in the Western Ghats Forest, the *T. paniculata* was chosen as it is an important dominant species. The field inventory was done to measure the distribution of this species in different sites to estimate the species richness and diversity in the site. Further samples of mature leaves were collected from the trees and seedlings in every sample plot and proteins were extracted. Further total genomic DNA was extracted and purification was done with ethanol gradient at-20°C over night. The following restriction enzymes were used: Eco RI, Eco RV and Hind III. The DNA digested was loaded to 0.8% agarose gel with ethidium bromide and run for 2 hours. The bands were visualised under UV light and interpreted. From the studies it is evident that, the regeneration and genetic diversity of *T. paniculata* is poor in the disturbed sites as compared to the undisturbed sites.

Morpho-Physiological Direction in Forest Tree Breeding: its Characteristics, Methodical Basis, and Perspectives of Development

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Modern tendencies of the development of the genetic and breeding investigations in the forest phytocoenoses allow to separate a new morpho-physiological direction, that forming on the bounder of the Forest Breeding and the plant physiology.

The morpho-physiological direction in the forest breeding is aimed at the study of the physiological-biochemical aspects of the genotypes vital activity in the concrete conditions of the environment. This direction foresees also the transition from the genetic-breeding investigations by the scheme "genotype-accumulation of the phytomass (or other breeding trait)" to the complex investigations: "genotype-concrete environment conditions-physiological-biochemical processes-accumulation of the phytomass". The principal difference of this direction from other ones is such, that the breeding process is aimed in this case not at the genotype only but at the genotype with taking into consideration the mechanisms of its realization in the concrete environmental conditions. The morpho-physiological direction foresees the breeding to the reciprocal action in the system "genotype-environment". This reciprocal action becomes apparent by the intensity of the physiological-biochemical processes. This way it is provided the organic connection of the forest breeding with the trees plant's physiology and the development of the breeding investigation with taking into consideration of the physiological-genetic regularities of the productive process.

It is worth while to include in the system of the genetic-breeding tests of the morpho-physiological direction:

- physiological-biochemical indicators, that reflected the general level of the metabolism and vitality of plants: bio-potentials, bio-electrical reactions to the dosed external irritant, impedance, polar capacity;
- physiological-biochemical indicators, that determined the production process: photosynthesis, temp respiration, photo-respiration, pigment contents;
- molecular-genetic criterions; terpens, isozymes etc.

As the additional criterions it should used the morpho-anatomic indicators of the leaf apparatus, biometrical indicators of trees and other physiological-biochemical traits.

For the receiving of the correct results it is necessary to carry out the frequent measurings and to time them to the main phenological phases and to difference after the enthogenesis stages.

The considerable increase of the effectiveness of the breeding could be achieves by the conducting of the investigations of the dynamics of the physiological- biochemical processes at the same time with the static measurings. It should be the transition from the static system of the indicators to the static-dynamic one, in which the physiological-biochemical parameters (as markers) become more greater importance. Therefore it is proposed for the decision of the different genetic-breeding tasks the new indicator-the degree of junction, correlation of changes (dynamics) of the physiological-biochemical processes in the time of the investigated objects.

The morpho-physiological direction in the forest breeding foresees three stages of the selection. It is recommended at the first stage to distinguish two trees categories by the morpho-physiological indicators - high-productive and low-productive trees. By the conducting of the deepened breeding works it is proposed to carry out the second selection among high-productive trees on the plus genotype and the increased level of vitality on the physiological-biochemical and the molecular-genetic parameters.

The third stage of selection foresees the examination on the high productivity of the plus trees, selected at the second stage on progenies.

The morpho-physiological direction in the forest breeding foresees three stages of the selection. It is recommended at the first stage to distinguish two trees categories by the morpho-physiological indicators – high-productive and low-productive trees. By the conducting of the deepened breeding works it is proposed to carry out the second selection among high-productive trees on the plus genotype and the increased level of vitality on the physiological-biochemical and the molecular-genetic parameters.

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The morpho-physiological direction of the investigations corresponds to the modern tendencies of the forestry and forest management development. One of the main tasks is the investigation of the individual variability of the trees in the populations of the main forest species by the intensity of the primary physiological-biochemical processes, that provides the active growth, the accumulation of the phytomass and the biological firmness of the plants.

Induction of Lammas Shoot Formation and Flowering in Japanese Red Pine by Heating in Spring

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Potted two-year-old seedlings of Japanese red pine (*Pinus densiflora*) were transferred into a greenhouse, which had an adjusted minimal temperature of 18°C, from the outdoors on February 20th, March 7th, and 22nd, 1990, before the initiation of spring flush. On May 22nd 1990, these seedlings were returned to the outdoors. The earlier the seedlings were transferred into the greenhouse, the earlier the second flush started, the greater the percentages of lammas shoot elongating, and the larger the lengths of terminal buds (the amounts of the secondary flush). In a second experiment, potted seedlings were divided into two groups. The first group included 139 seedlings grown in the greenhouse under the condition of a minimal temperature of 18°C from March 6 to June 4, 1990 (heated treatment), and the second group included 237 seedlings grown under outdoor conditions (non-heated treatment). The terminal buds of seedlings in both treatments were periodically sampled and the numbers of leaf primordia formed in the buds were counted under a microscope. In the heated seedlings, more than 90 leaf primordia were observed in August when rapid internodal elongation in the buds occurred. No internodal elongation occurred in more than 90 leaf primordia observed in the non-heated seedlings in September under short-day conditions. It is concluded that lammas shoots in Japanese red pine are the elongated buds with 90 through 100 leaf primordial that develop under 14 hours day length or more. However, many studies attribute the causes of the lammas shoot formation to the nutritional condition, soil water content, accumulation of stored substances inside the tree, day length and temperature. From our experiments, it is clear that those factors are secondary and indirectly relate to the formation of lammas shoots through their influence on the formation rate of leaf primordia. In a third experiment, potted seedlings were carried into the greenhouse on February 20th, March 2nd, 12th, and 22nd 1995. They were returned to the outdoors on May 21st. The earlier the seedlings were carried into the greenhouse, the greater the percentages of lammas shoots that elongated and the greater the lengths of terminal buds. The numbers of male flowers in the heated seedlings were more abundant than for the outdoor seedlings, while the numbers of female flowers in the heated seedlings were fewer. The elongation of terminal buds resulting from lammas shoot formation seemed to be related to the differentiation of the male flowers. The number of male flowers was infrequent in excessively elongated buds. Few seedlings had both male and female flowers in either heated or non-heated treatments.

Cloning of S-ACC Synthase and T-ACC Oxidase Genes and Expression of Antisense Constructs in Transgenic Plants

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This research project was aimed at obtaining an ACC synthase gene-homolog from *Populus deltoides*, constructing an expression vector containing an antisense fusion gene of ACC synthase and ACC oxidase, and obtaining transgenic plants in which ethylene production during flower senescence and fruit ripening were inhibited by antisense RNA.

A 1.5kb cDNA fragment of ACC synthase was amplified from cDNA of soybean and a 0.9kb cDNA fragment of ACC oxidase was amplified from cDNA of tomato through the polymerase chain reaction (PCR), cloned, and a fusion of the ACC synthase and the ACC oxidase genes constructed. The ACC synthase and ACC oxidase genes and their fusion gene were inserted into a binary vector, pBin438, in an inverted orientation between the CaMV 35S promoter and Nos 3? termination sequence, to construct expression vectors pBAACS, pBAACO and pBAACSO. The fusion gene was also inserted into pBI121, in sense orientation, to construct the expression vector pBSACSO. A genomic library of *Populus deltoides* was screened to obtain the ACC synthase gene of *Populus deltoides* using a cDNA of Soybean ACC synthase as a probe.

Transgenic *Populus deltoides* containing one of the three antisense genes, or the sense fusion of ACC synthase with ACC oxidase, and transgenic lily (*Lilium brounii* L.), babys-breath (*Gypsophila paniculata*), carnation (*Dianthus fragrans* Fisch), date (*Zizyphus jujuba* Mill. Var cui and *Zizyphus jujuba* Mill. Var Xiang), and kiwi-fruit (*Actinida chinensis* Planch var. Hayward) containing the antisense fusion gene, were obtained, respectively, by Agrobacterium-mediated transformation of leaves (except the sense fusion transgenic *Populus*, which was transformed by a partial bombardment method). Both PCR detection and Southern blot analysis confirmed the successful integration of a single antisense gene or a single sense gene in the genome of the transgenic plants, and more than 15 plants of each species were obtained. The results from reverse transcription PCR (RT-PCR) of RNAs isolated from the transgenic plant leaves confirmed that antisense RNA was present in the antisense transgenic plants, and that sense fusion RNA was present in the sense transgenic plants. The amount of ethylene released from the antisense transgenic plants was much lower than that released from non-transformed control plants, especially for the transgenic plants containing the antisense fusion gene, from which the amount of ethylene released was less than 9% of that from the control plants. Leaf senescence was delayed in these ethylene-deficient plants. The amount of ethylene released from some of the transgenic poplars containing the sense fusion gene was at different level, some released more ethylene and some released less ethylene than non-transformed controls. The effects of the antisense fusion gene on flower senescence and fruit ripening in transgenic plants are currently being tested.

Effects of RNA Editing on the Phylogeny Reconstruction Based on CoxI Gene

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CoxI genomic and cDNA sequences from gymnosperms and angiosperms were used to study the effects of RNA editing on gene evolution and phylogeny reconstruction. In six gymnosperms harboring edited coxI gene the number of nucleotide substitutions at 1st, 2nd and 3rd codon positions was similar. In contrast, in angiosperms, the number of nucleotide substitutions at 1st and 2nd codon positions was much lower than at the 3rd. The coxI gene in long-lived gymnosperms evolved much faster than in annual angiosperms. This accelerated rate of nucleotide substitution in gymnosperms is due to accumulation of T-C substitutions at edited sites that can randomly appear at all three codon positions. Editing predominantly occurred at 1st and 2nd codon positions as a result of selection against nonsynonymous T-C substitutions and other types of mutations. The tree topologies for the investigated species based on genomic DNA data were in concordance with their taxonomic positions. The trees based on polymorphic edited sites agreed with trees derived from complete sequence information. This indicates that edited sites are reliable sources of phylogenetic information especially for species that contain many edited sites. However, the fast evolution rate of coxI gene in gymnosperms has caused the long branches in the phylogenetic trees. The inclusion of the species with a processed paralog i.e., edited form of the coxI gene, affected the topology of phylogenetic trees, especially when the taxon with a processed paralog was closely related to the other species analyzed.

Effects of AMF Alkaline Phosphatase Activities on *Hippophae rhamnoides* Drought-Resistance under Water Stress Conditions

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The relationship of AMF alkaline phosphatase (ALP) activity and drought resistance of the mycorrhizal fungus *Hippophae rhamnoides* was studied under water stress conditions with histochemical techniques. Total hyphae and functional hyphae provide the base for the active hyphae, and amounts of these hyphae decrease in the order of total hyphae > functional hyphae > active hyphae. Active hyphae play an important role in biomass accumulation of the host tree. Active hyphae with ALP activity have a beneficial effect on *Hippophae rhamnoides* growth and its drought resistance. In addition, high ALP activity is related to an increase in the fresh weight of the host trees and a reduction in wilting. The direct participation of ALP in the exchange of phosphorus nutrient substances with host trees can improve the nutrition and water status conditions of trees as well as their drought resistance.

Interspecific Hybridization between *Populus alba* Oliv. and P. *euphrotica* L. using *In Vitro* Technique

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An *in vitro* method was used to produce hybrid plants between *Populus alba* L. and *P. euphratica* OLIV in two directions. Developed ovaries and ovuels were isolated from *P. alba* L. female branches which were pollinated with *P. euphratica* pollen grains by using twig and pot breeding technique. The same procedure were carried out in the case of *P. euphratica* OLIV female branches with *Populus alba* L. pollen grain. Isolated ovaries and ovules of both crosses were then transferred to growth regulator free half concentrated MS agar medium for embryo germination. Fourteen days old *Populus alba* L. ovary and ovule embryos produced the highest plantlets, while 45 days old ovary and ovule embryos of *P. euphratica* OLIV were necessary to obtain hybrid plants. Maximum two to three plantlets were observed in both *Populus alba* L. and *P. euphrotica* OLIV ovary culture. More than 90% of pollinated *P. euphrotica* OLIV and *Populus alba* L. ovules successfully produced plantlets, whereas the efficiency of pollinated ovaries to produce plantlets was 70% for *Populus alba* L. and 67% for *P. euphrotica* OLIV. Plantlets were cultured in the same medium within jars, before being transferred to potting soil. Seventy five interspecific *P. alba* L.x *P. euphratica* Oliv and twenty six of *P. euphratica* OLIV x *Populus alba* L. Hybrid plants were successfully acclimatized in greenhouse.

Agroforestry in Dry Areas

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Limitation of soil water is one of the most important plant stress variables in many parts of the world, particularly in monsoon and savannah climates. The tree and crop component species of an agroforestry practice in a dry area may compete with each other for soil water leading to a negative interaction between the components. However, differential responses of trees and field crops to drying soil could overcome this situation. Understanding the competition and complementarity between component plant species in an agroforestry system with limited soil water supply may aid design of a system with enhanced productivity.

Competition for water can cause leaf water potential and stomatal conductance of component species to be reduced. However, competition for soil water may be reduced if a deep-rooted component is able to transport water from deep moist subsoil to the surface soil enhancing available water for a shallow rooted component. Conversely reduced development of root mass in a drying soil may lead to reduction in the competitive ability of that component species.

The key to effective agroforestry practice in dry areas is the efficient use of water throughout the soil profile. Increase in the root/shoot ratio and deep penetration of roots in gradually drying soil together with differential ecophysiological characteristics of the component species could facilitate maximum root exploration and water use throughout the soil profile. In addition, reduction of stomatal conductance and leaf expansion during soil drying can reduce transpiration resulting in the conservation of available soil water. Suitable choices of complimentary species components in agroforestry could facilitate sustainable production in dry areas.

Diversity of Arbuscular Mycorrhizal Fungi and their Associations with Angiosperms of the Western Ghats Region of Southern India

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The Western Ghats extend for about 1600 km from the Tapti River in the North to the peninsular tip in the south. This is a floristically rich region next to the Himalayas, and is one of the 18 areas in the world recognized for high biodiversity. Mycorrhizae have long been known to be important in symbiotic relationships with many forest species. Most plants in natural ecosystems rely on mycorrhizae for the uptake of water and nutrients; these associations are obligate for many tropical plants. The diversity of arbuscular mycorrhizal (AM) fungi of the Western Ghats was investigated. We examined the soil and root systems of 329 angiosperms, representing 60 families, from three vegetation types of seasonal forests, scrublands and grasslands.

The incidence of mycorrhizae in the 329 angiosperms was significantly higher than that reported for other ecosystems. AM associations were identified in 308 species, with 159 of these being recorded for the first time. In addition, AM associations were found in families that typically lack mycorrhizae. A total of 36 AM fungal species were identified as follows: 4 *Acaulospora*, 2 *Gigaspora*, 21 *Glomus*, 4 *Slerocystis* and 5 *Scutellospora* species. Five *Glomus* species were previously undescribed and two are an addition to the Indian Glomales. The mycorrhizal status of the plant species seems to be associated with plant life form and life cycle patterns. Similarly, the fungal richness and spore populations of AM fungi tended to depend on the vegetation types. The importance of conserving AM fungal diversity and preserving their role in natural ecosystems of the Western Ghats is discussed.

Studies on the Biochemistry of Nitrogen Fixation in *Acacia Catechu* and *Robinia Pseudoacacia* L.

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Robinia Pseudoacacia, a fast growing tree legume, has been successfully grown in the degraded hill conditions of the Himalayas. This species is planted on dry sites that experience water deficiency during summer and winter. Studies of water stress effects on various biochemical parameters in nodules and leaves of three-month old seedlings of *R. pseudoacacia* were undertaken. Water stress applied for 3, 7 and 10 days followed by re-watering for the same number of days gave signs of recovery from water stress in all the seedlings. However, the seedlings subjected to 10 days of water stress showed complete wilting followed by re-emergence of leaves, regeneration of nodules and recovery of biochemical parameters after re-watering. These results indicate that seedlings of *R. pseudoacacia* are capable of enduring short periods of water deficit shocks during transplanting.

The regulation of sucrose hydrolysis and utilization of hexose were investigated with partially purified alkaline invertase from developing nodules of *R. pseudoacacia*. The enzyme was purified 78 fold with 71% recovery. Sucrose seems to be the main factor controlling invertase activity.

Acacia Catechu willdenow, a nitrogen fixing tree legume of the west Himalayan sub-tropical zone and Shiwalik Hill area, occurs widely on degraded sites. Apart from its utility in agroforestry, it is widely used for the extraction of tannin. In addition to the process of symbiotic nitrogen fixation, leguminous crops also make use of nitrate assimilation for meeting their nitrogen requirements. Nitrogen metabolism of A. catechu seedlings was studied after 5, 10 and 15 days of daily application of 20 mM nitrate. The results suggest that application of nitrate (20 mM) for short periods (15 days), before seedlings are transplanted for afforestation, is beneficial. The survival rate of nitrate-treated seedlings may be improved. The long-term effect of applied nitrate affects the partitioning of photosynthates.

Metabolism of phosphoenol pyruvate in developing nodules of *A. catechu* was studied on 4 to 5 month-old seedlings that had well a developed tap root and lateral roots. Nodules at this stage of development were healthy and showed no sign of degeneration. The activities of enzymes involved in carbon metabolism viz., NAD-malate dehydrogenase, NAD (P) isocitrate dehydrogenase and pyruvate kinase were highest at this stage. Seedling survival rate was 100% when transplanted at this stage. However, by the end of November, when leaves started falling, nodules showed signs of degeneration. Attempts were also made to partially purify and characterize the above mentioned enzymes at this stage.

Genetic Variation on Growth and Selected Wood Properties of *Acacia auriculiformis* Provenances

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A trial at Universiti Putra Malaysia (UPM) Serdang, Malaysia consisting of twenty eight provenances of *Acacia auriculiformis* A. Cunn. ex. Benth was assessed at four years for total height, diameter at breast height, specific gravity and fibre length. Of these provenances, 7 were from Queensland (QLD), 15 from the Northern Territory (NT) and 6 from Papua New Guinea (PNG). The provenances and geographic regions differed significantly at $p<0.05$ in their growth performance. Generally the Queensland provenances recorded the best growth in both height and diameter followed by the Northern Territorry and Papua New Guinea Provenances. The mean total heights for provenances from Queensland, Northern Territory and Papua New Guinea were 13.38m, 12.37m and 11.89m respectively. The mean diameters at breast height for provenances from Queensland, Northern Territory and Papua New Guinea were 12.6 cm, 11.04cm and 10.69cm respectively.

A similar pattern of variation was found in the wood properties except for wood specific gravity where there was no significant difference encountered between the three geographic regions. However, there were significant variation between provenances on both wood properties studied. The mean specific gravity ranged from 0.53 for the provenance from Balamuk on Bensbach (PNG) to 0.61 for the provenance from South Balamuk (PNG). The mean fibre length ranged from 0.865mm for the provenance from Balamuk on Bensbach (PNG) to 0.993mm for the provenance from Coen River (QLD).

Generally, the percentages of variance components due to between and within provenances were high for growth and wood properties. Most of the genetic variation was contributed by the variation of the traits between individuals within provenances. This was shown in the residual variance components of all traits that ranged from 32-71%. Based on the basic information obtained on the genetic variation of this species, the alternative selection strategy recommended for the species is through selecting more individuals within provenance levels from all geographic regions.

Keywords: Geographic region, Provenance, genetic variation, total height, diameter at breast height, specific gravity, fibre length, variance component

Effects of Aluminum on Growth and Physiology of Woody Plants

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We have found that aluminum application to hydroponic solutions increased the root dry weights of *Betula grossa* and *Quercus myrsinaefolia* seedlings. These experiments have now been extended to a more detailed study of growth of aluminum-treated species, with emphasis on relationships between phosphorus and aluminum in culture solutions.

Experiment 1: Two-year-old seedlings of each of *Eucalyptus viminalis*, *Quercus acutissima* and *Cinnamomum camphora* were used in this experiment. Culture solutions (pH 4) containing 0, 0.05, 0.5, 5 and 50 mM Al were prepared. The seedlings were cultured for 35 days and dry weights of leaves, stems, and roots were determined separately. In each species treated with 5 mM Al, dry weights of both shoots and roots were greater than those of other concentrations of Al. Newly-formed roots of *Q. acutissima* and *C.*

camphora in the solution containing 5 mM Al were the largest among all of the plant parts.

Experiment 2: To determine interactive effects of P and Al on growth, 1/5 Hoagland medium without P was prepared. Using this medium, 19 different culture media (pH 4) were prepared by mixing 0, 0.02, 0.2 and 2 mM P and 0, 0.05, 0.5, 5 and 10 mM Al in all combinations. The control medium containing P but no Al was pH 5.8. Two-year-old *E. viminalis* and *Q. acutissima* seedlings were cultured for 4 and 7 weeks, respectively. One half of E. *viminalis* seedlings cultured under 0, 0.02, and 0.2 mM P in combination with 10mM Al died within 4 weeks. The biomass of both shoots and roots in the surviving E. *viminalis* seedlings was reduced. In the *Q. acutissima* seedlings the dry weight of new roots increased in the solutions containing 0.5, 5, and 10 mM Al. However, the application of 2 mM P to the solutions containing 0.5 or 5 mM Al suppressed the seedling dry weight increment. All of *Q. acutissima* seedlings cultured in 10 mM Al solution with or without P survived and the dry weights of new roots increased. These results suggest that the root formation in the seedlings cultured with soluble Al is highly related to the reduction of toxic effects of Al in shoots of seedlings.

Experiment 3: To determine the effect of Al on the growth of P- or Ca-deficient plants, 1-year-old *Q. acutissima* seedlings were cultured for 9 weeks in 3 different hydroponic solutions as: 1) 1/5 Hoagland medium; 2) 1/5 Hoagland medium without P; and 3) 1/5 Hoagland medium without Ca. At Day 64, the seedlings from each of these hydroponic treatments were divided into three groups and transplanted to three different media (pH 4) containing 0, 0.27, 2.7 mM Al, respectively, and cultured for 6 weeks. The seedlings were harvested, the dry weights of plant parts were determined, and Al, Ca, P, Na, Mg, Ca and K contents of each part were analyzed. In the Ca-deficient solution without Al, the rate of root elongation declined within 9 weeks. The dry weights of new roots significantly increased after 6 weeks in the solution without Ca and containing 2.7 mM Al. The biomass of both shoots and roots was reduced in the P-deficient medium containing 2.7 mM Al. Under the treatment of 2.7 mM Al, high levels of Al were detected in roots and leaves. These results indicate that the presence of Al in plants increases P uptake into roots and excludes Ca from the roots.

Clonal Propagation Technology for Neem (*Azadirachta Indica* A. Juss) to Improve Productivity

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Neem (*Azadirachta Indica* A. Juss) is a globally important tree species. The azadirachtin obtained from it is used as an environmentally safe insecticide. It is an evergreen tree but it shows complete leaf fall for short duration (10 days) followed by bud break). Clonal propagation technology through branch cutting of the mature neem tree is the standard propagation technique. Cuttings (20cm length and 1.0 cm diameter) collected from mature trees (25 to 30 years) are treated with 1000ppm IBA (indole butyric acid) and when cut during leaf fall/bud break, give rise to greater than 80% rooting. At other times rooting is only 0 to 20% effective. It is presumed that some root forming substances are synthesized from the emerging new sprouts, which induce root formation. There is a direct relationship between peroxidase activity and adventitious rooting in neem. High root formation coincided with less peroxidase activity and poor rooting with maximum activity, and the peroxidase can be used as a biochemical marker for rooting potential in neem cuttings. Cuttings from the lower, middle and upper crown of the tree did not show any significant variation in rooting. The juvenile cuttings collected from two year old seedlings gave good rooting in most of the season. Air-layering technique in neem tree was also developed and it was successful (>90%) but only during the rainy season. In neem, high seed yielders and high azadirachtin content are the main criteria for selection of superior trees. The propagules raised through cuttings from superior trees fruit after two years. This technology will be useful for mass multiplying the superior types for plantation and thereby augment the productivity. It is also helpful for establishing clonal seed orchard and breeding populations for further genetic improvement of the species.

Production of Transgenic Poplar with Antisense OMT Gene via *Agrobacterium tumefaciens*

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Lignin, a major component of secondary cell walls, is formed from polymerization of three cinnamic alcohol precursors, p-coumaryl, coniferyl, and syringyl alcohols. This provides rigidity and impermeability of the plant cell walls that serve as mechanical and chemical barriers against outer environments. The content of lignin in woody plants is especially important for the pulp and paper industries, since toxic chemical treatments are needed to remove the lignin closely associated with cellulose. Development of reduced lignin content in woody tissues by genetic engineering techniques has significant benefits by alleviating the environmental safety and operational costs of the delignification process. O-methyltransferase (OMT) is the best candidate enzyme for this genetic engineering purpose. This is a methylating enzyme involved in lignin biosynthesis that catalyzes the methylation process of both caffeic and 5-hydroxyferulic acids. Down regulation of the OMT gene by the antisense RNA technique will influence the expression of the OMT gene resulting in a reduction of the lignin content in plants. This research has been the focus of low-lignin poplar plant development using the antisense RNA OMT gene via the Agrobacterium transformation system.

Populus nigra x maximowiczii leaf segments were co-cultivated with *Agrobacterium tumefacience* harbouring plasmids with OMT antisense and neomycin phosphotransferase (NPTII) chimeric genes. Leaf segments from in vitro grown poplars were detached and infected with an Agrobacterium strain. Following co-cultivation, the leaf segments were cultured on MS basal medium without growth regulators for two days, followed by growth on MS medium with 2,4-D at 2 mg/l and antibiotics, such as cefotaxime and kanamycin. Calli were induced after 5 months under dark conditions; however, growth rates were very slow compared with control plants. After one year of antibiotic selection, calli were transferred to a regeneration medium (MS supplemented with BA at 4 mg/l and antibiotics) under light conditions. Following 6 months in culture, shoots produced calli, and putative transgenic plants were transferred to a hormone-free medium to accelerate their growth rate. Molecular analysis of transgenic poplars has been undertaken to confirm the presence of the foreign genes (NPTII and OMT). The putative transformed poplars currently show a phenotypically normal status. In this research, independent transgenic lines are being continuously selected to achieve poplar plants with low-lignin content.

Physiological effects of low concentration of SO_2 on *Eugenia grandis*

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Atmospheric pollution in urban areas is a major environmental issue in many countries. In Malaysia, public authorities and experts are trying to improve air quality in these areas. Efforts have been taken by prohibiting open burning, and stringent checks on smoke emitted from industries and vehicles. However, with the rapid increase in industries and motor vehicles, it is difficult to curb the air pollution problem completely. It was reported that emission of sulphur dioxide from industries in 1999 was estimated to be 69,000 ton/year, is anticipated to double by the year 2000 (Leong and Lim, 1994) in Klang Valley, Klang Valley houses Kuala Lumpur, the national capital, industrial areas like Petaling Jaya and Shah Alam and a sea port.

Sulphur dioxide (SO_2) is one of the most deleterious atmospheric pollutants for plants. A review by Darrall (1989) suggested that SO_2 caused both acute and chronic injuries to plants. Physiological decline is more prevalent when plants were exposed to low levels of SO_2 concentrations. One of the criteria for early recognition of incipient pollution damage in plants is disturbance in photosynthesis and alteration in stomatal opening and closing (Larcher, 1995).

A two-year study was conducted in the urban environment of Shah Alam to evaluate *E. grandis* responses to urban air pollution. *E. grandis* was chosen due to its popular choice as a landscaping tree. It is fast becoming a popular way side tree due to its oblong crown with dark green leaves. It grows quickly when young and does not produce any buttresses or surface roots. In addition, this tree does not shed its leaves frequently and has a thick bark that enables it to withstand lalland fires.

Changes in plant performance were considered in relation to the status of ambient air quality in the study area. Assessment was conducted by comparing the physiological parameters; leaf gas exchange patterns of trees grown in polluted area; Shah Alam and control site, Pangkor Laut. Six trees were chosen in each site and monitored monthly.

Reductions in photosynthetic rates, stomatal conductance and transpiration were correlated to air pollution levels at different sites. The study showed that the SO_2 and NO_2 increased the mesophyll resistance and reduced the photosynthetic rates. In this case, there was no significant difference in stomatal limitations between the control and pollution exposed plants, thus implying the decreased photosynthetic rates in the treated plants were due to biochemical limitations. The A/C_i curve suggested that these pollutants had affected the primary carboxyls and electron transport in vivo. The increase in C_i in the treated plants further substantiated that the stomata were closing as a result of this. Thus, the mechanism of stomatal closure was a result of an increase in mesophyll resistance.

Interactions Of *Acacia nilotica* Willd. Ex. Del. on *Oryza sativa* Linn.

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The germination responses of rice (*Oryza sativa* Linn.) seed treated with fresh aqueous extracts from live babul (*Acacia nilotica* Willd. Ex. Del.) bulk samples derived from leaves, stem, twigs, root, flowers and seed were determined. Results indicated a positive germination response with lower concentrations of extract and inhibitive effects with higher concentrations. However, a pot culture study revealed that shoot and root lengths of rice were significantly reduced as the concentration of extracts increased. Nevertheless, seedling dry weight per plant and total biomass per pot were significantly higher as extract concentrations increased. In contrast, grain yield per plant increased in pots treated with dried litter powder up to 50 g per pot and 7.5% fresh extract concentration. Grain yields declined at higher levels of litter powder and fresh extract treatment.

Isolation of Differently Expressed cDNA Following Laser and Blade Cutting of Axillary Buds from Woody Species

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In a previous study on sectioning of *Persea indica* and *Arbutus unedo*, with laser beam and with surgical blade, it has been verified that a laser beam can be used as a good alternative to surgical blade sectioning of plant material in order to induce buds to break dormancy and to promote shoot development in micropropagation of woody species during winter time. The effect of laser cutting of the explants on axillary bud development seems to depend on the species used and on the period of the year for explants cutting. When the cutting is performed in November or December, cutting with a laser beam promotes break of dormancy and faster development of axillary buds. However, when the explants cutting is done in February, shoot development seems, in general, independent of the cutting method.

In vitro plants from *P. indica* and *A. unedo* even when kept under similar photoperiod and temperature conditions along the year, present, during winter time, some degree of dormancy which bring difficulties whenever in vitro multiplication programs has to be performed in winter time. This does not seem to be the case of *Populus alba* that presents, all over the year, a similar behaviour in terms of shoot bud development. In this species, the bud development in vitro was independent of the cutting method.

DDRT-PCR studies performed on *Persea indica* (an evergreen plant presenting high degree of bud dormancy *in vivo* and in vitro) and on *Populus alba* (a deciduous plant, presenting a low degree of dormancy *in vivo* and no dormancy *in vitro*) enabled the isolation, until now, of two differentially expressed cDNAs from explants of *Persea indica* and three explants from explants of *Populus* alba, when shoots were sectioned in November. The relationship between the expressed / repressed genes with the sectioning method is being evaluated. The characterisation of these cDNAs as well gene(s) expression at the cells/tissues levels and its possible role in bud development following cutting will be presented and discussed.

Change of Composition and Maintenance of Free Amino Acids in Tissues and Organs of *Pinus sylvestris* Under Flooding

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During the period of intensive cambial activity, the composition and maintenance of free amino acids in tissues and organs of *Pinus sylvestris* were studied in three plots on a raised bog with differing aeration conditions in the soil root layer. Trees growing in a nearby pine-lichen forest were taken as control. Free amino acids accumulated in tissues of pine growing in the raised bog. As aeration of the root layer decreased amino acids increased in the tissues of roots and underground organs. The special role of glutamic acid in free amino acid metabolism was shown by the high proportion of glutamic acid (up to 43%) in the free amino acids of tissue samples collected during vegetative growth. Root anaerobiosis in pine resulted in high contents of alanine, proline and gamma-aminobutyric acid in tissues. These amino acids are closely connected with the Krebs cycle reactions, and under anaerobic conditions these reactions are slowed down. Utilization of amino acids in anaerobic metabolism may be limited by energetic difficulties or the absence of oxidative de-amination. The ability of pine trees to reuse internal reserves of organic nitrogen appear to be an important adaptive property for the vitality of pine under natural hypoxic stress. The study is supported by the Russian Foundation of Fundamental Research (grant 98-04-48136).

Interactions of *Dalbergia sissoo* Roxb. and *Cajanus cajan* (Linn.) Cradish

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The germination of perennial pigeon pea seed was studied through bioassay, using both aqueous and ether extracts of *Dalbergia sissoo*. Extracts were obtained from separate plant parts viz., leaves, stem, twigs, flowers, root and seed, as well as from the whole plant. Germination was inhibited by both lower and higher concentrations of fresh extracts obtained from live bulk samples. This inhibition was relatively low in lower concentration and high in higher concentrations. The highest inhibition of germination was up to 48.5%. Shoot length and seedling dry weight decreased up to a maximum of 24.1 and 16.9% of control values, respectively with extract treatment. Root length was promoted up to 9.6% with 5.0% fresh extract; however, this response gradually decreased after four weeks.

Pot culture studies with pigeon pea were conducted for three consecutive years using six levels of well-decomposed litter followed by fresh extracts of *D. sissoo* obtained as described above. Litter was adding every year at 3 levels in proportion to the litterfall obtained at a *D. sissoo* agroforestry field trial and at three levels above the normal for extrapolation of results. The density of seedlings was lower in pots receiving higher extract concentration than with lower concentration. Plant height, number of branches, number of leaves, number of flowers, 100-seed weight, root and shoot biomass and total biomass were also determined. Plant height increased with higher extract concentrations as was found for the number of branches, number of leaves, number of flowers, root and shoot biomass and total biomass per plant. However, the total yield per pot seems to be higher with the third and fourth level of litter treatments than with either lower or higher extract concentrations. Maximum biomass was found with litter applications between 30 to 40 g/pot, being equivalent to 2.4 to 3.2 t/ha, which is the litterfall rate in the fifth year of an agroforestry system. Higher levels of litter and fresh extracts caused a reduction in yield which suggests that litter levels in excess of about 3 t/ha should be avoided by removing excess litter from fields and using it as manure in other locations. The 100-seed weight was highest in the second year under higher concentrations of litter.

The field growth data on interactions have revealed that the growth of both the crops *D. sissoo* at 5m x 5m and pigeon pea at 1m x 1m are positively correlated up to three years from establishment of the agroforestry system. In the fourth year the pigeon-pea crop has been resown and the yield results have not yet been determined.

The inhibitive actions of fresh and decomposed litter have been related to the presence of certain allelochemicals such as phenolics and tannins. It was observed that phenolics and germination % are negatively correlated in bioassay experiments, whereas in pot culture, tannins and phenolics are negatively correlated with germination but not to the extent of the bioassay results.

Central America and the Dominican Republic Strengthen their Supplies of Genetically Improved Seeds

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Forest cover in Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica, Panama and the Dominican Republic is characterized by a wide diversity of broadleaf and coniferous species. Lack of planning on the wise use of land, harvest for timber and other forest products and population growth among other factors, have caused destruction of a great part of these natural forests; the negative impacts of this process are well-known.

A way to diminish some of the negative effects caused by the destruction of the forest cover is to promote reforestation. For this activity to be successful, it is necessary to define objectives, select the species, and use reproductive material of improved genetic quality, along with intensive silvicultural management, in order to guarantee higher production.

The Tropical Agricultural Center for Research and Higher Education (CATIE), located in Turrialba, Costa Rica, through the implementation of research and transfer projects on silviculture of plantations, has been supporting the above seven countries during the last 20 years. As a result of this cooperation process, native as well as introduced species with potential to promote the development of silviculture have been identified.

One of the problems being faced in the promotion of forestry plantations has been the lack of genetically improved material of priority species. Many of the plantations have been established using material of unknown origin, or without being genetically assessed.

Thus, CATIE took the responsibility of providing the necessary support to the seven countries in order to improve the genetic and physiological quality of seed of the priority species being grown, and with the economic support of the Danish Agency for International Development (Danida), it started the implementation of the Tree Seed Project (PROSEFOR) in September 1992.

During these six years, PROSEFOR has been working intensively in a joint effort with national institutions responsible for the forestry sector, in order to enable National Tree Seed Banks to satisfy national demand for genetically improved seed.

Through technical assistance and training, a complete process has been developed to identify and select the best seed sources of priority species in each country. Subsequently, technical management of these sources was initiated to improve the genetic quality of the seed to be produced. Presently, 310 seed sources of 78 priority species have been selected. Most of these seed sources have already supplied seed to the users.

To complement this important task, PROSEFOR has simultaneously strengthened National Tree Seed Banks in order to improve seed collection, processing, storing and distribution systems. Nowadays, each country has its own seed source register, which guarantees that the user will receive basic information on site and seed source characteristics.

Allelopathy in Agroforestry Systems: Interference of *Populus* and *Dalbergia* with Wheat and Maize

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Agroforestry, a traditional and widely practiced land use system in India, is presently being recognized as a well-developed science of resource management. Current research in this science is directed toward understanding ecological and economic aspects based on major key factors such as sustainability, profitability, complexity and competitiveness. In the tropics, including India, the practice of agroforestry has advanced rapidly in recent years. Most of the studies have shown beneficial aspects of agroforestry. Nevertheless, some negative aspects of tree-crop combinations, such as competition among roots, shading effects and allelopathy, are also being realized. Hence, an ideal agroforestry model will have a balance between the positive and negative aspects. Allelopathy, which is now an established science in many managed and natural ecosystems, has also been investigated in many agro-ecosystems where trees are planted with crops without much planning. Since, trees are the dominant and long-lived components, their inhibitory effects on the adjoining crops cannot be ignored. In India, fast growing trees like *Eucalyptus*, *Populus* and *Leucaena* are favoured for agroforestry, and these genera have been extensively planted in agricultural fields with the aim of gaining short-term profitability.

A study was conducted in fields with 2-row shelterbelts of *Populus deltoides* and *Dalbergia sissoo*. A poorer performance of crops, particularly wheat and maize, was observed in the fields sheltered by *P. deltoides* as compared to *D. sissoo*. The inhibitory effect was observed close to the tree line rather than at distances away from the tree line. This decline in growth and yield of crops was attributed to allelopathy, particularly caused by senescent and decayed leaves, which fall abundantly and accumulate on the soil surface as litter. The allelochemicals from this litter layer are released either through leaching and/or through microbial decay. Upon release, the allelochemicals adversely affect germination, growth and yield of crops. In laboratory bioassay studies, the aqueous leachates of fresh, senescent and decaying leaves of *P. deltoides* significantly decreased germination and growth of wheat and maize. These leachates contained significant amounts of phenolics, which have also been extracted from the soil under *P. deltoides*. These studies show that *P. deltoides* is an allelopathic tree and crops grown in association with *P. deltoides* should be thoroughly screened for their susceptibility to allelochemicals. The understanding of allelopathic phenomena is essential in agroforestry ecosystems in order to obtain suitable crop production.

Initiation of Rooting in Stem Cuttings of *Salvia officinalis* L. through Growth Regulator Treatments in the Western Himalayas

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Salvia officinalis L. is a new essential oil bearing crop in Western Himalayas. It is one of the most important culinary herb. Its oil finds use in perfumes as a deodorant, in insecticidal preparations, for the treatment of gingivitis and as a carminative. It is also extensively employed in the food industry as a standard spice. It was introduced from Germany through the National Bureau of Plant Genetic Resources, New Delhi, India in mid-hill zone of Himachal Pradesh. *Salvia officinalis*, being an exotic species, has shown weak performance for rooting of stem cuttings and seed germination under Indian conditions. Hence, the present studies were conducted on the rooting of stem cuttings by taking GA3, IBA, IAA and NAA hormones and treating stem cuttings with 0, 1000, 1500 and 2000 ppm concentrations using the quick dip method for 10 and 20 seconds. Treatments with growth-promoting substances significantly promoted rooting in all cuttings over untreated cuttings. Among the different treatments, cuttings treated with 1500 ppm of IAA for 10 seconds took the least time for rooting (81/3 days), stimulated the highest percentage of rooting (84.3%), and also promoted large numbers of roots (40.7) with increased length (31.1 cm).

Genetic Engineering in the Improvement of Forest Trees: a Review

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Forest tree genetic improvement is a relatively long process limited by the rate of growth of the species involved and by the quantity of improved seeds that can be obtained through each breeding cycle. It is also a costly process because it requires the establishment of seed orchards, complex breeding plots, and often, programmes to accelerate flowering. Plant genetic engineering makes it possible to shortcut this process by allowing the isolation of specific gene(s) and transfer of single gene traits, and by using tissue culture procedures permit the production of an unlimited number of plantlets. The different approaches for transferring the foreign genes into plant cells may be divided into direct and indirect techniques. Apart from microprojectiles, with direct gene transfer methods (electroporation, microinjection, PEG-mediated and liposome-mediated delivery) the isolation of protoplasts is required. The indirect approach employs *Agrobacterium*-mediated gene transfer, using its different plasmid vectors (Ti and Ri). This system is based on the natural capacity of *Agrobacterium* to integrate its T-DNA into the plant genome. Considering its efficiency, the *Agrobacterium* system is certainly the method of choice, if the plant to be transformed is within its host range. The advantages are that complex explants, not only protoplasts, can be transformed, and that the genes are stably integrated into the plant genome and inherited in a dominant Mendelian fashion.

The development of efficient genetic transformation systems for forest tree species is of great importance to forest biotechnology. Forest tree genetic engineering is a logical complement to forest tree breeding, with the difference that it is more precise and focused. Reliable protocols for genetic transformation of forest tree species have been developed using Agrobacterium-mediated gene transfer techniques in *Allocasuorina, Azadiracta, Eucalyptus, Juglans, Larix, Populus, Robinia and Santalum*. Most research to date has been focused on the engineering of traits that relate directly to the traditional roles of industry in forestry, such as control of insects, weeds, plant diseases and lignin content. Progress has been rapid and genes conferring some of these traits have already been successfully introduced into *Populus* species. Traits such as lignin content can be manipulated through the introduction of gene(s) and could allow the production of wood tailored for specific industrial uses. As more becomes known about the molecular biology of forest tree species, more opportunities will be identified for improving forest tree growth.

Construction of *Populus deltoides* Marsh x *P. cathayana* Rehd. Molecular Linkage Map

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A molecular linkage map was constructed for *P. deltoides* Marsh x *P. cathayana* Rehd. based on random amplified polymorphic DNA (RAPD) markers. The mapping pedigree consisted of three generations with the F1 produced by interspecific hybridization between a *P. deltoides* female and a *P. cathayana* male. Three-hundred random 10-mer RAPD primers were screened in amplification reactions using DNA isolated from the parents and a sample of their F1 recombinant-inbred population. Of these primers, 180 revealed at least one polymorphic RAPD locus which could be used in mapping. We identified 20 linkage groups spanning 1900 cM (110 RAPD markers) with an average distance of 17 cM between markers. Linkage groups ranged from 188 to 37 cM in length and included 3 to 10 markers, respectively. This map should facilitate the identification of markers that 'tag' genes for pest and disease resistance and other traits in poplar. This is the first genetic map for *P. deltoides* x *P. cathayana*, and an important step towards the molecular breeding of poplar.

Keywords: Molecular linkage map, RAPD, *Populus deltoides* Marsh, *P. cathayana* Rehd.

Biochemical Response of Siberian Conifers to Water Deficit

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The productivity of forest stands in Russia varies over a wide range, reaching a maximum only in the most favourable climatic conditions. About one half of all wood stocks in the country is located in Siberia, where productivity of the economic forest species is limited for a large part of the forest territory by natural limiting factors. Water deficit is a dominant limiting factor, particularly in the southern boundary area of the Siberian forest. Biochemical responses to water deficit were examined in *Pinus sylvestris* L. and *Larix sibirica* Ledeb. in three habitats in eastern Siberia with varying precipitation. Annual precipitation at the three study areas ranged from 460mm in Krasnoyarsk to 350-360mm in the southern locations of Minusinsk and Khakasia. Total and protein nitrogen, free amino acids, starch and the low molecular carbohydrate content in needle, xylem and inner bark of stem and rough roots, as well as, the cellulose and lignin content in stem and root xylem samples were determined.

Pine and larch trees from Krasnoyarsk populations exceed growth parameters of trees from southern populations in diameter and height increment by 30-40%. Drought caused sugar accumulation with higher monosaccharide concentrations in root bark and the cambial zone of pine trees subjected to greater water deficit. The content of non-protein forms of nitrogen, in particular, free amino acids also increased in reserve bark tissues, photosynthetic tissues and in the cambial zone. Total nitrogen and especially protein content were higher in root bark than stem bark of larch but not for the pine. In stem and root xylem of pine reserve carbohydrate compounds were dominant, whereas, proteins were dominant in larch xylem. Water deficit had no influence on the content of cellulose and lignin in the xylem of either species.

We suggest that the tissues of current shoots may be used for identification of biochemical indices of water stress in pine and larch. The combined concentrations of arginine, ornithine and citrulline in current shoots increased with decrease in the water content of the 20-cm surface soil layer, whereas, the sum of glutamic acid, proline and gamma-aminobutyric acid concentrations decreased with decrease in soil water content. The proline proportion in free amino acids increased under drought impact only in some tissues. The maximal concentration of this amino acid was found in current year shoots and did not exceed 0.1% of tissue mass. This concentration is insufficient to supply a significant osmotic effect usually attributed to proline. The study is supported by the Russian Foundation of Fundamental Research (grant 98-0448136).

Assessing Genetic Diversity of Two Different Timber Species (*Shorea parvifolia* and *Eusideroxylon zwagerii)* in Central Kalimantan Using DNA Markers

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Genetic diversity of *Shorea parvifolia* and *Eusideroxylon zwageriio* on two sites in Central Kalimantan, Indonesia, was assessed using DNA markers. Genetic diversity parameters, (number of alleles per locus, effective number of alleles per locus, number of polymorphic loci, Shannon's diversity index and Nei's gene diversity), were calculated based on four RAPD (random amplified polymorphic DNA) markers. AFLPs (amplified fragment length polymorphisms), were also used on some samples for a comparison to RAPDs. Results of RAPD analysis showed that more than 80% of the loci of *S. parvifolia* are polymorphic, whereas for *E. zwagerii* it is more than 90%. Despite logging in one site the levels of genetic diversity of both species found in two sites were similar to that of other countries.

Effects of the Application of Plant Hormones and Plant Growth Regulators on Growth and Flushing of Dormant buds in *Aesculus turbinata* seedlings

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The present study deals with the effects of application of 10 different kinds of plant hormones and plant growth regulators (PGRs), including GAs (GA_3 and GA_4), IAA, trans-zeatin (t-Z), (+)-abscisic acid (ABA), Ethrel (ET), 24-epi-brassinoride (24-epi-BR), (±)-jasmonic acidmethyl ester (±)-JA-Me), uniconazole-P and AMO-1618, on growth and flushing of dormant buds in 2-year-old *Aesculus turbinata* seedlings. Seven different concentrations of PGRs from 0.0001 to 500 µg/10 µl (50% acetone solution) were prepared and each 10 µl solution was applied to the apical bud of each seedling by injection with a micro-liter syringe. Four seedlings were used for the same treatment. A 10 µl of 50% acetone solution was also applied to seedlings as a control. The treatments were started on June 6, 1998 and repeated 4 times at 7-day intervals.

The application of GA_3 and GA_4 at higher concentrations increased the growth of apical buds. However, the growth was suppressed by the applications of low concentrations of IAA, high concentrations of t-Z, (+)-ABA, Ethrel, uniconazole-P and AMO-1618. The growth of lateral buds was accelerated by the applications of high levels of GAs, uniconazole-P, and AMO-1618. These results suggest that the GAs are essential in the growth of dormant buds in *A. turbinata* seedlings.

The applications of GAs, IAA, (±)-JA-Me and Ethrel enhanced the flushing of dormant buds at various concentrations, suggesting the roles of these PGRs in bud breaking. In IAA-applied seedlings, the apex of apical buds became round shaped. The leaflets on apical buds abscised in the IAA or Ethrel treated seedlings.

Reproductive Potential of Siberian Forest Forming Conifer Species in Destructive Forest Ecosystems

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The extreme conditions in Siberia (unfavourable ecological factors, region of geophysical anomalies) influence greatly on viability and productivity of forestforming tree species. The change of crown structure, defoliation of needles and decrease of viability of generative organs are considered to be a response of conifer species to unfavourable ecologicalfactors. The loss of apical dominance, the appearance of subapical zone of degradation in shoots of male sexualization (*Abies*) as well as appearance of various tumors on trunk, branches and roots can be considered as biological parameters of species response under ecological stress. Another parameter of unfavourable ecological conditions is the viability of generative organs. Reproductive potential of species (seed productivity, quality of pollen and seeds) decreases under these conditions. It hampers the natural regeneration. The genetical study and selection of conifers in the region with unfavourable ecological condirions with help of parameters of generative organs, crown structure and devoliation of needles allow to determine species sensitive (*Abies*) and species resistent (*Larix*) as well as show resistent, productivity genotypes and tree mutants. The selection and breeding of genotypes which have not change in crown structurea and produced fertile pollen and seeds will promote Siberian forest composition. Thus, the habitus of trees and the their reproductive activity allow to evaluate the atate of forests under unfavourable ecological conditions.

QTL Detection and Candidate Genes Mapping for Marker-assisted Selection in *Eucalyptus*

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The forestry department of CIRAD is developing clonal varieties of *Eucalyptus* for the tropical region of Congo. The breeding programme is based on a reciprocal recurrent selection scheme between *E. urophylla* and E. *grandis*. Quantitative genetics methods are successfully used througout the selection process. However there is still interesting information that remains unaccessible to the breeders (e.g. the number of major genes controlling trait variation, their effects, etc.). We are now using the genetic mapping approach to adress these questions for economically important traits (growth, stem form, cutting rate, physical and chemical wood properties). The objective of this study is to give some preliminary results on the following specific questions:

1- are selection criteria under oligogenic control with mendelian components (QTLs) that could be manipulated by the breeders ?

2 - what about QTL stability across ages and genetic backgrounds ?

3 - what is the biological meaning of QTL ?

Saturated genetic maps of two parental elite trees were first constructed using the two-way pseudotestcross mapping strategy based on dominant markers segregating in 200 interspecific F1 progenies. These maps comprised 269 and 236 RAPD markers for the *Eucalyptus urophylla* and *Eucalyptus grandis* individual parents, respectively. For the afro-mentioned traits, several regions controlling part of the phenotypic variation were identified by interval mapping. Because growth and stem form were studied from the plantation in 1992 to the exploitation in 1998, QTL x Age interaction could be analyzed. Some QTLs were found to be stable after 3 years of growth (half rotation age).

The maps are now being completed with candidate genes potentially involved in the trait variation. For wood quality (density, growth strains, lignin content and S/G ratio), 5 genes of the lignification pathway (PAL, COMT, CCoAOMT, CCR, and CAD) have been mapped using SSCP (single strand conformation polymorphism). Four other genes (C4H, 4CL, C3H, F5H) will be studied in the near future. For growth and cutting rate, two genes in relation with cellular division and rooting ability (EgTub and EgPar) have also been mapped. The relationship between these genes and trait variation is under analysis. If co-localisation between these genes and QTL are obtained, then we will look for linkage disequilibrium between alleles of candidate genes and allele of QTL, in the population. The association between RAPD polymorphism and trait variation was also evaluated in a broader genetic background (12 x 12 factorial design), for wood density and vigour. Such molecular information should ultimately be useful firstly to assist the selection of parents for further generations of breeding, and secondly to choose the best trees in the best families, to be vegetatively propagated for clonal varieties production.

The Growth and Initial Photosynthetic Processes of *Pinus sibirica*

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The activity of the photosynthetic apparatus is a genetically determined function that is important in growth, productivity and organism adaptive capacity. Chloroplast functional activity was studied in fast-growing and slow-growing seedlings of *Pinus sibirica* under different growth conditions, including extreme conditons for tree growth. The rates of ferricyanide photoreduction and the noncyclic photophosphorylation reaction were greater for fast-growing seedlings than for slow-growing ones. Fast-growing seedlings had higher basic and coupled electron stream (in presence of ADP and inorganic P) than in slow-growing seedlings. The "photosynthetic control" and R/2e ratio, that provide an index of noncyclic photophosphorylation of electron streams coupling all chain reactions with photophosphorylation, were not essentially different between the two seedling groups. The reaction of ferricyanide photoreduction is described by the electron stream in the photosynthetic chain connected with Photosystem II (PHS II) and the activity of phosphorylase determining ATP production. The initial processes of photosynthesis in *Pinus sibirica* seedlings are connected to the growth and electron stream reaction of PHS II. Fast-growing seedlings produce more energy-active photosynthetic apparatus.

An increase in altitude influences plastid formation and quantities of photosynthetic pigments. Needles of *P. sibirica* growing in subalpine areas contain lower amounts of pigment and carrotinoids. The content of chlorophylls is reduced up to 23% at the expense of chlorophyll b. This shows some distinction in the heterogeneity of pigment forms connected with PHS II and the light-harvesting complex (LHC). Changes in a pigment complex not only involve the total content of green and yellow pigments, but also their ratio. The ratio of chlorophyll a/b increases from 2.3 to 3.0 with altitude, and the chlorophyll content in the LHC may be reduced by 23%. In contrast, the chlorophyll content in Photosystem 1and PHS 11 may be increased by 15.6% with altitude. A preferential decrease of chlorophyll b and increase of the ratio of chlorophyll a/b supports the assumption that the LHC role in formation of grana declines with increase in altitude. Assimilation reactions of *P. sibirica* also vary with changes in a pigment complex caused by anthropogenic factors. Change in the ratio of pigment components may be an adaptation to changes in environmental conditions. These changes also appear to be a reason for assimilate accumulation in the plant. The functional activity of chloroplasts was investigated with measurements of the reaction rates of ferricyanide photoreduction and non-cyclic photosphorylation of needles. These measurements revealed some specific dependence between the primary photoactive processes in a plant and the site of growth activity. Photoactivity of chloroplasts decreases with an increase of basic electron transport and electron-coupled transport rates. The activity of the C-hyll reaction in the presence of the phosphate-acceptor system is evidence for potentially high reduction activity of chloropasts and for effective coupling of electron transport with photophosphorylation. Differences in chloroplast functional activity result from the distinction between photosystem organization and the content of reaction centers of PHS II. Differences in chloroplast funtional activity at the different elevations may represent some adaptation of the photosyntetic apparatus of *P. sibirica*.

Change in Sex Expression in Clones of *Casuarina Equisetifolia* Forst

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Flowering pattern in sex identified clones, of *Casuarina Equisetifolia* Forst. grown as hedges in the clone bank of Institute of Forest Genetic and Tree Breeding, Coimbatore, India revealed that sex change occurs in this species. The population assembled and rooted ramets from three year old trees selected from Chengalpet and Chidambaram area of Tamil Nadu, India consisted of constants males, constant females and monoecious individuals at the time of introduction during 1992 and remained so till 1997. The data on flowering collected during the months of September, 1997 and March, 1998 showed that content males, constant females and bisexuals accounted for 59.26% and 4% of the population respectively. Six clones (11% of the population) changed their sex in various ways. Four clones viz., CHCE 1003, CHCE 2903, CHCE 0109 and CPCE 3702 were females originally changed their sex to bisexuals. Clones CHCE 0401 and CPCE 3501 were originally males and transformed into monoecious plants by producing female cones approximately five years after introduction. Continuous hedging may bring out plasticity of sex expression in a small percentage of population.

Modeling and Experimental Research of Canopy Structure, Photosynthesis, and Transpiration of *Cunninghamia lanceolata* (Lamb). Hook. Stands

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Cunninghamia lanceolata (Lamb.) Hook. (Chinese fir) is an important timber and native species in southern China. The physiological and ecological basis for productivity in Chinese fir is investigated since little research has been conducted in past decades. Canopy structure, light [including Photosynthetically Active Radiation (PAR)] distribution, photosynthesis and transpiration of three Chinese fir stands at the Subtropical Forestry Experimental Center of the Chinese Academy of Forestry in Fen-Yi County, Jiangxi Province were determined and modeled. A bottom-up method used in the research gave the following results.

First, linear relationships were found between branch length, branch inclination, and the height of the branch. The canopy layers with densest leaves shifted upward from 8-year-old to 13-year-old crowns, and the relationship between relative leaf area density and branch height fitted a Beta distribution model.

Second, the distributions of total solar radiation and PAR in relation to canopy structure were determined along with the energy budgets of the three different Chinese fir stands. Close relationships between nitrogen content of needles and soil water content with photosynthesis of the three different stands were obtained.

Third, measurements of daily and seasonal changes of photosynthesis, respiration and transpiration were made with a LI-6200 portable photosynthesis system. The relationships of PAR, temperature, and humidity with stomatal conductance, photosynthesis, respiration, and transpiration of needles of different ages in different crown layers were described and modeled. The basic photosynthetic characteristics, including light-compensation, light-saturation, maximum photosynthesis rates and transpiration ratio, of needles of different ages and different position in a branch were determined.

Finally, a simplified model of radiation transmission and light-photosynthesis curves (A-PAR curves) of needles of different ages in different layers of the canopy were obtained. The simulation model of net photosynthesis rate and transpiration rate of Chinese fir plantations was developed from the field data, the A-PAR curves, and the aerodynamic characteristics and energy balance of the stand. Leaf level responses from the LI-6200 system were successfully integrated to the canopy scale, and the model gave reasonable outputs. Simulation modeling is a new development in production ecology of plantation forestry in China. The combination of modeling with the experimental results provided a new approach and direction for calculating and evaluating the productivity of Chinese fir plantations and other forest plantations.

Effects of Depth of Flooding on Growth, Stem Morphology and Anatomy of *Taxodium distichum* Seedlings.

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The aims of this study are to examine the influence of depth of flooding on growth, stem morphology and anatomy of baldcypress (*Taxodium distichum*) seedlings. The effects of gravitropic stimuli on the anatomical characteristics of flood-induced hyperplastic stems are also studied.

I. Depth of flooding study: Twenty-eight, 3-year old baldcypress seedlings were divided into 4 groups of 7 plants, and each group received one of four treatments: (1) unflooded seedlings, (2) flooded seedlings at 3 cm above the ground level, (3) flooded seedlings at 38 cm above the ground level, and (4) submerged seedlings above shoot apices. The 15-week flooding treatment was initiated on May 18, 1998. After the determination of height and diameter increment, the seedlings were harvested, separated into leaves, stems and roots, and their dry weights were determined. Stem segments also were sampled for microscopic observations from each seedling at 3 cm and 23 cm above the ground level. The following results were obtained: (1) Flooding at 3 cm above the ground level stimulated the biomass increment of the seedlings. The seedlings submerged above shoot apices survived but showed little growth. (2) Flooding enhanced diameter increment of submerged portions of stems. The position of the most vigorous diameter increment was located just beneath the water level and raised as the water level was raised. (3) The tracheids in hyperplastic stem portions were expanded in both radial and tangential directions. However, flooding reduced the thickness of the tracheid walls.

II. Study of gravitropic stimuli: Forty-eight, 3-year old baldcypress seedlings were divided into 4 groups of 12 plants, and each group received one of four treatments: (1) unflooded, untilted control seedlings, (2) seedlings flooded at 28 cm above the ground level, (3) seedlings tilted at 45ø, and (4) seedlings flooded at 18 cm above the ground level and tilted at 45ø. The 8-week flooding and tilting treatments were initiated on May 24, 1998. At Day 10, 5 seedlings of each group were harvested for determination of the amount of ethylene released from the stems using gas chromatography. On July 27, the seedlings were harvested, separated into leaves, stems and roots, and their dry weights were determined. The following results were obtained:

(1) The rate of angle recovery from of stem inclination was greater in the flooded and tilted seedlings than that of the unflooded and tilted seedlings. (2) In the unflooded, tilted seedlings the diameter increment was vigorous in the vertical direction of inclined stems, whereas that was vigorous in horizontal direction in the flooded, tilted seedlings. (3) Compression wood tracheids were formed on the lower side of inclined stems of the unflooded, tilted seedlings. In the flooded, tilted seedlings thin-walled tracheids with expanded cell diameter were observed on the upper and the lateral sides of inclined stems. Compression wood was formed on the lower side. (4) Ethylene production was remarkable in the flooded seedlings. Tilting did not affect ethylene production.

Studies on the Mechanism and the Artificial Induction of Foxtailing in *Pinus spp.*

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Pine trees in the tropics and subtropics often exhibit the continuous growth of the shoots throughout the year, being understood as the phenomenon of foxtailing. In contrast, *Pinus densiflora* SIEB. et ZUCC., a species of the temperate zone, normally shows the periodic development of lateral buds. We investigated whether the pine trees from temperate and subtropical zones can be changed between periodic and continuous growth by changing the photoperiodic and/or air temperature conditions.

Young plants of *P. densiflora* exposed to a 20-h photoperiodic condition, showed the continuous growth of the shoots without the formation of lateral buds during an experimental period of 28 months. P.luchuensis MAYR, a species seen to grow in Okinawa (the subtropical zone in Japan), showed the periodic growth of the shoots as the plants were grown with a 20-h photoperiod. When the plants were grown with 12-h and 13-h photoperiods, 80% of the pines continued to grow the shoots, which was the highest occurrence among treatments.

The periodic growth pattern of the subtropical pine with a 12-h photoperiod however disappeared when the growth chamber temperature was controlled at 25°C in daytime and 15°C at nighttime. The present study suggests that differences between *P. densiflora* and *P. luchuensis* in their growth patterns were related to the length of photoperiod and ambient temperature and associated changes in the correlative inhibition between the internode elongation and primordia differentiation of leaves in the apexes.

2.01.17 Vegetative propagation

Coppice Management of Clonal *Eucalyptus* Commercial Plantations in the Congo

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Keywords: Coppice; Replanted sites; Commercial plantations; *Eucalyptus*; Congo

Since 1978, 42,000 ha of clonal *Eucalyptus* plantations have been established in the Pointe-Noire region for pulp production. These plantations, owned by ECO sa (*Eucalyptus* du Congo Societe Anonyme), are based on two natural hybrids (E.PFI and E.12 ABL* *saligna*). As felling age is 7 years, management of coppice appeared very early as a main issue. More than 10 trials focusing on this goal have been therefore established since 1985. Moreover, complementary experiments were set up to compare coppice and replanted sites production.

The trees can be cut at ground level, without impact on latter coppice production. From 4 months after cutting, there are marked differences in growth between coppice shoots. These differences increase with age: from 2-3 years the only two bigger shoots per stump, that represent 70% of the total basal area, keep on growing. Coppice reduction increases growth of the remaining shoots. This operation can be carried out during the first year, as soon as the dominant shoots can be identified (from 4 to 9 months old). Optimal coppice reduction intensity depends on soil fertility and stump density: as observed with planted crop, the maximum production is obtained between 600 stems/ha in the low fertility sites and 800 stems/ha in the best sites. As initial stand densities vary between 400 to 800 stems/ha, one to two shoots per stump must be selected. Secondary coppice shoots have to be controlled, manually with bush knife, or chemically using glyphosate (Round up). This last manner allows weed control at the same time, with an application of 3 to 4 litres of glyphosate perha , mixed in 250 to 350 litres of water. It provides the best results for shoot control and stem growth and induces the lowest costs. A fertilisation of 200 to 250 kg/ha N-P-K (13-13-21) must be applied one year after the harvesting of the previous stand (planted crop or coppice).

Coppice stumps can be weakened with a 40% glyphosate solution (Round up). The solution must be applied by spray at a dose of 25-30 ml/stump, just after stem harvest i.e. less than one hour. No return time is then necessary. A site replanted with the previous clone exhibits about the same mean annual increment as coppice. Moreover the loss of production during the period between harvesting and planting must be taken into account. It appears therefore that a plot may be replanted only if a much better vegetal material can be used (*E. urophylla* * *E. grandis* vs natural hybrid). These results contribute to manage efficiently the congolese commercial plantations consisting at present of 9,000 ha of planted crop, 18,000 ha of coppice and 15,000 ha of replanted sites.

Asexual Propagation and Mycrorrhizal Inoculation of Selected Dipterocarps in the Philippines

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Keywords: Asexual propagation; Mycorrhiza, Dipterocarps

The rapid disappearance of dipterocarps in the Philippines requires immediate steps to reestablish these ecologically and economically important forest species. However, efforts to reestablish dipterocarp stands are hampered by lack of quality planting materials. This is due to irregularity in seed production, short viability of seeds, and lack of appropriate seed technologies. Moreover, the degraded nature of soils in logged-over areas make dipterocarp establishment difficult.

Two promising technologies involving the reestablishment of forest trees are asexual propagation using cuttings and mycorrhizal inoculation. Asexual propagation enables the production of clones of selected trees even during non-seed years, while mycorrhizal inoculation helps in the establishment of the clones in degraded soils. However, the two technologies have to be tested in dipterocarps.

This study aimed to develop appropriate technologies for asexual propagation using cuttings and mycorrhizal inoculation of selected dipterocarp species. Four separate experiments were conducted to determine the effect of growth hormones (no Hormone, IBA at 10 ppm, and Rootone F), number of leaves of cuttings (0, 1, 2, and 3 leaves per cutting), or cutting positions on donor plant (1st and 2nd, 3rd and 4th, 5th and 6th, and 7th and 8th nodes below the terminal shoot) on rooting of dipterocarp cuttings. Initial effects of mycorrhizal inoculation using rooted cuttings were assessed in terms of height growth. All experiments were conducted in a screenhouse under 20% sunlight. The cuttings were rooted in sand-soil medium in polyethylene covered basins maintained at 85-95% relative humidity.

Dipterocarp species varied in their response to hormone treatments. In *P. malaanonan*, best rooting (78%) was achieved using Rootone F powder, while 10 ppm IBA did not improve rooting over that of control. In *S. contorta*, Rootone F and IBA slightly improved rooting by 98% compared to control (84%). In *A. thurifera*, IBA (95%) was comparable to the control (90%) but Rootone F (64%) depressed rooting. In *H. manggacapui*, all treatments gave 95% rooting.

Number of leaves on cuttings showed significant effect on the rooting of dipterocarps. In all species tested, leafless cuttings did not root at all. Best rooting of *A. thurifera, S. contorta and S. guiso* occurred if cuttings contained 2-3 leaves, while best rooting of *D. grandiflorus* occurred in 1-leaf cuttings.

Shoot proliferation of three potential tropical plantation tree species

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Keywords: Micropropagation, *Acacia auriculiformis*, *Acacia crassicarpa*, *Azadirachta excelsa*, 6-benzylaminopurine, Multiple shoots.

It has become increasingly important to reforest and preserve individual germplasm for continuous supply of elite genetic material for breeding and raw material for the industries. Extensive afforestation programs with the establishment of large-scale-forest plantation have been undertaken in many countries. This is to meet the rapidly growing demand for wood supply especially the hardwoods. Tropical trees species like *Azadirachta excelsa*, *Acacia crassicarpa and Acacia. auriculiformis* have been identified as potential plantation tree species, which have good wood quality, good growth performance and broader market prospects. Eventhough, these species can be propagated by seeds there is a need for vegetative propagation if rapid breeding is to be done especially for *A. excelsa* which produces recalcitrant seeds. *A. crassicarpa* on the other hand, only produced seeds once in two to three years. While for *A.auriculiformis*, most of the good form trees produce very small amount of seeds as a result from their small crown and few branches. The conventional methods of tree improvement and selection offer only limited possibilities of meeting the rapidly growing demands. In this regard, vegetative propagation is worth special attention particularly tissue culture. Micropropagation through tissue culture technique offers an alternative tool to propagate selected trees for plantation purposes. Therefore, this experiment aimed to study the possibility of micropropagating *A. crassicarpa, A. auriculiformis* and *A. excelsa* via shoot proliferation.

Nodal stem segment and young leaves *of A. crassicarpa* and *A. excelsa* obtained from 2-3 months old seedlings and 7 months-old seedlings respectively were used as explants in this study. However, explants for A.auriculiformis were obtained from nodal stem segment of 5 month-old seedlings and 6 year-old plus trees. They were cultured in three types of medium viz Murashige and Skoog (MS) Gamborg (B5) and Woody Plant medium (WPM) supplemented with 5 concentrations of 6-benzylaminopurine (BAP). Multiple shoots developed from nodal stem segment explants of each species except for leaf explants which was cultured in the medium supplemented with 0.5 – 6.0 mg/1 BAP. For *A. crassicarpa,* the highest mean number of shoots (4.3≅4) and the longest mean root length (4.9≅5 mm) were obtained from the medium supplemented with 2.0 mg/L BAP. As for *A. excelsa*, the highest mean number of shoots (1.6≅2) and the longest mean shoot length (2.7≅3mm) were also obtained from the medium supplemented with 2.0 mg/L BAP. Besides callus formation, nodal stem segment explants from both species also tend to produce callus when cultured on the medium supplemented with BAP. As for *A. excelsa*, the highest mean number of shoots (1.6≅2) and the longest mean shoot length (2.7≅3 mm) were also obtained from the medium supplemented with 2.0 mg/L BAP. Besides callus formation, nodal stem segment explants from both species also tend to produce callus when cultured on the medium supplemented with BAP. For A. *crassicarpa*, formation of callus was observed on the medium supplemented with higher concentration of BAP (10.0 mg/L) and the intensity of callus produced was very low (+). The calli produced were compact and light green in colour. As for *A. excelsa*, the callus produced was compact and white brownish in colour, and was produced at a higher intensity (+++).. For *A.auriculiformis*, low concentrations of BAP (0.1 – 0.5 mg/L) were sufficient for shoot initiation. However, longer gestation period was observed for the explants taken from mature tree before the shoots initiated can start multiplying. It can be concluded that the large scale micropropagation of these species are possible and thus it is an excellent tool to complement the conventiaonal vegetative propagation of multiplying selected trees.

Somatic Embryogenesis in *Pinus gerardiana* Wall

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Keywords: Edible nuts; *In vitro*; Osmotic potential; *Pinus gerardiana*; Somatic embryogenesis

Somatic embryogenesis refers to methods whereby embryos are produced *in vitro* from small pieces of plant tissue or individual cells. The embryos are referred to as somatic because they are derived from the somatic (vegetative) tissue, rather than from the sexual process. Propagation through somatic embryogenesis has the capability to capture all genetic gain of desirable individuals. Moreover, it has a great potential to produce large number of clones for reforestation purposes. Also, the capacity to induce somatic embryos from somatic tissue of mature trees is very important as it may lead to rejuvenation.

Pinus gerardiana Wall., a conifer of dry temperate Western Himalayas, is highly valued for its edible nuts. The nuts of this species are highly nutritious and have aphrodisiac value. Due to over exploitation and low regeneration capabilities, the species has become threatened during the last few decades. Keeping in view the great regenerative potential of somatic embryogenesis, this species was studied for its somatic embryogenesis. Aseptically removed mature zygotic embryos were used as the explants for these studies. Zygotic embryos were placed on basal culture medium for conifer somatic embryogenesis supplemented with 3.0 mg/l Naphthaleneacetic Acid (NAA) and 1.5 mg/l N6-Benzyladenine (BA) for embryogenetic tissue initiation. The initial cultures were kept in dark at 25+2 0C. The embryogenetic tissues obtained from initial cultures were maintained on the same medium but with reduced hormones i.e. 1.0 mg/l NAA and 0.75 mg/l BA. Somatic embryos were developed and matured by using a higher osmotic potential by adding maltose, Polyethylene Glycol (PEG) and Abscisic Acid (ABA). Development medium did not contain any hormones. Good quality somatic embryos were obtained by this process.

The process of somatic embryogenesis in this species clearly offers an important tool to assist in genetic improvement of this important conifer of dry temperate region of Western Himalayas. The system is not only developed for clonal propagation, but also as a interface for genetic engineering techniques for the purpose of producing transgenic clonal planting stock of this conifer.

Somatic Embryos Induction of *Cyclobalanopsis glauca*

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Keywords: Somatic embryo; *Cyclobalanopsis glauca*

Immature embryos of *Cyclobalanopsis glauca* were transferred onto MS basal medium supplemented with 1 mg/l NAA and 0.5 mg/l BA to get the seedlings *in vitro*.

Three kinds of materials were used for callus induction: (i) immature embryos, (ii) cotyledon and (iii) hypocotyls of *in vitro* seedlings. The results indicated that both immature embryos and hypocotyls on MS basal medium with 1 mg/l NAA and cotyledon on MS basal medium with 0.5 mg/l 2,4-D gave the better induction. However, among these three kinds of materials, the greatest amount of calli were induced by immature embryos. Additionally, callus characteristics were observed to vary according to the type of plant growth regulators used . We found that the embryogenic callus induced on the medium with 2,4-D could be used as suitable materials for suspension culture.

The formation of the few somatic embryos from the embryogenic callus of hypocotyls and cotyledon was investigated. The results indicated that direct somatic embryos could be induced from the embryogenic callus obtained from immature embryos. Supplementing the culture medium with 0.5-1 mg/l ABA, improved the growth of the somatic embryo.

2.02.00 Future of breeding and plantations in a sustainability-oriented world 1

Investigation of Wood Specific Gravity Variation of Hornbeam (*Carpinus Betulus* L.) from Different Origins.

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Keywords: hornbeam, *Carpinus Betulus*, wood specific gravity.

Hornbeam (*C betulus* L.) is one of the major forest species in northern Iran. It covers over 31% of total timberlands of the region. Among other native hardwood species, hornbeam has the longest fiber length. Thus, hornbeam has been considered to be a suitable candidate species for the pulp and paper industry of Iran. For these reasons developing a tree breeding program for this species to improve such economic traits as fiber length and wood specific gravity (WSG) is desirable and economically justifiable.

In this investigation variation of WSG of hornbeam from three different ranges of altitudes at two geographic regions were studied. The ranges of altitudes were low (0-250 m), medium (400-550 m) and high (900-1000 m) above the sea level, and the geographic regions were Noushahr and Shastkola, which are about 300 km apart from each other. Hence, in this study, a total of 6 locations were selected to be searched for sampling purpose. At each location a total of 30 trees with the best phenotype were used for sampling. The samples were obtained using an increment borer. Wood specific gravity was determined using volumetric technique. A nested design was used for statistical analysis, along with Duncan's multiple range test to compare the mean values. The results showed that out of the total variation of WSG found in hornbeam, individual trees within altitudinal range, altitudinal range within geographic region and geographic region accounted for 83.5%, 12% and 0.08% of the variation respectively. The overall means for WSG in Noushahr and Shastkola regions were 0.763 and 0.768 g/cm^3, respectively, which were not significantly different from each other. Moreover, there was not any significant difference among WSG values in the low, medium and high altitudinal ranges of Shastkola region (0.756, 0.756 and 0.758 g/cm^3 respectively). However, in Noushahr region, the WSG value in the medium altitudinal range (0.813 g/cm^3) was significantly different (at 0.05 statistical level) from those in the low and high altitudinal ranges (0.740 and 0.751

g/cm^3). The results of this study suggest that using the individual tree selection method in the correct geographic region could achieve a significant genetic gain for WSG of hornbeam.

Intra Species Genetic Variability of *Picea abies* (L.) Karst. and *Picea abies* var. *Misicii* Mat. et Pav.

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The species *Picea abies* (L.) karst. has the greatest morphological variability in the family *Pinaceae*, which results in the description of a high number of intraspecific taxa. Vidakovic (1982) cites, after Krüssmann (1972), more than a hundred cultivars and forms. In the characteristics of these forms there is not a single description that corresponds wholly to the morphological characteristics of the "mutant" spruce (Matovic 1988; Matovic et al. 1994; Matovic and Vujkovic 1994a, 1994b). This paper compares some morphological and quantitative characteristics of the "mutant" and the common spruce (*Picea abies*) growing in the same stand. During the last field investigations (1994) from the mutant spruce site at the mountain Kamena Gora near Prijepolje, additional data and material were collected on the common spruce. In addition to the description of the habit, data have been obtained for needle length and thickness, annual growth increment, levels of branching and the number of needles per centimeter of branch length. The unusual spruce was described as an unnamed "new mutant form". Based on these descriptions, this mutant form has been ascribed to the taxonomic level of variety, and has been named *Picea abies* var. *misicii* - Misic's spruce, in honor of the prominent researcher of the flora and vegetation in Serbia - Dr. Vojislav Misic.

The state of the stand where *P. abies* var. misicii grows has changed compared to the first description obtained by Matovic when he discovered the stand in 1984. The regenerated vegetation, most likely vegetative, has been cut along with many adjacent common spruce trees. From the previous state of the stand, only a few broadleaf species remain in the tree layer (*Populus tremula* L., *Acer pseudoplatanus* L., *Sorbus aucuparia* L., *Betula pendula* Roth.), along with one *P. abies* var. *misicii* and one common spruce. The two spruce trees are approximately of the same age, height and basal diameter.

The girth of Misic's spruce is 98 cm at 40 cm above ground, and the bole forks at a height of 70 cm. Needle lengths on shoots of the same age, grown in 1992, 1993, 1994, are regularly longer (15.3 to 21.7mm) than needles (12.2 to 16.8mm) of the adjacent common spruce. Needle diameters from different parts of the canopy of the adjacent common spruce range between 0.7 to 1.2mm, and were smaller than the 1.1 to 2.0mm needle diameters of Misic's spruce. The number of needles per one cm of shoot length for the adjacent common spruce (48 to 76 range, average 59) is twice that of the mutant spruce (21 to 34 range, average 29). The top of the crown of Misic's spruce is widely conical, and from the upper third, crown edges curve gradually downward so that the crown is widest at the middle of the bole.

In Misic's spruce, a higher number of primary branches occur in the whorl of the older part of the stem than in the younger part, which has 2-3 branches per whorl. The majority of primary branches make a mildly acute angle compared to the stem, being almost pleiotropic. Some branches deviate significantly from the radial position of a whorl. These include branches that develop subsequently within or out of the whorl, and branches of later orders up to the tertiary level. These unique characteristics distinguish the mutant spruce from almost all of the members of the genus, family, and perhaps even wider.

Genetic Variations of Allozyme in Natural Stands of Hiba (*Thujopusis dolabrata* var .hondae.) in Tohoku Region

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1. Introduction

Hiba (*Thujopusis dolabrata* var *hondae*) is major forest tree species in Tohoku Region. It is distributed form Tosika-pen. in Hokkaido to Noto-pen. in Honshu. For the conservation of genetic resources, forest-trees must be conserved mainly in situ as population in the field, because of the extremely long time required for rotation of a generation , and consequently for their evaluations and utilization for genetic improvements. Recently, the genetic variation within and among populations of forest tree species have been investigated using allozyme loci encoding enzyme systems as genetic makers. In this study, the genetic variation and differentiation within and among natural hiba stands at the allelic level using the 7 putative loci as maker genes were investigated so as to have basic information for making of a study of the methodologies of in situ conservation of hiba as a genetic resource.

2. Materials and methods

Leaf samples of individual trees for this study were collected form 4 natural hiba stands (Kawai Sado Natsuse Hiyama). Those were collected 40 to 60 individuals for each of 4 natural hiba stands between October and April. Samples were stored at -60 until isozyme analysis was conducted. Isozyme analyzed by Polyacrylamide vertical slab gel electrophoresis. It was conducted following the procedures of Tsumura and Ohba (1993). Enzyme systems were stained: shikimate dehydrogenase (ShDH), eucine aminopeptidase (LAP) 6-phosphogluconete dehydrogenase (6PG), lucokinase (GK), lutamate oxaloacetate transaminase (GOT), osphoglucoisomerase (PGI). From these, 7 putative loci with a total 19 alleles were inferred.

The following statistics were used to estimate genetic diversity with in each population: 1) the proportion of polymorphic loci (Pl,95% criterion); 2) the effective number of alleles per locus (Ne); 3) the average observed hetrozygosity (Ho).

3. Results

The 7 putative loci were polymorphic (95% criterion). The2-test was carried out at every polymorphic loci to investigate the deviation form Hardy-Weinberg equilibrium . The results of the tests were not significant at 7 putative loci. The values of Pl ,Ne, Ho were calculated (Table 1)

Table 1The average of P_l ,N_e, H_o in 4 natural stands of Thujopsis dolabrata var .hondae

	kawai	Sado	Natsuse	Hiyama	Mean
P_l	0.86	0.57	0.86	0.71	0.75
N_e	1.54	1.40	1.42	1.61	1.49
H_o	0.33	0.25	0.28	0.34	0.30

The Character of Genetic Variation in Siberian Stone Pine Seedlings

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The development of methods for sustainable use and conservation of biological resources in forest ecosystems requires extensive studies of the forest species genofond. The molecular genetic methods, in particular electrophoresis of isozymes, allowed a genetic variation in tree species to be evaluate, and near 50 conifer species have been described in recent year (Kani Isik et al., 1997).

236 Siberian stone pine seedlings (the progeny of 25 trees growing in the Altai Mountain, 450m a.s.l.) were investigated by starch-gel electrophoresis. Methods of enzyme extraction, electrophoresis and histochemical enzyme staining followed the Goncharenko et al. (1989). The vegetative tissue was used in the experiment, and it was difficult to determine some isozyme fractions. The genotypes of seedlings were detected on the 22 loci coding 14 enzyme systems. 15 loci appeared to be monomorphic, 7-polymorphic.

All the analysed loci have been found in Hardy-Wainberg equilibrium. The averaged value of the heterozygosity to be expected (He) is 0.271, the observed heterozygosity (Ho) was 0.225 in the sample of Siberian stone pine seedlings. So, we observed some insignificant deficiency in heterozygotes. It should be noted that null-alleles have been found in two analysed loci (Lap-2 and Skdh-1), which does not allow heterozygous genotypes to be identified in diploid tissue. This in its turn might lead to distortions in criteria of heterozygosity.

Chloroplast DNA Polymorphism in Italian Natural Populations of European Aspen (*P. tremula* L.)

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In order to estimate inter- and intra-population genetic variability of *Populus tremula* L., an analysis of chloroplast DNA polymorphism was carried out on natural populations from northern, central and southern Italy. European aspen is a widespread species, distributed in the whole Eurasian continent. It spreads from the Mediterranean countries in the south to Scandinavia in the north and from Spain to the

Pacific Asian coastal regions. Unlike other poplar species, which are appreciated for the production of wood and pulp, European aspen is usually not cultivated and its economic value is mostly related to the possibility to obtain inter-specific crosses. Besides, its occurrence in forested areas is only sporadic and its presence in Italy is mostly restricted to some mountainous areas, where this aspen has often decreased following reforestation with other species. On the other hand, due to its pioneer behaviour, P. *tremula* has a particular ecological relevance; its capacity of gr owing on abandoned and degraded soils, as well as on soils destroyed by fires, might be exploited for habitat restoration. For these reasons it is of particular ecological interest. The study of genetic diversity on this species may constitute a basic knowledge background for genetic resource conservation programmes. The work was carried out by studying chloroplast DNA polymorphism in order to obtain information both on genetic diversity and on geographic structure of variability. This latter level of information is peculiar of cytoplasmic markers (chloroplast and mitochondrial DNA), as they are - with only few exceptions - uniparentally inherited. As most of other Angiosperms poplars shows maternal inheritance of chloroplast DNA and, therefore, the variation of this marker follows the direction of the seed component of the gene flow. Leaf and bud samples were collected in ten different areas all over Italy (four in the north, three in the centre and three in the south). A special care was taken in collecti oplast DNA was observed not only among different populations but also within the populations.

Keywords: *Populus tremula*, chloroplast DNA, genetic diversity

Allozyme Variation in Natural Populations of Chir pine (*Pinus roxburghii* Sarg.) in Himachal Pradesh

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The present studies were conducted selecting eight natural populations of *Pinus roxburghii* in Himachal Pradesh covering Shiwalik and Himalayan ranges of species distribution. Eleven enzyme systems; ACO, AAT, GDH, IDH, LAP, MDH, PGI, 6PGDH and SKDH were analysed using starch gel electrophoresis to assess the genetic variability within and among the populations.

For the eleven enzyme systems studied, 25 gene loci were identified out of which 18 (72%) were polymorphic. Most of the polymorphic loci showed segregation pattern according to Mendelian expectation of 1:1 gametic segregation. In total, 50 alleles were found to code for 25 gene loci. The allelic diversity of the gene pool was low (1.130). The range of hypothetical gametic diversity among the populations was large (9.591-56.581). The actual heterozygosity for populations ranged between 0.096 and 0.169 with a mean value of 0.147. Three populations showed significant positive fixation indices in seeds. Whereas highly significant negative fixation indices were recorded in parent trees in all the populations. A low amount of allelic differentiation among the populations was reflected by the mean gene pool value, δ=0.045 which means on an average the populations differed from their complement populations by 4.5% of the effective number of alleles. A small differentiation among populations and large variation within populations reflected by small value of GST (0.041) revealed that 96% of the total genetic variation resided within the populations and only 4% among the populations.

2.02.00 Genetic improvement

Genetic improvement and sustainable forest management

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Approximately 0.7% of the forest are lost annually in the world and Mexico is one of the more deforested countries, it has an estimated loss of 600 000 Ha annually, not only in tree surface but also in genetic characteristics susceptible to be handled in order to support the forest productivity and satisfy the society’s necessities.

Many conservation strategies have been proposed to avoid the loss of these resources, because the natural forest permanency is important in the species distinctive genome in all its natural distribution range that support the variation and permitting adaptation and evolution to new environments. However, generally these strategies have not considered that the forest conservation needs a future management vision that will be sustainable now and under the actual improvement system but considering the necessities of the growing population that maybe need other products that we do not use nowadays. If the forest management continue to be dysgenic, we are not able to preserve the genetic information for the future product requirements.

To get a sustainable forest management requires strategies that allow the use and preservation of variation: one strategy is the genetic improvement which allows to select at field level desired tree characteristics by seeds collection or vegetative explants to probe them in species, provenance or provenance/progeny trials. With this strategy the tree preservation and forest management for other tree products extraction is necessary.

However, the natural forest is too exploited, in such way that the preservation of the original parental sources during the period required to perform the genetic tests is difficult. So it is very important to develop a strategy to protect the desired characters, in order to get identical replicas from a single tree tested in different and obtain a high productivity to provide efficiently commercial and recreation products and services and decrease the wind, rain and noise effects. With this strategy is possible to improvement the environment quality and the human life quality.

In Veracruz state, Mexico there is a forest genetic improvement program. Many stands, seeds production areas of four species to immediately better quality seeds collection had been established. 7 species, 32 provenances and 375 families had been evaluated in 16 provenance and progeny tests. We will obtain a lot of quality seeds in these trials to use it in the appropriated sites. However we have a great challenge to define the size site for this species and know the movement of the specific genetic characters for specific purposes.

Flowering and Fruiting Phenology in an Exotic Population of *Grevillea robusta*: Implications for Improved Seed Production

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The flowering and fruiting process within *Grevillea robusta* was carried out in a 5-year-old provenance-progeny trial at Malava, western Kenya. Field studies involved a detailed examination of patterns of flowering and fruiting, including the flower structure and development. The studies were carried out at the individual tree, family and provenance levels. The structure of the inflorescences and the nectar reward suggest the species is most likely bird- or mammal pollinated. Inflorescence production peaked in October for most trees, although there was considerable variation between trees with respect to the total number of inflorescences produced and length of flowering season. Within a family, the relative contributions of individual trees to pollen flow and fruit production may change with time. The variation in flowering patterns creates temporal changes in the distributions of potentially mating individuals in the stand. It was found that the heavy flowerers are the heavy fruit producers. The effect of this variation in flowering on the genetic quality of the progeny is important with a narrow genetic base for the seed produced. The study found no evidence of weather effect on flowering period and intensity. However, it is suggested that the environmental conditions at Malava are marginal for flowering for *G. robusta*.

Keywords: *Grevillea robusta*, *Proteaceae*, flowering, fruiting, seed production

Age Trend of Genetic Parameters on Height Growth *of A. mangium* in South Kalimantan - Its Implications for Selection Strategies in Seedling Seed Orchard

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Assessing the age trend of genetic parameters is essential in determining an optimum selection strategy for a seedling seed orchard, because the selections in the orchard have to be practiced much earlier than rotation age. It is well known that genetic gain by this type of selection is primarily dependent on the size of heritability and genetic correlation between selection age and harvest age. However, age trend of the parameters and expected gain at rotation age have not yet been reported on *A. mangium*, although seedling seed orchards of this species are widely used for genetic improvement in the tropics.

In this report, an optimum age for selection of *A. mangium* was investigated by analyzing height data measured repeatedly up to five years of age in two seedling seed orchards in South Kalimantan. In the orchards, a population from Queensland (QLD) and that from Papua New Guinea (PNG) were

tested separately. Data used for the analysis included 11 sets of measurements started at four months after planting up to 56 months. They were fitted individually to the height growth curve of Richards function, then they were extrapolated until rotation age of eight years. Adjusted data and those of extrapolated parts were subject to analysis of variance and covariance to derive selection index for evaluating early selection in the orchard. Genetic variance increased exponentially in relation to stand height until three to four years of age when they started to decline slightly in QLD and sharply dropped in PNG populations. Age-age genetic correlations were generally higher than the phenotypic correlations due to the decline of genetic variance, whereas the correlation between the first year height and that of rotation age reached almost zero in both populations. Genetic gain at rotation age was predicted as an indirect response by selection index with changing the age of selection. Expected gains by early selection were found to be very small at rotation age, even though it will bring some amount of gain at around the age of selection. On the other hand the selection during the latter half period of rotation will bring slightly greater gain at the rotation age with diminishing the gain in the early growth. Thus the final selection for the second generation plus trees might be better to start at around five years of age for this species.

Douglas-fir Provenance Tests in Serbia

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To test the introduced coniferous species, Institute of Forestry in Belgrade established two Douglas-fir (*Pseudotsuga menziesii* Mirb. (Franco) provenance tests at different sites. To assess the genetic potential, provenance diversity and adaptation of the introduced species, Douglas-fir seed was collected from the stands in a part of the natural range of the species, from New Mexico to British Columbia. The range of latitude is from 32°9, to 49°, longitude from 105°7, to 124°, and altitude from 150 to 2682m.

The first test on Mt. Juhor in central Serbia consists of 2° provenances on beech (*Fagetum submontanum* Jov.) site, extending between 43°47, and 43°55, north latitude and between 18°52, and 18°58, east longitude, at the altitude of 600-700m. Parent rock is composed of schists, soil type is acid brown (dystric cambisol) over gneiss, it is sandy, loamy, brown, deep, light, fresh and humus. The climate of the locality is predominantly temperate continental with cold winters and rather warm summers.

The second test plot includes 29 provenances covering the greatest part of Douglas-fir natural range. The experiment was established as a random block system in the natural site of Hungarian oak and Turkey oak (*Quercetum farnneto-cerris* Rud.) at the altitude of 370m. The geographical position of the sample plot Tanda is 44°14, north latitude and 22°09, east longitude. The climate of this locality can be characterized as subhumid to humid. The soil type is eutric brown soil (eutric cambisol).

To get more complete information about Douglas-fir adaptability, variability and suitability, during the study period, the following parameters were measured, observed and analyzed: plant survival, plant height, height increment, diameter of root collar, phenological characteristics and frost hardiness.

By the end of the second year, the percentage of Douglas-fir seedling survival was from 5.3% to 51.9%. Four-year-old seedlings were transplanted in two sample plots where the percentage of twelve-year-old plant survival ranged between 46.9 and 87.5%. Root collar diameter was from 4.9-12.0 cm, height from 2.1-5.6 m and height increment from 43-91 cm. The observation of bud break showed that the earliest bud break of twelve-year old Douglas-fir provenances begins on April 20th and the latest on May 25th. During the study period there were no frost damages in any of the sample plots.

Geographic Variation in Casuarina equisetifolia subsp. Equisetifolia Provenances Grown in Northern Australia

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Casuarina Equisetifolia subsp. *equisetifolia* is a nitrogen-fixing tree of considerable social, economic and environmental importance in tropical/subtropical littoral zones of Asia, the Pacific and Africa. The species has a wide natural range, occurring on subtropical and tropical coastlines from throughout Malesia to northern Australia, Melanesia and Polynesia. It is frequently used in agroforestry systems, for soil stabilisation and reclamation work and in coastal protection and rehabilitation. Despite its wide natural distribution range, widespread planting and known morphological variation, very little has been done to explore and exploit the genetic variability within the species. A provenance trial of 59 provenances and landraces of *C. equisetifolia* was established in February 1994 at Weipa, north Queensland, Australia. Provenances were from natural stands in Australia/the Pacific and South East Asia whilst landraces are from Africa and Asia. Height and diameter growth together with 12 morphological characteristics (axis persistence; stem straightness; density, thickness, angle and length of permanent branches; length and thickness of deciduous branchlets; stem and foliage damage; and flowering and fruiting) were assessed 30 months after outplanting. There were significant differences between provenances and landraces in most characteristics assessed. Natural provenances from eastern Malaysia and Thailand generally grew faster than other sources but lacked stem straightness whilst Kenyan seedlots, though inferior in growth, were superior in stem form. Natural provenances from Australia and the Pacific region showed lower growth and poor stem form, but had lighter branches, short and fine deciduous branchlets. However, no one provenance showed superior performance for all characteristics, suggesting that inter-provenance hybridisation may be useful in genetic improvement programs. Principal component analyses for all assessed traits suggested a pattern of geographic variation among provenances from the natural distribution, with provenances from Australia and the Pacific Islands forming a separate group from those distributed in South East Asia. The wide geographic range and extensive cultivation of the species offer great potential for selection of genetic material for tree improvement programs.

Potential of Forest Genetic Improvement of *Eucalyptus urophylla* S. T. Blake on the Physical-Mechanical Properties of Wood for Sawmill

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The FAO foresee that the world consumption of wood for sawmill will increase from 1.6 billion cubic metres registered in 1991 to 2.6 billion cubic metres by 2010, and that our national consumption shall increase from about 17 million cubic metres in 1990 to 59 million cubic metres until 2010 (increase of 350%). The motive of utilizing the reforestation wood are several, from the necessity of finding alternatives for brazilian native trees, subject to ecological pressure by environmental entities, to the high cost of forest extraction and freight due to long distances to consumer centers. There are enterprises which knowing the technical and the economical potential of reforestation wood, have already developed new lines of products (Vilela Filho, 1996).

Among species of *Eucalyptus*, the *Eucalyptus urophylla* is one of the most planted and with more potential of growth in Brazil. The *E. urophylla* is a species of Subgenus *Symphyormyrtus*, of high open forest, with gum or fibrous bark, with a good wood shape, density about 0,5 g/cm^3 and presents lignotuber, good budding at the second rotation and resistance to water absence. Besides that, it reacts to space variation and to fertilizer application and still possesses cline variation and ecotypes which are very important to the genetic improvement of the species (Ferreira, 1992).

Problems as growth tension, that causes fissure, warping, toughening, collapse and dimensional timber movement are some of the defects that make it difficult the use of rapid growth wood in sawmill. The work will be developed in an origin (9)/progeny (63) test, with a 19-year-old population of *E. urophylla* of Flores Island, managed to sawmill. It will be analysed the silvicultural characteristics: top of tree, bark, fruit, leaf, shape, strength, commercial volume, and technological characteristics: basic density, humidity, timber and piece extremity fissures, arching, resistance to normal traction and to parallel compression to the fibre, modulus of elasticity and flexibility, revenues on sawed green wood and secondly sawed wood.

We believe that it will be possible to correlate silvicultural and technological characteristics and to propose a program of genetic improvement based on these characteristics. This work is in process and we believe that we will have the results until the day of this symposium.

Methodologie de Suivi de Croissance de Plusieurs Provenances de *Khaya senegalensis* (Desr.) A. Juss. En Stations

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Au Burkina Faso, les peuplements naturels de Khaya sont rares, la regéneration naturelle est absente et les plantations artificielles aux abords des avenues sont vieillissantes (G; W. Talkamp et al., 1992). Des études ont montré que l'espèce est un excellent bois d'oeuvre. Cependant, elle est beaucoup attaquée en pepinière comme dans les plantations par le borer des acajous: *Hypsila robusta* moore (CTFT-Burkina Faso, 1985). Des essais comparatifs de plusieures provenances de différents pays d'Afrique sont mis en place en 1988 dans différentes stations écologiques du Burkina Faso, par le Programme amélioration génétique afin d'identifier les meilleures selon les critères recherchés dans les scieries. Les variables mesurées, permettent d'évaluer la performance des provenances par rapport à la hauteur, au diamètre, aux niveaux de ramifications, à la rectitude du tronc et surtout au degré d'attaques des borers. Notre étude a montré l'adaptation de certaines provenances aux différentes conditions climatiques du Burkina et l'existence de plusieurs groupes par rapport à la qualité du bois recherché. Ces résultats sont interressants pour des travaux futurs en amélioration génétique.

Mots clés: Burkina faso-*Khaya senegalensis*-Provenances-Methodologie de suivi-Borers

2.02.00 / 2.08.00 Future of breeding and plantations in a sustainability-oriented world 1

Assessment of Forest Sustainability

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Tanzania has vast natural forest resources covering an area of about 33.5 million ha. These forests are subject to deforestation at a rate of 130000-400000 ha/yr occurring mostly on public or non- reserved forest land which is about 57% of the total forest area. The focus of forest management in these areas has traditionally been on valuable timber species and commercial forest products harvested under license.

In Singida Rural District tree planting and forest reservation was thought to be a solution not only for deforestation but also for satisfying local people's forest product needs. Exotic tree planting and campaign programmes were initiated in the early 70's with the Village Forest Programme (1971-1983) and were followed by a Community Forests Programme (1983-1992) and a Regional Forest Programme (1993-1995). Despite all these efforts forest degradation and deforestation have continued at an alarming pace.

Reserving forest areas in officially gazetted forest reserves is one strategy the government has used to prevent further deforestation. By the early 1980's the Mgori forest (study area) had been surveyed and demarcated by the government with the intention of officially gazetting it as a reserve. The villagers living around the Mgori forest objected to the gazettment as this threatened their livelihoods. In response to this threat Village Forest Committees were formed and management plans formulated. With the formal recognition of these management plans by the District council the local people regained control over their forest resources and collaborative forest management was the result.

The aim of this study was to compare the sustainability of forest (dry miombo woodland) in an area with collaborative/participatory forest management (Mgori) with an adjacent area where there is no collaborative/participatory management (Mungaa). Principles, criteria and indicators were used to compare the sustainability of the two forests. The principles, criteria and indicators were validated by field data gathered in and around both forests.

Conclusion:

Principles, criteria and indicators for sustainable forest management can be applied in miombo woodland to assess, monitor and evaluate the sustainability of forest and forest management. The results from this study suggest that collaborative/participatory forest management is more sustainable than non-collaborative / participatory forest management.

2.04.01 Conservation and management of forest gene resources

Strategy for Long-Term Conservation of Teak (*Tectona grandis*) Genetic Resources.

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Currently, there are several thousand forest tree species in the tropics with potential value. However only a few of these species have been included in *ex situ* conservation programs due to a variety of reasons. In general, the seed in an important form of genetic material that can be used in the conservation strategies. Erratic and recalcitrant behavior of seeds from certain species to conventional storage techniques is the most crucial problem to conservation.

Teak (*Tectona grandis*) is a well-known timber tree species mainly found in Southeast Asia including Malaysia. Teak has been tested for use in forest plantations in Malaysia. Long-term ex situ storage of teak germplasm is important in order to maintain the genetic diversity for use in subsequent breeding programs. Unfortunately, conventional methods of storage of teak seeds are not very suitable, as the seeds tend to deteriorate over time. Thus, another alternative method is to cryopreserve these seeds for long-term storage.

Several cryopreservation techniques were tested on teak seeds. They include air desiccation, encapsulation-dehydration and vitrification. All seeds (except control treatment) were maintained in liquid nitrogen (-196°C) and then subsequently thawed to evaluate their survival and capability to grow back into normal healthy seedlings.

Keywords: *ex situ* conservation, genetic diversity, breeding, cryopreservation, seedling survival

Ex-situ conservation of some endangered and wild medicinal plant species found in Indian forest ecosystems

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Different degrees of threats to biodiversity caused by several anthropogenic factors has resulted in the extinction of several medicinal plant species. Therefore, efficient conservation strategies need to be worked out to prevent this malady. *Rauvolfia serpentina*, *Tylophora indica* and *Kaempferia galanga species* were collected from Western ghat forest region of Kerala state in India and relocated to ex-situ ecosystems of Karnataka. Besides maintaining the species in field gene banks, attempts were made to bring them to aseptic conditions. Shoot tips and nodal explants were used to optimise protocols for in vitro multiplication of *R. serpentina* and *T. indica*. For in vitro multiplication of *Kaempferia galanga* sprouting buds were used. MS basal medium supplemented with BAP and NAA induced multiple shoots in the three species. Root formation occurred simultaneously along with shoots in *K. galanga* and *T. indica*. A separate medium (supplemented with IAA) was required for rooting in *R. serpentina*. The micropropagated plants were successfully field planted in the Karnataka ex situ ecosystem after hardening in glass house with varying survival rates recorded for different species. Slow growth experiments were carried out under Reduced Culture Condition (RCC) light and temperature. Vitro plants could be conserved for a duration of 6-12 months depending on the species. Post storage eco-rehabilitation studies for all species were carried out under ex-situ field conditions of Karnataka state ecosystem. In order to perceive any change after storage, total phenolics and alkaloid contents of treated and controls were estimated in two species (*T. indica* and *K. galanga*). No morphological changes were observed after in vitro storage in all the 3 species. Attempts were also made to reintroduce the species to the Kerala state forest ecosystem after multiplication.

Genetic Diversity, Genetic Effects of Forest Management and Natural Disturbance, Conservation and Sustainable Forest Management

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Genetic diversity is the foundation of forest sustainability and ecosystem stability, as it is the basis of all biodiversity and provides raw material for adaptation, evolution and survival of species and individuals. The Canadian Standards Association has identified genetic diversity as one of the criteria/indicator for registration, certification and audit of sustainable forest management system. Forest management practices relying on forest harvesting and natural and/or artificial regeneration systems, including tree improvement, and natural disturbance, such as forest fires, can significantly impact gene pools and their genetic diversity in subsequent forest tree generations. Characterization of genetic diversity and biological processes that affect genetic diversity in forest tree populations and subsequently determining genetic impacts of various silvicultural management practices can provide resource managers with guidelines to manage for long-term forest sustainability and ecosystem health. Application of management practices without accounting for their genetic impacts can carry a risk of genetic degradation.

We have been conducting research on genetic diversity, genetic structure, mating system and other population genetic parameters in natural pristine populations, and determining impacts of forest management practices and forest fires on these genetic parameters in *Pinus strobus*, *Picea glauca* and *Picea mariana* using allozymes and DNA markers. Genetic diversity was found to be reduced by 25% to 50% in the postharvest residual gene pools of old-growth *P. strobus* harvested under a partial-cut (seed tree) system. In *Picea glauca*, natural stands showed the highest genetic diversity. Selections of phenotypically superior trees were found to have the lowest genetic diversity. Correspondingly, genetic diversity was significantly reduced in plantations when compared to natural stands. These results and other case studies have implications for conservation and sustainable management of forest genetic resources.

Keywords: genetic diversity, conservation, harvest, fire, forest management

Gestion de ressources génétiques forestières à Madagascar

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Mots clés: biodiversite, especes autochtones, génétiques, conservation, valorisation

Les forêts malgaches diminuent à un rythme sans précédent et ce sont des écosystèmes entiers qui sont menacés, des espèces animales et végétales qui disparaissent et les fonctions principales de la forêt qui ne sont plus remplies. Bref, c'est l'ensemble de la biodiversité qui se trouve être affecté.

Un problème moins souvent évoqué car moins visible mais tout aussi alarmant est la diminution rapide de la diversité génétique. Celle-ci est le soutien de la stabilité biologique et la base pour l'évolution naturelle et l'adaptation des espèces à des environnements changeants. Lorsque le "genepool" est érodé, l'espèce est condamnée tôt ou tard à disparaître.

Des capacités de récolte, de conservation et d'utilisation orientée des ressources génétiques forestières doivent être ainsi développées. Cela s'apparente à la mission d'une Centrale de semences forestières qui doit se doter d'un Plan National Intégré conçu pour l'orientation future à court, à moyen et à long terme de l'offre et de la demande en semences forestières avec un regard sur les actions de gestion de ressources génétiques.

La compréhension des dynamiques biologiques des populations dans lesquelles survivent les espèces ciblées est déterminante pour pouvoir prévoir la perte de gènes et de développer des stratégies pour les arrêter.

Il est aussi obligatoire de prendre connaissance de la variabilité génétique des espèces et de procéder à leur conservation et améliorer leur valorisation.

Un plan stratégique est mis sur pied et repose sur le principe de tentative de conciliation de l'écologie et de l'économie. Une logique argumentée composée de deux étapes est suivie pour le plan: étape de diagnostic et d'analyse et étape de définition des axes et objectifs stratégiques. La considération des options politiques et stratégiques nationales dans le domaine environnemental, concernant notamment les ressources naturelles et la biodiversité est mise en évidence. Il en est de même pour les aspects législatifs et juridiques reliables à la gestion des ressources génétiques.

Les essences forestières autochtones visées à Madagascar sont d'une part, celles qui sont dotées d'une importance capitale sur la biodiversité originelle de la flore malgache et d'autre part, celles qui offrent des produits forestiers d'une grande valeur socio-économique qui doivent en priorité rapporter aux communautés locales. Il s'agit des espèces nobles de la forêt naturelle malgache, notamment celles des deux genres *Dalbergia* et *Diospyros* tout en poursuivant les activités déjà initiées sur d'autres espèces comme le *Khaya madagascariensis*.

Notre étude de cas concerne cette dernière espèce avec laquelle un programme de conservation des ressources génétiques a été conduit depuis janvier 1995 et a abouti jusqu'à maintenant à une installation de conservation *ex-situ*. Le *Khaya madagascariensis* est très menacé de disparition à cause du défrichement car souvent elle colonise des terres utilisables en agriculture, d'une exploitation abusive pour la haute valeur technologique de son bois, et d'une cueillette destructive pour la propriété médicinale de son écorce.

Management and Conservation of Genetic Resources of *Quercus mongolica* var. *grosseserrata*

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Quercus mongolica var. *grosseserrata* (*Fagaceae*) is a representative tree of the cool-temperate forests of Japan and is important as a source of commercial timber. Historically, the huge resources of oak in Hokkaido in the northern part of Japan have supplied the country with high quality oak timber. Natural regeneration usually occurs after large disturbances such as forest fires or typhoons. Regeneration success, however, is often not achieved where the forest floor is overgrown with dwarf bamboo (*Sasa kurilensis* or *Sasa senanensis*). In order to utilize *Q. mongolica* var. *grosseserrata* while conserving the genetic resources, a study was conducted to elucidate the genetic characteristics in this oak and to establish techniques for effective forest management in natural stands. Materials from forest tree conservation stands, individual trees, provenance test fields, and artificial hybrids were selected for study. These materials were evaluated by allozyme and cpDNA analyses, leaf characteristics, and phenology, in consideration of Hokkaido geography and inbreeding depression.

Allozyme analyses did not detect geographic differences, however, other characteristics revealed distinct differentiation between trees grown in the eastern part and the western part of Hokkaido. It was found that the natural oak stands have a genetic patch structure. In stands, about half of the individuals had produced many male flowers each year. Under artificial pollination, this oak showed self-incompatibility and high inbreeding depression indicating high pollen-dispersal and relatively limited acorn-dispersal. Closer management of the natural oak stands is proposed to establish mid-story advanced regeneration as isolated stands would be vulnerable to genetic reduction. Large trees should be selectively cut within a stand to maintain genetic diversity. When artificially regeneration is used, a local seed source should be used. Natural regeneration requires disturbance of the sasa cover by soil scarification.

Conservation and Management of Oak Genetic Resources Impacted by Oak Decline in Russia

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Oaks in Russia are important ecological and economic species. The Forest Fund Inventory data of 1993 show the area of oak forest in the European part of Russia to be 3.72 Mha, including 1.34 Mha of high forest and 2.37Mha of coppice woodland. The main oak forest areas (% of total oak forest area) are concentrated in four economic regions: North-Caucasian (29.3%), Povolzhskij (22.9%), Central-Chernozemnij (15.9%) and Central (11.4%).

Pedunculate oak (*Quercus robur*) decline is currently causing significant loss of oak gene pool as well as decline in biodiversity of oak ecosystems. In the last 5 years, the total area of oak forest declined by nearly 0.175 Mha. The main reasons for oak decline are considered to be improper silviculture and over exploitation of oak forest during the last 3 centuries which has led to a decrease in stress tolerance of oaks. Further, extreme climate conditions, pests and diseases have added to oak decline over a wide area of Russia. Thus, effective measures for the recovery, management and conservation of oak genetic resources are needed.

A special conservation program for the pedunculate oak gene pool was developed in the Povolzhskij region. This program is based on a preliminary study of intraspecific variability in morphological traits and isoenzymes combined with a study of oak population structure, history and status in the region. Conservation measures of establishing genetic reserves and propagating selected superior oak trees are two key elements of the genetic resources program. A study of the selection and management history of oak groves originally intended for shipbuilding were reviewed, and oak groves in the best stand were selected for the establishment of oak gene reserves. These "shipbuilding" groves received special long-term management that makes them particularly suitable for setting a baseline of oak genetic resources.

Management of declining oak stands directed toward recovery, maintenance and improvement of the stands is another important aspect of our conservation program. Recovery is aimed at creating tolerant, multistoried mixed stands of oak and attendant species which favors oak growth. We have developed studies of natural and artificial regeneration with preference being given to enhancing natural regeneration based on the "gap" paradigm. This method consists of the formation of clearings (gaps) of 400-600 m^2 in the stand which receive litter scarification and management to favor self seeding and growth of seedlings. Future investigations will compare artificial recovery of oak with natural recovery after harvest by dividing a felling site into plot areas for artificial and natural regeneration. These plots will be large enough for four mature oak crown diameters which will allow development of mixed high tolerant oak stands.

Study on Variability within Pedunculate Oak Populations in the Middle Near Volga Region of Russia and Conclusions for Gene Conservation and Silviculture

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The pedunculate oak (*Quercus robur* L.) populations indigenous to the Middle Near Volga region of Russia represent a valuable gene resource. These oak forests grow on the northeastern boundary of pedunculate oak's natural range in the Europe and have existed for a very long time. Oaks in this region are characterized by some peculiarities in intraspecific variability and genetic structure. Three phenological forms have been distinguished by differences in timing of autumn coloration and leaf fall. Progeny tests of the different forms show differences in early growth rate and demonstrate higher susceptibility to leaf damage. This study assessed intraspecific variability of trunk, branch, crown, bark, and leaf morphology. Two groups of populations were distinguished:

Privolzhskaja forest and Zavolzhskaja forest-steppe. The latter group is comprised of two subgroup populations growing in a forest-steppe zone of region: Mokshansko-Surskaja (highland) and Zavolzhskaja (high plain). Isoenzyme analysis detected 12 loci that revealed high genetic diversity of oak populations in this region. The mean percentage of polymorphic loci (58-66%), by 95% criterion, and the average number of alleles per loci (2.4-2.5) was determined. The observed heterozygosity varied from 16.1-17.8%, and the expected heterozygosity ranged from 16.2-18.4%. Thus, the observed heterozygosity was only slightly lower than expected and insignificant. Overall, genetic diversity of oak populations in this region is slightly higher than Finland populations, but was much lower than populations in Germany or France. The populations have uniform gene pools with intensive exchange of genes between them. Genetic distance (Nei) between them varied f rom 0.0016-0.0065 and Gst was 0.013. The concentration of variability within a population as opposed to between populations suggests that allocation of three large or four to five smaller genetic reserves over a variety of sites would adequately conserve a significant portion of the genetic variability.

Keywords: *Quercus robur*, progeny test, isoenzyme, heterozygosity, genetic variation

Conservation Potential for Trees and Shrubs in Arid and Semi-arid Areas of China

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The arid and semi-arid zones in China occupy 3.31 million square kilometers containing more than 1,000 woody plants that have a potentially important role in landscape rehabilitation and local economic development. Studies on the biology and ecology, particularly stress biology, have been conducted on major trees and shrubs. Drought-resistance and salt-resistance studies have been made of woody species from different genera including: *Calligonum, Tamarix, Haloxylon, Hedysarum, Canagana, Salix, Populus, and Hyppophae*, More than 70 species have being tested in 12 ecological sites for shelterbelts, cash crops, and green fodder respectively.

Provenance trials and genetic improvement experiments have been established for major species. Vegetative propagation by rooting cuttings, grafting, and tissue culture have made prominent progress for a number of species. Gene engineering techniques have been used in a few cases to identify and clone new genotypes of stress-resistant plant.

A number of trees and shrubs have been conserved in situ or ex situ. Seventeen botanical gardens and arboretums have been established in arid region, each containing approximately 300 to 500 woody plant species. Many studies have focused on the methodologies for plant gene conservation, as more than 20 woody plant species become endangered species.

Woody plant introduction and domestication is necessary in the region. Introduced species highly valued for shelterbelts and landscape rehabilitation are: *Populus euramericana*, *Pinus sylvestris* var. *mongolica*, *Hedysarum scoparium, Tamarix spp., Haloxylon ammodendron, Robinia Pseudoacacia,* and *Amorpha fruticosa*.

2.09.00 Seed physiology and technology

A Comparative Study on the Effects of Moisture Content and Temperature on the Storability of an Orthodox, Intermediate and Recalcitrant Forest Tree Seeds

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Keywords: *Instia palembanica, Swietenia macrophylla, Hopea odorata*, shedding moisture, cryopreservation

Only two categories of seed storage behaviour, orthodox and recalcitrant, were recognized 30 years ago. Orthodox seeds are those that can be dried to low moisture content without affecting their viability, and that are tolerant of low temperature. In contrast, recalcitrant seeds are sensitive to drying, and die below a critical moisture content. Recalcitrant seeds are also very sensitive to low temperature. About 10 years ago a third storage category, intermediate, was introduced for seeds between orthodox and recalcitrant in terms of storage behaviour.

The effects of moisture content and temperature on the storability of examples of seeds from these categories, namely, *Instia palembanica* (orthodox), *Swietenia macrophylla* (intermediate) and *Hopea odorata* (recalcitrant) were studied. The objectives were to determine the critical and optimal moisture contents (MCs) and storage temperatures, to evaluate the combined effects of these two factors, and to investigate the potential for cryopreservation of these species.

The study was divided into 4 parts comprising 12 experiments. In Part 1, the effects of oven (35±0.2°C) drying seeds to various target MCs on germination and vigor (germination index and dry matter content) were evaluated. In Part 2, seeds at their shedding MCs were stored for 4 weeks over a range of temperatures, and germination percentage, germination index and dry matter production were assessed after 2 and 4 weeks. In Part 3, seeds were stored at selected MCs and temperatures for 9 months based on the results from Parts 1 and 2, so that the combined effects of optimal MC and temperature for could be determined; germination was tested after 1, 3, 6 and 9 months. In Part 4, the potential for cryopreservation of naked embryos was investigated.

From Parts 1 and 2, it was observed that seeds of *I. palembanica* (orthodox type) with a low shedding MC of 10%, tolerated dessication; the critical and optimal moisture levels were 6% and 8-10%, respectively. The intermediate-type seeds of *S. macrophylla*, the shedding moisture content of which was 37%, were much more sensitive and did not tolerate excessive dessication; the critical and optimal moisture levels were 15% and 25%, respectively. The recalcitrant-type seeds of *H. odorata* had a very high shedding moisture content of 48%, and were highly sensitive to even slight dessication; the critical and optimal moisture levels were also high, 29% and 32-35%, respectively.

From Part 3 it was found that orthodox seeds of *I. palembanica* withstood sub-freezing storage at –20°C, maintaining high viability for 4 weeks; the optimal storage conditions for this species were 8-10% MC and 5°C. Intermediate-type seeds of *S. macrophylla* also withood storage at -20°C, but the optimal storage conditions for this species were 25% MC and 15°C. Recalcitrant seeds of *H. odorata* were highly sensitive to low temperature and all seeds died at 5°C. Seeds of this species could not be stored by conventional methods and almost all seeds died within 3 months even under the optimal conditions of 32-35% MC and 20°C. Part 4 showed that embryos of orthodox *I. palembanica* could be directly frozen in liquid nitrogen at 10-11.9% MC, with 75% survival. More than 70% of *S. macrophylla* embryos similarly frozen at 18% (and lower) MC survived also. No embryos of *H. odorata* survived liquid nitrogen freezing irrespective of MC.

Thus, for orthodox species such as *I. palembanica*, whole seeds stored well at low MC and low temperature and embryos could be cryopreserved even at a shedding MC of 10%. For intermediate species such as *S. macrophylla*, MCs and temperature had to be higher for conventional storage, but embryos could be cryopreserved if dessicated to 18% or lower MC. Storage of recalcitrant species such as *H. odorata* was very difficult, with no whole seeds surviving conventional storage for 3 months even under optimal conditions, or cryopreservation at all MCs.

Effect of Pretreating Temperature on Seed Germination of *Idesia polycarpa*

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Idesia polycarpa is a tree species distributed between the Subtropical Zone and the Temperate Zone of Japan. To determine the variation in seed germination, especially the response to pretreatment temperatures, experiments were carried out using seeds collected from two provenances, Nago City in Okinawa prefecture (the Subtropical Zone) and Owase City in Mie prefecture (the Temperate Zone). Pretreatments comprised combinations of six temperatures of 5º, 7º, 10º (as prechilling), 15º, 17º and 20ºC (as conditioning) with five durations of 0 (control), 20, 40, 60 and 80 days. Germination of treated seeds was tested under a constant temperature of 25ºC for 24 days and alternating temperatures of 25º/15ºC, each for 12hr, for 30 days. Counts of germinated seeds were made at three days intervals.

Alternating temperatures were more effective than the constant temperature. Pretreatment at 5º and 7ºC inhibited the germination of Okinawa seeds, but promoted those of Mie provenance. When pretreated at 15º and 17ºC, the germination of Okinawa seeds was considerably promoted, and these temperatures were effective also for Mie seeds. From these results, it is speculated that Temperate Zone seeds of *Idesia polycarpa* in Mie prefecture have gained a chilling requirement while keeping their subtropical genetic character.

Viability Retention in *Pongania pinnata* (L.) Pierre and *Syzygium cumini* (L.) Skeels Seeds of Different Sizes

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Keywords: moisture content, seed storage, protein, carbohydrate, lipid

Changes in the biochemical processes associated with seed deterioration are initiated before germination exhibits any decline. These include changes in storage compounds, respiratory pathways, enzyme activities, membranes and chromosomes. The poster reports changes associated with seed deterioration and viability retention in size-graded seeds of *Pongamia pinnata* (L.) Pierre and *Syzygium cumini* (L.) Skeels during storage.

Mature pods of *P. pinnata*, and fruits of *S. cumini*, were collected locally and extracted seeds were size graded according to length using sieves. For *P. pinnata*, seeds 2.6-3.2 cm long were classed as large, those 2.0-2.5 cm were medium, and those 1.6-1.9cm were small. Similarly, for *S.cumini*, seeds 1.4-1.6cm long were large, 1.0-1.3cm were medium, and 0.6-0.9cm were small. After grading, seeds were stored in cotton bags at room temperature, 29±2°*C*. To test viability retention, at 15 day-intervals samples of seeds of all sizes were removed from the storage bags and germinated on sterilized sand at 29±2°*C*. Seed moisture contents were determined from duplicate samples using the low constant-temperature oven method.

In *P. pinnata*, germination was 98, 86 and 70% in fresh large, medium and small seeds, respectively. After storage for 5 months, germination decreased to 54, 40 and 7%, respectively. Viability was retained in large seeds for 8 months, in medium seeds for 7 months and in small seeds for 5 months.

In *S. cumini*, germination was 98, 95 and 80% in fresh large, medium and small seeds, respectively. After 2 months of storage, germination decreased to 43, 41 and 11%, respectively. Viability was retained in large and medium seeds for 4 months, but for only 2 months in small seeds.

The moisture contents of fresh seeds of *P. pinnata* were 5.6, 6.3 and 7.2% in large, medium and small seeds, respectively. During storage (8months), moisture content in *P. pinnata* seeds decreased gradually. For *S. cumini*, the moisture contents of fresh seeds were 44.8, 45.7 and 46.8% in large, medium and small seeds, respectively. During storage (2 months), moisture contents of *S. cumini* seeds decreased rapidly.

Protein, carbohydrate and lipid contents were determined in fresh and stored seeds until they lost viability. In fresh seeds of *P. pinnata* protein, carbohydrate and lipid contents were in the order of 114.6, 22.7 mg/g and 24% in large; 96.9, 20.5 mg/g and 21% in medium, and 67.1, 18.2 mg/g and 17% in small seeds, respectively. Similarly, in fresh seeds of *S. cumini* protein, carbohydrate and lipid contents were 22.8, 20.6 mg/g and 0.6% in large, 20.1, 18.6 mg/g and 0.5% in medium, and 18.9, 16.8 mg/g and 0.4% in small seeds, respectively. In fresh seeds of both species, large seeds showed higher proportions of protein, carbohydrate and lipid content followed by medium and small seeds. In general, as storage duration increased, germination, moisture content, protein and carbohydrate levels decreased, while lipid contents increased, in all three seed sizes of both species.

Cross-sectional, Image-guided, Minimally-invasive Phytobiopsy

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Keywords: computerized tomography, magnetic resonance imaging, chemical analyses

Using computerized tomography (CT) for biodensity of morphology, and magnetic resonance imaging (MRI) of mobile proton distributions for comparative physiology, a slightly invasive procedure allows quantitative chemical analyses. The supplemental procedures provide a useful comparison of dormant and germinated seed tissues to correlate form, function, and amount of metabolic substrate during treatments and storage trials.

CT uses thin, contiguous, nondestructive slices of single-plane images to identify and quantify in area and volume any tissues within a 5000 Hounsfield unit biodensity range. The data are expressed in either histograms of densities or numerical mapping of the same density units. MRI provides presence and distributions of the Hydrogen ion density for bulk water and/or fatty acid molecules. These mobile proton distributions are visually displayed by both area and volume (pixel and voxel determinations). The biopsy is sample extraction through a 1.0-3.0-mm bore penetrating the seedcoat. Chemical analyses are quantitative for elemental and organic changes in challenged tissue.

Division 3
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3.02.00 Effects of nursery and silvicultural operations on the environment and society

Energy Consumption and Emissions to the Air in Timber Production - a Life Cycle Inventory Approach from Seedling to Log in Northern Sweden

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Keywords: Life cycle analysis; Timber production; Forest operations

Forestry has a major role in Swedish foreign trade and it is thus important to the economy and to employment. There is increased concern over environmental issues in forestry during the last decade. Cleaner timber production is not only beneficial for the environment, it might even improve market access for forest products. Knowledge about the environmental load from different forest operations is needed in bench-marking and serves as a quantitative base for certification. Such information also allows comparisons between different forest operation techniques or systems. Life cycle assessment is one tool to describe the impact of a product from cradle to grave.

A Life Cycle Inventory was carried out in a forestry district in northern Sweden, Lycksele förvaltning, Assi Domin AB. The aims of the study were to describe the energy consumption and the emissions to the air from timber production in order to provide data to be used in Life Cycle Assessments for various forest products.

Data were collected using a bottom-up approach to obtain detailed information about the entire chain of operations, e.g. container-seedling production, site preparation, planting, cleaning, fertilising, thinning and final felling. This means that production and transportation of necessary commodities to the nursery and also transportation of seedlings, machinery and labour to the work site were included in the study. All data were related to cubic meters of produced timber.

The approach used in the study made it possible to compare the various activities in the production chain with respect to their need of fossil fuels and emissions to the air. Carbon dioxide dominated the emissions, followed by nitrogen oxides. The logging operations required the largest amounts of fossil fuels. Logging was also a major source of emissions per cubic metre of timber. The use of energy and the emissions per m^3 timber from logging in thinnings exceeded the energy use and the emissions from logging in final felling. This was due both to a smaller diameter and larger distances between the trees to be cut in the thinning operation compared with the final felling operation. Site preparation was the most energy-consuming silvicultural operation, but it was still a minor user of fossil fuels compared to logging. The most important source of emissions in seedling production was the heating of the greenhouses.

Effect of Potting Media and Size of Root Trainers on *Shorea Leprosula* Seedlings

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Keywords: Container-grown; Seedlings; Malaysia; Potting media

A factorial experiment, consisting of 6 potting media and 2 sizes of root trainers, was carried out in the nursery of the Forest Department District of Lentang, Pahang, Peninsular Malaysia. Potting media used were: 1) 100% coconut husk, 2) commercial peat mix, 3) oil palm mesocarp fibre. A further three media were prepared, consisting of each of the above media mixed with rice hulls in the ratio of 3:1. These mixtures were filled into two sizes of root trainers (500 & 700 cm^3) and were tested with *Shorea leprosula* seedlings. Height and diameter were measured and a survival count was made after six months of potting. Measurements taken at 6 months showed that increments in height (50.8 cm) and diameter (3.8mm) of *S. leprosula* were significantly better in plants raised in oil palm mesocarp fibre compared to the other potting media. No significant differences were observed in the height and diameter increments of plants grown in the two sizes of root trainers. In term of survival, high survival of more than 90% was obtained in all media. From the results obtained, decomposed oil palm mesocarp fibre has the potential to be used as a lightweight potting media for potting forest seedlings. It is easily obtainable and cheap, as it one of the wastes from oil palm mills. This lightweight medium will greatly facilitate transportation of seedlings to the planting site.

Performance of *Khaya Ivorensis* Rooted Cuttings in a Field Trial

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Keywords: Cuttings; Establishment; Malaysia; Growth

The performance of *Khaya Ivorensis* rooted cuttings was evaluated to assess the suitability of rooted cuttings as a source of planting material for plantation purposes. The cuttings were made from selected seedlings based on their vigour. The trial was conducted in Sg. Chinoh Estate, Perak, where the site has a moderate to shallow soil depth (less then 50-cm effective soil depth). The experiment was carried out on a randomized complete block design with three replications. Growth rates (height and diameter at breast height), survival, health, and response to wind throw were recorded. At 3.5 years, the mean total height of the rooted cuttings had reached 16.7 metres, with a mean diameter at breast height of 12.3 cm. The survival rate of the trees was high, i.e. more than 90%. After a heavy storm, only 3 trees (1.2%) were uprooted and 6 trees (2.4%) had their trunks snapped. Due to high survival rates, good growth and good resistance to wind throw, the potential of using rooted cuttings for mass production of *Khaya Ivorensis* is very promising.

Evaluation of Post-Harvest Establishment Techniques on the Initial Growth of *Eucalyptus grandis* hill. Ex maiden in the Northeast of Argentina

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Keywords: Site preparation, Slash management, Fertilization, *Eucalyptus grandis* Hill ex Maiden, Argentina.

The objective of this work was to study the effects of different site preparation techniques such as slash management, soil cultivation and fertilization on the growth of *Eucalyptus grandis* Hill ex Maiden. The study area was located on a Kandiudalf soil, in the Northeast of the Corrientes province, Argentina. The place was located at a longitude of 55°43'W, a latitude of 28°05'S, and an elevation about 100 m asl. The annual average temperature was 21°C and the annual average rainfall was 1700mm, with a uniform distribution.

From 1978 through to early 1997, the experimental site was planted with *E. grandis*. The experiment was established between September and November 1997, using a factorial design of 2x2x3 with four replications. The applied treatments were combinations of: (1) slash and litter management of burning or retaining the slash; (2) soil cultivation by subsoiling to 40 depth or ploughing to a depth of about 15cm; (3) fertilization of 0, 150, 300 g/seedling, with 15% N, 15% P_2O_5 and 15% K_2O fertilizer.

In August of 1997, the remaining slash and litter from the harvesting operation were sampled and they were classified according to size into two types of thin (those with diameter of less than 1 cm), and thick (those with diameter between 1 and 15 cm). Sub-samples from both classes were analyzed in laboratory for N, P, K, Ca, Mg, and Na concentrations. In September 1997, the slash management and soil cultivation treatments were applied; at the end of October, the trees were planted; and 20 days later, the fertilizer treatments were applied. In July 1998, leaf samples were collected to estimate the nutrients by each treatment.

The dry weight of the thick residual debris was the 7.80 tn.ha-1, whereas the weight of the thin residual debris was 16.74 t.ha^{-1}. The Ca, N, and Mg levels were quantitatively more important, with a total of 457.4; 68.6 and 39.4 Kg.ha^{-1}.

Statistical analysis of the growth, 9 months after planting, did not show any significant difference for ground-line diameter (GLD) or total height, between the slash and litter management treatments nor the soil cultivation treatments. However, the interaction between both factors was significant, with the best growth from ploughing combined with the burning treatment. With the fertilizer treatments, the statistical analysis showed significant differences (P= 0.01) between treatments, mainly in those that had been fertilized, compared with the control without fertilizer. The GLD was 5.4, 6.2 and 6.5 cm and the total height of the trees was 213.8, 273.2 and 288.8 cm for the fertilizer rates of 0, 150, and 300 g.seedling^{-1}, respectively.

The foliage concentrations of N, P, K, and Ca were similar to those reported in the literature for one-year-old leaves and the concentrations could be considered optimal for the growth of *E. grandis*.

3.02.00 Effects of nursery and silvicultural operations on the environment and society

Nitrate Leaching Potential of Slow Release Fertilizers in Bare-root Pine Nurseries

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Keywords: Nitrate leaching; Nursery; United States of America; Bare root

The Southeastern United States produces about 1.2 billion bare-root pine seedlings annually, with 1-0 loblolly and slash pine (*P. taeda* and *elliottii*, respectively) accounting for 95% of this production. A typical fertilization regime in the region uses ammonium nitrate at 168 kg/ha of elemental nitrogen top-dressed in 5 applications of 33.6 kg N/ha during the summer months when shoot biomass expansion is highest. While this time-tested formula produces a seedling of acceptable morphology and quality, during the past decade there has been growing concern about the potential loss of nitrate (NO_3) to the environment through leaching. Slow-release fertilizers may possibly increase nitrogen use efficiency, and hence reduce nitrate losses, because they release nutrients more similarly to the actual use requirements of the plant.

A randomized, complete-block design, with 3 blocks and individual plots 40 feet long, was used to test two slow-release fertilizer materials and ammonium nitrate at equivalent rates of 224 kg N/ha N. The SLRs were two polymer-coated ureas; a 21-7-14, 270-day release, and a 13-13-13, 180-day release. They were applied in early April and worked to a 5 cm soil depth using a bed shaper. The ammonium nitrate was applied in 8 biweekly top-dress applications of 28 kg N/ha each. This particular nursery uses 336 kg N/ha liquid ammonium nitrate as its standard treatment and areas immediately adjacent to each of the experimental blocks were also sampled, allowing for a direct comparison with the granular fertilizers. Two zero tension lysimeters (16.5 cm diameter) were placed in each plot at a depth of 30 cm and sampled during the growing season according to rainfall amount.

The area received a total of 962mm of rainfall from April to January. Lysimeter samples were taken on 7 occasions during this period. There was considerable variability both in the amount of water collected in each lysimeter as well as the nitrate concentrations. Volumes collected in the 24 treatment plot lysimeters varied between 0 to 1.1 l. Water samples varied from 1 to 204 ppm nitrate concentration. Statistical analysis revealed the amount of water leached did not vary between treatment or block. There were significant differences, however, in the amount of nitrate leached, with averages of 26.0, 22.8, 10.0, and 2.4 kg/ha of nitrate leached during the sample period for the liquid, 180-day release, ammonium nitrate, and 270-day release fertilizers, respectively.

About 80% of this loss occurred during the summer months (during the application period). There was also a significant difference between rates of leaching, with averages of 13.2, 9.2, 7.1, and 1.9 mg of nitrate per litre of water leached for the liquid, 180-day release, ammonium nitrate, and 270-day release, respectively. The higher leaching rate for liquid fertilizers can be expected, as it was applied at a 50% higher rate. When calculating nitrate leaching as a percent of nitrogen applied, the liquid, 180-day release, ammonium nitrate, and 270-day release compounds, lost 7.7%, 10.3%, 4.5%, and l.l% of their applied nitrogen. All of these figures are lower than expected, as nitrogen use efficiencies for seedlings are typically around 50%. The effectiveness of slow-release fertilizers to reduce nitrogen loss through leaching is directly related to the release rate of the compound and the speed at which seedlings can utilize released nitrogen.

Artificial Pruning: Technical, Productive and Economic Considerations - a Review

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Keywords: Artificial pruning; Thinning; Certification

The pruning of the best stems in growing stands has been applied as a tending operation for centuries. According to Mayer-Wegelin (1952), interest in this operation dates from the 18th century when Carlowitz discussed it in his paper on wild trees (Silvicultura Oeconomica 1713).

In the evolution of artificial pruning, there has been a shift of silvicultural models from the traditional type (characterised by high stockings, light thinnings, and long rotations) towards a more dynamic one, involving the use of fast-growing species, widely-spaced plantations, heavier thinnings, and shorter rotations. Pruning is not considered a necessary intervention with traditional silviculture, because high stockings help control branch size and there can be a high rate of natural branch shedding. However, with the new dynamic silviculture, it is a fundamental economic and technological component to maximise the production of clear high-quality timber, while minimising the undesired effects (production of lower quality timber, characterised by low density and a high proportion of juvenile wood, as well as very large branches (knots).

Taking into account such evolution, this poster aims to provide an overview of different issues related to artificial pruning. Based on over 200 references published worldwide, it focuses on the most relevant characteristics of artificial pruning such as:
- Definition, types, objectives, and effects of pruning.
- Knots and their influences on timber qualities and end-uses.
- Pruning characteristics (e.g., species to prune; diameter of branches to cut; position of cuts; pruning height; pruning intensity and number of lifts (stages); pruning season; number of trees perha to prune; pruning tools; economics of pruning; pruning certification; and pruning and other silvicultural tools such as wide spacing, thinning, and fertilising).

Pruning is an expensive intervention and, as a consequence, is rarely practised on large scale. A model framework for artificial pruning is recommended as follows:
- Prune only the potential final crop trees (straight, vigorous, dominant and co-dominant, healthy and as evenly spaced as possible) for high-quality uses and from high-yielding and quality stands.
- Start pruning at an early age, when diameter at breast height is no more than 10-12 (max 15) cm.
- Cut only small branches (max diameter=3 cm).
- Use natural target pruning (protects both branch collar and branch bark ridge).
- Do not leave stubs.
- Use wound dressing only in special cases (e.g., widely damaging fungi).
- Prune up to a maximum of 6 m in 2-3 lifts.
- Do not remove more than one third of the live crown at any time (intervention).
- Always maintain a 50% live crown/bole ratio.
- Prune dead branches at any time of the year and living branches, with some exceptions, at the end of dormant season.
- When possible, use a combined pruning-thinning regime.
- Certify pruned stands as a label of quality and thus make higher prices for pruned timber possible.

However, when considering the need for pruning, it must be remembered that "If done carefully and correctly, pruning can increase the value of the trees. If done carelessly, it can do more harm than good" (Schlesinger 1988).

3.04.00 Operational planning and control; work study

A study on the productivity and work loads of natural forest harvesting in Turkey

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Keywords: Natural forest harvesting; Productivity; Work loads

The objective of this research is to collect data on the productivity and work loads of natural forest harvesting in order to establish productive and environmentally sound forest operations with low work loads. Tower yarders of Urus MIII or Koller K300 have recently been introduced to forestry in Turkey. The clarification of the productivity and work loads is important because they are significant factors in mechanized forestry operations. Such data is also necessary to improve forestry operations so that they can be environmentally sound with high productivity and low work loads. This research was conducted in the northeast of Turkey in late June 1998. In this study, newly-introduced harvesting systems using tower yarders were compared to conventional systems using a stationary yarder of Gantner USW 60D or a skidder of MB trac Turbo 900 in terms of productivity and work loads. The productivity of each system was calculated based on the data of time study. The work loads of forestry workers were also measured using watch-type devices measuring heart rates. Furthermore, WBGT, an index of thermal conditions of work environment, was measured to clarify work conditions in natural forest harvesting.

The results showed that the productivity of the tower yarder system was a little less than the one of the others. However, tower yarder is easy to be set up and to be removed and therefore the productivity of this system is higher than the one of the other systems when setup and removal time are incorporated into productivity calculation. The productivity of the stationary yarder system was very high, however it must harvest trees from wider areas in terms of cost and benefit because it takes a lot of time, usually nearly one month, to set up or remove it. As a result, soil erosion, less forest cover and damages to the forest ecosystem are serious problems in Turkish forestry when using stationary yarders. We know that skidding system also often damages the forest ecosystem although this system is easy and productive on relatively flat terrain. Tower yarders are expected to improve such a situation in Turkish forestry by enabling us to thin trees from natural forests at an adequate level with lower impacts on the forest ecosystem. To introduce tower yarders, however, more forest roads are necessary and the construction of them may have negative impacts on the ecosystem. Therefore, it is necessary to construct forest roads minimizing environmental impacts on the ecosystem in order to introduce more tower yarders. The work loads of various kinds of work at various sites are classified based on the scale of Christensen. As a result, the work load of a chainsaw operator was found to be classified into heavy while the one of a yarder or skidder operator was lower than the work loads of the other workers and it was classified into light. The WBGT was high on the forest road while it was moderate in the forest. Thermal conditions were not critical because it was not in midsummer but in late June.

In this study, we clarified the productivity and work loads of natural forest harvesting in Turkey. We suggest that we should introduce more tower yarders to Turkish forestry and they should replace stationary yarders, which have been widely used in Turkey. More forest roads are necessary to use more tower yarders, but it is known that forest roads often damage the ecosystem. It is necessary that excavators should be used for road construction in order to avoid using bulldozers or dynamite and to make as narrow forest roads as possible or to make forest roads with as low impacts on the forest ecosystem as possible.

Harvesting System Optimiser: An Integrated Window-based System for Selection of Timber Harvesting System

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An integrated optimisation system with characteristics of the graphic user interface consultation has been built to select timber harvesting system in wood procurement chain. The system centres on the structure and function of building knowledge base system, and module-based architecture of system is a basis of problem-solving procedure under the control of friendly graphic user interface development environment. This integrated system is currently comprised of several modules built in a visual development environment: 1) A harvesting machine data-base system describes the harvesting machines' attributes and functionality. It can be retrieved in terms of specific description or users requirements; 2) Consultation module of harvesting system's operability under given conditions is based upon the topographic conditions, statistic data and information of forest stand, forest soil types and environmental requirement as well. It identifies a harvesting system adapted to a set of conditions in a given logging area; 3) Costs calculation model for individual machine or machine chain is built to generate the actual data which could be stored in data base for purposes of harvesting system simulation and optimisation; 4) Environmental evaluation module of timber harvesting operations gives an emphasis on minimising the effects of harvesting operations on forest area based on the environmental-oriented selection of harvesting system; and 5) Harvesting system simulation and optimisation module is based on the harvesting system behaviours and functionality on wood procurement chain, in which optimal harvesting system could be identified for the final decision making. The goal of integrated system is to select a sound harvesting system under which conditions users are specifying a set of real circumstances concerning timber harvesting operation mode, for instance, either ground-based system or cable logging system. An integrated optimisation system gives a user more flexible choice of decision making procedure, which is satisfied with the different situation from place to place or from country to country. This window-based program built on PC environment for general purpose harvesting system optimisation is suitable for users at different level.

3.05.00 Forest operations in the tropics

Ensuring Sustainable Supply of Wood: Impact of Some Harvesting Options on the Nutrient Stores in a *Nauclea diderrichii* Stand in the Ghanaian Rain Forest

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To counter the anticipated wood shortage in Ghana, extensive plantations of both exotic and indigenous tree species have been established in most parts of Ghana. One of the indigenous species, which has been found to be fast growing and therefore recommended to be grown in plantations, is *Nauclea diderrichii* (Opepe). This species has been found to be ideal for most of the domestic and industrial uses *Milicia exclesa* is noted for. The proposed, rotation is between 15-20 years and mainly by clear felling and removal of as much utilizeable materials age for harvesting is possible. However, such harvesting intensities in recent years, have been of concern to many researchers. That such harvesting intensities involve the removal of substantial quantities of available nutrients form sites and therefore lead to nutrient deficiencies within relatively short periods. Thus to determine the potential impacts of harvesting and utilization options on sustained productivity of *Nauclea*, the nitrogen, phosphorus, potassium, calcium and magnesium (N, P, K, Ca and Mg) stores in a *Nauclea diderrichii* (Opepe) plantation stand were estimated. These were used to determine the impacts of three harvesting methods (i.e. thinning, coppice with-standard, and clear-felling) combined with three levels of utilisation (i.e. stemwood only, bole only and bole together with branches). These were viewed against sustained site productivity of the *Nauclea diderrichii* stand.

To achieve the above objective, field studies were conducted in *Nauclea diderrichii* stand using modified Ovington et al unit area ratio method. The assessment was done in three temporary plots as fully stocked as possible. Dry matter production was determined as well as nutrient concentrations of the various tree parts. Litter and undergrowth quantities in the stand were determined, nutrients in the soil reserves, litter and undergrowth were analysed for N, P, K, Ca and Mg concentrations. All these were used to assess the quantities of these nutrients in the *Nauclea* stand.

Clear felling combined with any level of utilisation exerted the greatest impact on the nutrient stores. On the other hand, thinning below half of the stand density coupled with even complete utilisation of the above-ground biomass impacted a minimal stress on the nutrient reserves.

Rates of depletion were not specific but differed for individual nutrients, phosphorus drain from the stand was the most rapid followed by K, N, Mg and calcium being the slowest. Thus P and K are likely to severely limit the site productivity of *Nauclea diderrichii* stand if harvesting options like clear felling or coppice with-standard are adopted. There is no adequate data on these in Ghana. In order to adopt an efficient and sustainable management system that could delay the application of soil ameliorants, there is the need to forecast the order in which nutrients in the stand would drain and therefore become limiting.

The combination of harvesting and utilisation options as well as limiting nutrients to forecast the potential productivity of *Nauclea diderrichii* forest stand are discussed.

Keywords: Impact, harvesting, utilisation, limiting nutrients, *Nauclea diderrichii*, sustained Productivity.

The Human Aspect of Reduced Impact Logging under the Ground Skidding Logging System in Peninsular Malaysia

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Manpower constitutes one of the major inputs in a production process along with other factor inputs such as machines, raw material and the man-machine interaction. Manpower's ability to work and produce efficiently at all stages of the operation is of paramount importance for the economy of the forest enterprise as a whole. Unfortunately few studies have been conducted in the tropical rain forest environment in the past on the manpower element as a factor in a timber enterprise production system; both as an individual as well as a social group. This glaring lack of knowledge and appreciation of the human element has been deemed the "missing link" in the attempt to successfully realize the Sustainable Forest Management (SFM) principle especially in those areas concerning (1) re-designing of work structure and procedures; (2) re-tooling of machines for better work performance (including reduced impact logging); (3) Prevention of hazardous work practices; and (4) identification of individual worker's well-being and training needs. The poster discusses findings from a study on the development of a reduced impact logging system in a timber enterprise in Peninsular Malaysia vis-à-vis the problems and roles of the forest workers with regards to reduced impact logging objectives and the challenges faced by the management and the forestry sector in general.

Reduced Impact Timber Harvesting in the Indonesian Selective Cutting and Planting System

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Timber harvesting being one form of utilization of the tropical natural forests in Indonesia is carried out by practicing a silvicultural system known as the Indonesian Selective Cutting and Planting System ("Tebang Pilih Tanam Indonesia/TPTI").

Conventional Timber Harvesting (CTH) being practiced until now is often considered to be the culprit of forest degradation. Concession holders usually carry out their timber harvesting operations in the simple way, mostly without sufficient detailed timber harvesting plans and proper work instructions for the timber harvesting operations, using improper technique and lacking control. Reduced Impact Timber Harvesting (RITH) on the other hand is based on: (1) Forest surveys prior to harvesting, for data required to design layout of felling compartments and inventory units and to plan the timber harvesting operations; (2) A tree location and topographic map as a basis for designing timber harvesting plan which serves as a guide for felling and skidding in timber harvesting operations; (3) Cutting of lianas before timber harvesting; (4) Regular training of workers, monitoring, supervision and block inspection; (5) Routine briefing on procedures and techniques (6) Adopt a base-pay and incentive-pay system based on quantity of production, quality of work and level of terrain difficulty.

The implementation of RITH in the TPTI system consists of some aspects as follows:

1. RITH Planning

RITH planning is a part of the overall forest management planning. It should be completed long before the loggers enter the site and must be developed comprehensively both strategicly and operationally to ensure that planning mechanisms protect all forest values at all times during timber harvesting.

2. RITH Technique Guidelines

RITH technique guidelines is one of the important factors to help guarantee successful implementation of RITH. RITH technique guidelines for the TPTI system should consist of: (1) RITH planning technique; (2) Controlled felling; (3) Felling technique of normal tree, leaning tree and tree with buttress; (4) Controlled skidding; (5) Skidtrail construction technique; (6) Winching technique;

(7) Skidding technique and (8) Prevention technique of post harvest environmental damage.

3. RITH Training

One of the best strategies for improving and socializing skills and work motivation of timber harvesting crews is through training in technical matters and environmental understanding and awareness.

4. RITH Payment System

To maintain high work motivation and discipline among timber harvesting crews, one useful strategy is to apply a payment system based on productivity and work quality influenced by physical field condition. This based-pay and premium-pay should be determined transparantly.

5. Organizational Structure and Job Description

Smooth implementation of RITH depends also on clear, detailed and tested job description and organizational structure provided to timber harvesting crews.

The implementation guidelines of RITH in the TPTI system are as follows:

1. Development of a tree location and contour map (scale 1:2,000 carried out two years before timber harvesting)

2. Cutting of liana (carried out during the forest inventory and topographical survey, two years before timber harvesting)

3. Development of a timber harvesting plan (to be done one year before timber harvesting operations)

4. Haul road construction and marking of skidtrail network, landings and tree felling direction in the field (to be done one year before timber harvesting)

5. Skidtrail construction, felling, winching and skidding (carried out during the timber harvesting year)

6. Prevention of further environmental damage after timber harvesting (carried out after timber harvesting).

Impact of Different Intensities of Logging on the Recovery Capacity of the Residual Stand

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Keywords: logging, forest management, environmental impact, vegetable succession, Caparo.

This work is part of an investigation begun in 1987, at the Caparo Experimental Station, in order to evaluate the damages to and recovery of the residual stands generated from different intensities of logging. To achieve this objective three treatments were applied, according to the minimum diameter of cutting (mdc). It was applied an mdc of 20, 40 and 60 cm. In each treatment 3 replications were surveyed as well as two controls.

Mensurations were carried out before the intervention and in the later years, up to 1997. One result is that it is better to evaluate the impact of logging after about 5 years because some trees thought to be dead actually survived. Another result was that 22 to 48 % of the residual trees, about 6 to 23 % of the basal area, died from logging damage. Obviously the biggest damages happen in the treatments with more intensity of tree harvest.

In the parcels with low harvest levels, there were not significant changes in the Shannon Index (H'), the wealth of diversity increased and the floristic similarity (Index of Ellenberg) was lowered up to 80 percent. However, some species show important changes of IVI (Important Value Index) as they are reduced in presence. In the parcels with high harvest levels, there were significant losses of diversity (H'), although the wealth recovers to the ten years.

All trees species were assembled according to their ecological class and commercial value. In the most intense harvest levels, the pioneers dominated the recovery of the forest with a growth of 1.1 m^2/ha/year, while, in the low harvest levels, residual species proportions were similar to the pre-harvest conditions. It was also evidenced that the species with some commercial value are very scarce in the primary forest and their growth post-exploitation was very slow (0.1 m^2/ha/year).

Soil Compaction Effects of Timber Harvesting in the Amazon Basin

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One of the key elements of sustainable tropical forest management is the development of economically viable harvesting techniques that minimize environmental damage. Harvesting should be done so the immediate impacts do not damage the long-term ecosystem integrity. The objective of this study was to assess, using field plot techniques, some of the more relevant environmental impacts associated with conventional harvesting operations in the "terra firme" forests of the Brazilian Amazon. The location of the study was the Curua-Una Forest Reserve, a 72,000 ha tract in the east-central region of the Amazon Basin. A randomized complete block design was used to compare four harvesting intensities in three blocks. Each treatment plot was 80 m wide by 500 m long. Treatments were 0, 25, 50 and 75% removal of merchantable trees with diameters between 45 and 90 cm. Harvesting was done using chainsaw felling, and a rubber tired (50 cm width) Caterpillar cable skidder ("conventional methods") during the rainy season. Impact measurements were made in June, 3 months after harvest. Data were taken on tire rut width and depth as well as soil bulk densities in three disturbance classes: inside tire ruts, between the ruts, and 10 meters to the side of ruts ("minimally disturbed").

Harvesting removed an average of 184, 117, and 47 mü, from each of the 75, 50, and 25% commercial volume removal treatment plots, respectively. The volume of wood removed significantly impacted the amount of rutting with average rut crossectional areas of 1,357, 1160, and 531 cm^3 for the 75, 50, and 25% removal treatments, respectively. Soil bulk densities increased significantly on the harvested plots when compared to the control plots although bulk densities did not vary among harvesting intensities regardless of disturbance class. In the rut, between the rut, minimally disturbed, and check plot soil bulk densities averaged 1.25, 1.09, 0.99, and 1.02 mg/m^3 respectively.

These results are similar to those found in other regions of the world, where soil compaction occurs during the first 2-3 equipment passes and is insensitive to the number of passes thereafter.

Management and Decision Support System for Smallhold Tree Plantation Developers

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A decision support system in a form of a computer software was developed to assist smallhold *Gmelina* plantation developers in preparing a plan for their projects. The system analyzes site factors inputted by the user. It helps the developer prepare a plan which can be modified iteratively by the system. This allows the user to perform "what if" analyses and undertake simulation of plantation development under various conditions that may be specified by the farmer. These situations are dictated by the availability of labor and capital for fertilization and other cultural treatments.

Developed in dBase for Windows, the systems has two components: the database and the routines. The database contains knowledge about *Gmelina* plantations and technologies in their development. The routines include data entry, management plan preparation and inquiry and a cost tracking system which are driven mainly by process based growth and yield simulator.

Applications of the system showed it consistency in estimating plantation development scenarios. Results of different simulation of yields in various combinations of age, edaphic factors and treatments were not different from the observed actual yields in the different plantations.

The system is pilot tested in Bukidnon and installed in a government office there. It is operated by a systems administrator who shall assist farmers in using it and help the project in further refining it.

3.06.00 Forest operations under mountainous conditions

Comparison of Forest Skyline Systems for Harvesting in Turkey

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Turkey's forests cover 20.2 million ha, but only about 8.5 million ha of this area is productive. Unfortunately, these productive areas have been relegated to steep terrain, thereby creating forest management problems and more difficult logging operations. The construction of forest roads is more complicated and more expensive on these mountainous lands. Therefore, forest skylines are being used to help solve these technical and economic problems.

In Turkey, forest skylines are of three lengths: short, to 300 m; medium, 300m-600 m; or long, up to 1500-2000 m. The forest road density is approximately 8-10 m/ha. Because of this density, skylines are a very important factor in forest transportation, especially in the mountainous region of Artvin. Operational efficiency is achieved when skylines are strong, of reasonable distance, and quick and easy to set. Well-placed skylines will cause minimum harm to forest soil and the transported material. These mobile or yarder machines can transport forest products in two directions, and may be set up in different configurations at the harvest site.

The goal of our study was to review the use of these skylines over the past 10 years. Investigations were conducted at different test sites in the mountainous eastern Black Sea region in Turkey. The three systems - Koller K 300, URUS M III, and Gantner forest skylines - were examined for their technical and economical advantages during logging. We used the continuous-time measuring technique. The calculated values of operational costs were evaluated statistically according to a standard base distance. These methods have been approved by FAO.

Our results showed that hourly production was highest with the URUS M III system. In addition, this particular system of mobile skylines could be set up over longer distances, compared with the Koller K 300 system. However, the URUS M III skylines were more expensive to operate. In contrast, the Gantner forest skyline was more productive for distances over 600 m, although this system required more time for setting lines. Differences in productivity and cost among the tested systems depended on the production type of forest yield derived from the harvest compartment, the number of workers required, and the direction, distance, and slope of transport. From this study, we could also conclude that it is very important to first have a well-organized production environment in order to work more eight-hour days in a year with an insured and fully staffed team of equipment operators.

Testing an Experimental Rail-Type Machine (Tramcar II) for Operations on Steep Forested Slopes

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In Japan, artificial forests, or plantations, account for 40% (107 ha) of all the forested area. Because such sites comprise many young trees, they must be properly tended and thinned to provide a steady supply of wood, while also maintaining adequate levels of soil and water conservation, and disaster prevention. Many of these forests are located on steep mountains. Therefore, forest operations usually are done manually, which can be unsafe and inefficient. The expansion of the forest-road network is a pressing need because it is indispensable for mechanization. However, road development is at only 40% of the target value, because the costs of construction and maintenance are very high.

Accordingly, we have developed the Tramcar II for operating on forest slopes. Using a rack-and-pinion driving mechanism that runs on a rail, the new machine can move up and down 45-degree inclines. The power truck utilizes a rail-support system to transport workers, forest machines, and equipment in the forest. Mounted with a grapple crane, the work truck can load wood for transport on the rail network. Results of a two-year, on-going field test show that worker efficiency can be improved by 25%, while maintenance and management costs are decreased by 1/3. Moreover, the load on the rail has been measured and proven safe.

The mechanical outline and specifications for this Tramcar II include:

1) Power truck:

Water-cooled, 3-cylinder diesel engine with a modified deep oil pan; Engine displacement: 1642 cc; Horsepower: 36.8ps/3000rpm; Hydraulic driving-gear system; Hydraulic, multi-bored disk brakes; Fail-safe system.

2) Work truck:

Grapple crane (4.56 ton-m); Outrigger; Tilting angle of base: 30 degrees; Winch.

3) Other features:

Four hydraulic driving wheels (2WD+2WD); Universal-coupling connecting rod; Two rails (main and sub); Rack-and-pinion drive.

On our test course, we examined the power truck for running performance, operation performance, stress to the rail and vehicle, etc. Running speed was 0 to 50m/min, the safety rating was a '3', and operating performance was excellent. The work truck was equipped with a grapple crane, leg-type outriggers, and a winch. Stress on the boom, arm, outrigger, work truck, and rail was measured by applying a load to the crane. Loading capacity was 300kg at a position of 7m. Moreover, we confirmed the scope of operations of the machine. Finally, we developed an automatic divergence device powered by a solar battery. This has made dispersed forest stands more easily accessible, thus greatly expanding the system's utility.

Keywords: forest operations system; rail-type machine; steep mountains; Tramcar II.

Re-engineering of Existing Road Networks - A Case Study from Southern Germany

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Throughout the world, the main task when opening a forest for harvesting is the conception and construction of, or the extension of, a road network into areas where it has not yet been completed. Because of intensive cultivation by forest enterprises in central Europe, road systems have become denser in recent decades.

The costs for constructing and maintaining forest roads represent a substantial part of the total budget for a typical forest enterprise in Germany. Because of scarce financial resources and insufficient income, it is important that existing road networks be examined for their technical and economic value, while considering the changes in future goals and demands. The increasing need for maintenance and construction puts a heavy cost-pressure on the forest industry.

The German forestry road network is relatively dense (sometimes too dense), according to international standards. Because of new harvesting methods (e.g., harvester-forwarder systems), the road distances could become even greater. Consequently, maintenance and costs might be reduced by decreasing the density of the road system. A case study was based on the activities of a large, privately owned forest enterprise in Germany. Here, the existing road network and future needs were analyzed to determine the possibilities for reducing road density, while accommodating their highly mechanized harvesting system. Data from a geographical information system (GIS) were used in proposing alternatives that would reduce density without limiting the enterprise's access to all portions of the forest. The goal was to create a databank of corresponding spatial positions, which could be used in problem-solving. A special method was developed to complete and check this data. The (relatively) best solution was defined as one that would minimize future road maintenance costs as well as those incurred during harvesting and transport.

Using this method, road density was reduced by 30%, without any loss in site access. Consequently, a new plan for executing this concept incorporates greater time-independent flexibility as well as calculations for the relative investments that are required. The result of this study provides a practical means for decreasing the high cost of a too-dense road network by eliminating excess roads. Doing so would also enhance the sustainability of natural-resource management and benefit the needs of society.

Numerical Iterative Method for Optimizing the Disposition of Soil Masses during Forest-road Construction

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The job of transporting soil is inevitable during forest-road construction. How these soil masses are to be re-distributed at the site will affect mean transport distance, the number of machines engaged in the transport system, the period of transport, and total soil-transport costs. Among the methods for determining the best means for soil distribution, the optimal solution is obtained by a linear programming approach. This method provides several alternative optimal plans for moving masses of soil, depending on the objective function (minimizations of cost, mass movement, etc.). We used the Ford-Fulkerson algorithm, which is implemented with the Trans99 software package. An initial solution is generated by tabular calculations that are then iteratively improved until an optimum is reached. A case study was conducted at the construction site for the road Kamenica-Brezna, which is on the hillside of the mountain Goc in Central Serbia. The objective was to determine the optimum re-distribution of soil between seven cuts and five fills, at minimum cost for transport. The requirements for higher quality, and more economical and faster forest-road construction are key components when formulating a model that optimizes soil transport. We have demonstrated that this problem can now be solved efficiently by applying a linear programming approach. Because the cost of soil transport is such a large proportion of the total cost for construction, this analytical method is essential when trying to economically solve the problem of soil disposition.

3.07.00 Ergonomics 1+2

Forest workmanship in Turkey

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Forest areas in Turkey are generally located on the mountainous region. Therefore, forest labour is affected by the shape and conditions of the field. In forestry, regeneration, reforestation, maintenance, production (cutting, skidding, transport), forest road constructions, their repair and maintenance, forest conservation and land sliding protection are required substantial labour.

These works are mostly done by local people living in near forest villages or forest village corporations. General characteristics of forest workmanship can be outlined as below; working in heavy conditions, work in high elevation, rough and vast areas, the necessity of accommodation in forest, because of that working place is far from the social environment, the obligation of working generally in day-time hours, taking care of the silvicultural treatments, the situation of being tentative workers in general, having high accident risk resulting from working in open air conditions, having lower labour pays than the other labour branches.

The forest employees according to their annual working periods can be categorised into three different groups as follows; permanent workers, seasonal workers and tentative workers. Forest workers in Turkey generally work during the spring, summer and autumn. Most of the forest workers are tentative and seasonal forest workers and the rest are permanent workers. Because of the workers' feeding, education, housing and walking problems, forest labour is not very attractive job for the people. Approximately, there are 40 thousand forest workers in Turkey. These workers have the tasks of logging, cutting, skidding and transporting the logs. The demand to the forest labour has been getting decrease because of forest workers' health problems, unsatisfied payment, high risks of getting injured and their hard working conditions. These unwanted conditions negatively affected forest workers’ productivity. The forest workers health should be checked-up periodically, mobile bureau should be ready in case of emergency where needed, first aid materials should be kept ready to use in order to increase forest workers' productivity. In our country, rheumatism, back, shoulder, arm and leg injuries, liver, lung and heart problems have been detected in many forest workers. The forest workers should be get paid more and social security should be provided to them in order to motivate and increase their productivity.

Keywords: Turkey, Eastern Black Sea Region, Steep Terrain, Forest Labour, Worker Health

Analysing the Postures and Efforst Expended in Timber Harvesting Operations on the Northern Coastland of Bahia State

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This study aimed to analyze the timber harvesting activities, which require inadequate efforts and postures for improvement of the worker's health, well-being, safety and comfort. The specific objectives were: a) to characterize the worker during timber harvest; b) to characterize ergonomically the work environment; c) to analyze the harvesting operations which require abnormal postures, load manual lifting, strength application and high physical work load; d) to propose some recommendations for the improvement of postures, the reduction of the efforts and the optimization of the physical work. The research was developed with forest workers in *Eucalyptus grandis* yield areas on the northern coastland of Bahia State. Data were collected by individual interviews, measurements and tests applied to the workers and loads as well as to the machines, tools and equipment used during work. The results indicated a high percentage of poorly trained and analphabetic workers performing heavy activities and presenting health problems. The individual protection equipments were not used by everyone and the accident index was high. The work environment showed thermal overload and high noise levels in all activities except the lumbering one. The machines presented ergonomical deficiencies. The posture analysis showed a need for intervention in all operations, which was urgent in delimbing, lumber arrangement, log hauling and pushing for arrangement in the truck during loading. Only the delimbing and branch disposition registered a weight handing below the pattern limits. The log bucking and positioning on waist during lumbering presented an inferior compressive load in the spine disc relatively to the limit compression load. All activities exhibited some articulation with the percent capable assistants inferior to 99% and the worse situations being during the assistance in felling and log throwing on the lumber rick which presented a percent inferior to 25% in all articulations. The physical work load was classified as: moderately heavy for chainsaw operators; light for chainsaw assistants; moderately weighty for the debarking assistants which supplied the receptor table; light for the assistant supplying the debarker and for that receiving the debarked log; and moderately weighty for the lumbering assistants.

Keywords: Timber harvesting, posture and physical work.

Increasing Productivity and Controlling of the Work Fatigue in Mechanized Forest Operations by Using Prescribed Active Pauses

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Forest machine operators work very intensively during a work day, with a limited number of pauses, exposed to a variety of working conditions which affect their working capabilities and may cause work fatigue, health problems, and accidents. Fatigue causes decline in work performance, lower productivity, myoskeletal disorders, working errors, and accidents. The factors which affect work fatigue and deteriorate work performance may be grouped into three interactive categories: environmental factors (noise, vibration, temperature, humidity), human factors (age, sex, health, motivation, fitness,capabilities, trainings, emotional stability), and task factors (complexity, duration, skill, physical, mental or sencimotor tasks).

Work pauses are needed in maintaining working performance and efficiency required by work and in avoiding or decreasing fatigue effects. The effect of pauses on work performance is favorable more for shorter, about ten minutes, than for longer pauses.

A work/rest schedule for forest machine operators is proposed by providing prescribed active work pauses of ten (10) minutes duration after every fifty minutes of work. The ten minutes pauses will help the operators to recover from fatigue effects, to maintain work capacity and efficiency, to maintain

their adaptation to work task, and decrease exposure time to environmental factors. Active pauses (i.e.pauses with some gymnastics), on the other hand, will improve the restoration of overall work capacity and may have favorable effects on localized muscular fatigue. Also, ten minutes pauses may increase the net working time because operators may avoid taking spontaneous and disguised pauses.

Keywords: work fatigue, productivity, work pauses, forest operators, work/rest schedules

Questionnaires on Occupational Safety and Health of the Operators of Forestry Machines such as Processors, Harvesters, Tower Yarders, and so on

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The new forestry machines such as processors, harvesters, and tower yarders have been used in logging operations with the old model logging machines such as yarders and tractors in Japan. The new logging operations with these new forestry machines are contributing to not only logging efficiency improvement but also safe work and reduction of physical workload. But mental workload caused by intensive machine operations and static muscle tension caused by a fixed body posture are working environment problems in the operations of the new machines. In Nordic countries where highly developed mechanization work is executed, the new working systems such as shift systems or job rotation systems are used in order to reduce these problems. The aims of this study are to investigate the current status of logging operations with the new forestry machines and to obtain basic material to secure occupational safety and health of the operators. The author executed questionnaire survey about the work feeling (tension and monotonous feeling, etc.) and the consciousness symptom for the machine operators in the whole country.

The results of the investigation were as follows: The majority of operators were feeling the tiredness and the tension. About two-thirds of he operators were feeling the stress. The operators were complaining about the sense of incompatibility such as pains and stiffness by all the body parts except the elbow. The body part with a lot of the sense of incompatibility complaints was the lower side of the back, the neck, the shoulder, the wrist, and the upper part of the back. There were a lot of complaints such as tiredness of the eyes, anxiety, stiffness of the shoulders, and pain of waist. The factors that related to operators' consciousness symptom appeal were the rest time of a day, continuous working hours, and the operation days of a year.

How to develop forest machine enterprises - a holistic approach

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For sustainable development of the global forest economy, not only economic and ecological views are needed, but social considerations also have to be taken into account. The assessment of sustainable development should encompass the quality of the products, the biological diversity after treatment, and also the health and psychological wellbeing of the workers. This is where the life force of a person comes out, and this is a pillar of social sustainability.

In sustainable forest economy, the main challenge during the next few years will be to preserve the vitality of the entrepreneurs. Today, forest machine entrepreneurs are among the biggest employers in the forest economy and are quite important for employment in the regions where settlement is dispersed. The functioning of the forest industry, based on modern computer technology, is also largely dependent on the vitality of the forest machine enterprises.

In the 1990s there have been numerous changes in the Finnish forest industry, deeply affecting forest machine enterprises and entrepreneurs. Research on the consequences of these changes and information on them have not solved the problems. The situation is the same in other fields. In order to find a solution, the Finnish Ministry of Labour initiated, in 1997, a National Workplace Development Programme. This is based on practical implementation of multidisciplinary research results. The aim is to improve productivity in small and medium-sized enterprises, and the quality of working life.

The Ministry of Labour Development Programme, headed by the Finnish Forest Research Institute, the Work Research Centre of the University of Tampere, and experts representing the Association of Machine Entrepreneurs, engaged 12 forest machine enterprises. These companies had a total turnover of almost FIM 30 million. They possessed 45 forest machines and employed about a hundred persons on a permanent basis. Development was focussed on the following themes:

* Improved relations between client and enterprise;
* Increased cooperation and networking between companies;
* Improved profitability of enterprises; and
* Promotion of the psychological wellbeing of the entrepreneurs.

The results, so far, are promising, and they will be used to extend activities within the research-based development to a larger group of entrepreneurs in the forest industry.

Problems of Forest Use in Conditions of Radioactive Contamination of Ukrainian Forests

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After the Chernobil accident, a considerable part of stands with intensive forest management appeared in the zone of radioactive contamination, which was irregular by intensity, by radionuclide composition and by forms of deposits. Diversity of soils and species composition of plants and animals involved into forest management was the source of a large number of radioecological problems. Many purposes forest use became impossible because of considerable contamination of certain raw materials and/or impossibility of safety conditions for forestry workers.

Up today radionuclides accumulation in tree species continues. If in 1991 the transition coefficient for 137Cs from soil to wood was equal to 1.0-4.3 in different forest sites, then in 1996 it was equal to 2.6-13.0. In consequence of it in the poor and relatively poor sites 6-30% of the total radionuclides contents in the biogeocenosis were accumulated in the tree species. It undoubtedly told on the possibility of tree species exploitation. Like this, in the moist subor the timber of *Pinus silvestris* L. was used for the sawed planks production in 1991 on the area with radioactive contamination density of 1110 kBc/m^2, and in 1995-884 kBc/m^2. As the part of fuel and thin logs is rather high, especially after thinning cutting, the problem of its utilization even at rather a low level of radionuclides contents in the soil (over 125 kBc/m^2) appeared. The transition coefficient from soil to needles and shoots is ten times more than from soil to timber. Therefore the storage of these parts of tree for conifer&vitamin meal production became impossible in most parts of Polessje forests. It causes the problem of these materials' utilization after main and intermediate felling. After traditional burning down of felling residuals, radionuclides concentrate considerably in the burning sites, where the special activity of 137Cs in soil increases more than 30 times. It leads to an increase of mosaic distribution of radioactive contamination and of possibility of further radionuclide transition into non-woody production - mushrooms, berries and herbs. It is necessary to take into account forest site and tree species composition in forest use planning, because of differences in radionuclide accumulation. In the optimal growth conditions in 1995 the index of 137Cs accumulation in timber was equal to 0.23 in *Pinus silvestris*; 0.19 in *Betula pendula*; 0.09 in *Populus tremula*; 0.09 in *Quercus robur*; 0.04 - in *Alnus glutinosa*. The most intensive radionuclides migration to tree species was observed in the most poor and moist sites. So, in 1996 the coefficient of 137Cs transmission to *Pinus silvestris* timber in the moist bor was equal to 13.0, in the moist subor - 5.5, in the moist sugruds - 0.8, in the fresh - 8.8, in the moist - 16.6, in the wet - 24.3. Most problematic is the use of wild berries, herbs and mushrooms. The maximal 137Cs transition coefficients in the moist subors are found for *Vaccinium myrtillus* (10.6), *V. uliginosum* (9.4), *V.vitis-ideae* (8.3). These indices vary for the same species in different forest sites. Like this, transition coefficient for *V. myrtillus* berries is 9.1 in the moist sugruds, 68.3 in the moist subors, 100.1 in the damp subors. It is calculated that one can store *V. myrtillus* on the poor and relatively poor soils when density of radioactive contamination is less than 74.0 kBc/m^2, on the relatively rich soils - at 555 kBc/m^2; berries of *V. uliginosum* in the moist subor - 74.0 kBc/m^2, in the moist bors and damp subors - 37.0 kBc/m^2. Raspberry, snowball and ashberry accumulate radionuclides less intensively. Special peculiarities of 137Cs accumulation are most visible in herbs which can be divided into 5 groups by transition coefficient: in very strong accumulators it exceeds 100 (fruit bodies of *Inonotus obliguus*, berries of *V. myrtilis*, spores of *Lycopodium clavatum*), in strong ones it is 50.1-100.0 (leaves of *V.vitisioleae*, springs of *Ledum palustre*, herb of *Chelidonium majus*, *Centaurium erythraea*, leaves of *V.myrtillus*, buds of *Pinus silvestris*.); in moderate it is 10.1-50.0 (herb of *Viola tricolor* and *Tancetum vulgare*, bark of *Frangula alnus*, leaves of *Arctostaphylos uva-ursi*), in slight it is 1.1-10.0 (herbs of *Convallaria majalis, Urtica dioica, Origanum vulgare, Thymus serpyllum, Digitalis grandiflora, Polygonum aviculare*, bark of *Q.robur*, racemes of *Helichrysum arenarium*) and in very slight ones it is less then 1.0

(berries of *Juniperus communis*, rhizomes of *Valeriana officinalis* and *Acorus calamus*).

137Cs accumulates rather intensive in the fruit bodies of edible mushrooms. Therefore in the area with soil radioactive contamination more than 37 kBc/m^2 storage of only slight accumulators is possible (*Armillariella mellea*). *Suillus luteus, S.variegatus, Leccinum scabrum* are strong accumulators even at low level of soil contamination. Analysis of radioactive contamination of forest resources allowed to recommend to forbid the forest management on the 40.8 thous. of ha out of 30-km zone of Chernobil power station, use of wood production is limited on the 101.5 thous. ha, use of non- wood production - on the 1190.5 thous. ha.

An Analysis of the Operator-Chain Saw System in Cutting Activites at a Brazilian Forest Company

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This study was based on data from a paper and cellulose company in the State of Sao Paulo, Brazil. Its main objective was to analyze the operator - chain saw system in forest cutting activities. According to the obtained results, the following conclusions were drawn: The chain saw analyzed from the researcher's viewpoint on the one hand and the operators' on the other showed several ergonomic problems, so indicating the need for intervention into machine in order to improve the relation between the operator and his machine. From the operator's viewpoint, the ergonomic problems presented by chain saw were: all operators agreed in affirming that the used mensuration pole is prejudicial to operator, his performance and health. Relative to the variable exhaustion gases, 50% of the operators considered it as more aggressive to workers. A 21% percent of the operators considered the noise as the most harmful, whereas 12% claimed the vibration is troublesome to their work, and yet 10% considered the chain saw weight as excessive. The chain saw operators are subjected to tendon inflammation, lumbago, hearing loss and sight loss, which lead to suffering and to a lower working capacity in operators.

Heat stress research in forestry

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Heat stress can be defined as the situation where the body experiences problems to dissipate its excess heat to the environment. Due to the heaviness of many activities in forestry, it is obvious that forest workers experience heat stress during warm periods of the year or in regions with warm climates. Yet heat stress has been largely neglected in ergonomic research in forestry so far. A literature review was done to determine what heat stress research has been done so far, what forestry can learn from this research and what directions in heat stress research would be most desirable for forestry.

Methods for determining heat stress are found in abundance. Yet according to evaluation studies, none of them is very reliable due to the complex and individual different reactions of the body exposed to heat stress. ISO has adopted two methods as standard methods for measuring and determining heat stress. A concealed conception of most measuring methods, including the ISO standards, is that the prime solution to limit heat stress risk is to adapt the environmental conditions. High accuracy on measurements of the environmental conditions are therefore required by heat stress methods while the physical work load needs only to be estimated. Estimations of the physical work load may however according to some researchers deviate 50% from the real work load. In forestry, possibilities to limit environmental heat are small. Heat stress risk in forestry can mainly be controlled by limiting the physical work load. It seems therefore obvious to demand high accuracy in physical work load measurements as well. Direct measurement of the oxygen in the field is however seldomly feasible while the most common field method for determination of the work load, measurement of the heart rate, is influenced by the environmental conditions. It is therefore highly desirable that studies are conducted on work load determination in hot conditions.

In sport activities, there is a high level of awareness on the effects of dehydration on performance. In forestry work, where physical demands have similar proportions as in sports, this level of awareness is much lower. Research has shown that a reduction of 2% of body weight or 1.5l of sweat for a person weighing 75 kg, implies a performance decrement of approximately 20%. During forest work in Vietnam where workers neither ate nor drank at the work place, workers had lost 3.2% of their body weight. Besides supply of water it is also necessary to raise awareness among workers to drink sufficiently. A study in Polish steel plant showed that 25-40% of the sweat loss was not replaced by the workers although water was freely available. How much water a forest worker needs to consume should be determined in relation to activity and environmental conditions.

3.10.00 Harvesting, wood delivery and utilisation 1+2

Improving Transport Schedules: A Forest Research Contribution

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Keywords: dynamic programming; optimization; scheduling; transportation model.

A problematic aspect for forest production managers is to plan a forest company's resource use in a way that fulfills the manager's objectives and, simultaneously, satisfies legal, social, ethical, and market restrictions. In other words, forest managers are faced with trying to efficiently combine all the production factors.

Here, we have analyzed the schedules generated by a Transportation Scheduling System (TSS), and have focused on the rationalization of resources through reduced transportation costs. These schedules contains detailed information about departures and arrivals for each truck from the fleet at the garages, their production points and clients, and the eventual queuing times that depend on previous assignments.

The TSS system is composed of two modules (Fig. 1- not shown). The first module uses the Transportation Method Algorithm (TMA) for global minimization of transportation costs that correspond to the loaded trips. The purpose of the second module is to schedule activities for each truck in the fleet, via a Dynamic Programming-based algorithm, the Truck Scheduling Algorithm (TSA).

For trip assignments, we considered a continuous vector of hours so that the transportation schedules could allow the trucks to carry out partial trips, e.g., traveling to the loading point on one day, and traveling to the client on the next day. This was feasible because most of the fleet trucks worked continuously, alternating drivers from 0600 Monday to 1800 Saturday. Trucks that were not worked 24 hours per day were equally programmed. However, optimizing the transport schedules was limited because having to return to the garage made partial trips impossible.

Some pertinent aspects also are discussed with regard to implementation of the TSS. This heterogeneous situation originally was evidenced by the diverse financial, technical, and social conditions by which they characterized the truck owners, who, currently, are completely subcontracted. Initially, the direct beneficiaries were the truck owners, whose incomes were increased once the TSS reduced the day-to-day idleness of the trucks. When the increase in income for truck owners was forecast, however, the forest companies hiring the trucks viewed the TSS as an important tool for the freights-values negotiation, which oscillates between 3 and 9 R$/ton (US$ 1.00 = R$ 1.26, on January 1st, 1999).

Once completely established, the major benefit of the TSS will be its ability to minimize total transportation costs, reduce the idleness of some trucks, offer an important tool of negotiation aimed at reducing freight values, and, finally, contribute to a rational use of the resources that are annually spent on forest activities.

Extraction and Textile Application of Crude Dyes From Barks of *Dysoxylum altissimum* and *Pterospermum indicum*

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Crude dyes were obtained from the barks of *Dysoxylum altissimum* and *Pterospermum indicum* by hot water extraction and freeze drying. The yields of extract from the above-mentioned species were 6.7% and 19.62%, respectively. These extracts still contain sugar compounds and tannins particularly *Pterospermum indicum*.

Different mordants such as ferrous sulfate, copper sulfate, oxalic acid and potasssium dichromate were used on silk and cotton yarns. Colorfastness to washing was assessed separately on the dyed silk and cotton with respect to change in color and staining on dyed materials. Likewise colorfastness to light was done to assess the resistance of the color of dyed yarns to the action of light.

Results showed that the crude dyes had various effects on the fibers in terms of color, shade and brightness using different mordants. *Dysoxylum* sp. and *Pterospermum* sp. dyes had stronger affinity to silk than to cotton. Dyeing experiments for both extracts showed good to excellent ratings in terms of washfastness and light fastness on dyed silk and cotton yarns. The physical appearance of the dyed sample also exhibited fair ratings in terms of its color, shade and brightness.

This study suggests that natural dyes are promising in view of their dyeing applicability to textile and a follow-up study should be conducted on dyes from the bark of those belonging to the lesser known tree species (LKTS) or if possible, those from fast growing tree species.

FAO's Non-Wood Forest Products Program (NWFP)

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Rural and urban people in Africa are heavily dependent on non-wood forest products (NWFP) for a wide range of needs including food, medicines, construction and shelter materials, fibres, dyes, resins, oils, aromatics and a variety of animal products like honey, beeswax and bushmeat. Many of these NWFP are important sources of income and employment at the local level, with some being traded at the international level.

It is often assumed that harvests of NWFP have less impact on forests than logging. However, sometimes this assumption is unfounded as harvesting of non-wood forest resources can affect wild plant and animal populations negatively. In order to ensure the sustainable exploitation and utilization of NWFP, more information is needed on harvesting and inventory methods as well as about forest dynamics (e.g. regeneration). In addition, socio-economic aspects affecting NWFP have to be taken into consideration.

In the framework of an EU-FAO Partnership Programme on "Data collection and analysis for sustainable forest management in ACP countries: linking national and international efforts" quantitative and qualitative information was gathered on the exploitation practices and production levels of major NWFP in (collaboration with) 52 African and Caribbean countries. The preliminary findings of this programme were discussed in five regional workshops held in East Africa (Kenya), Southern Africa (Zimbabwe), Central Africa (Gabon), West Africa (Côte d'Ivoire) and the Caribbean (Barbados).

These workshops revealed that practical methodologies for assessing socio-economic and biological factors affecting NWFP are not available and that an appropriate classification system for NWFP is much needed. In addition, a practical and widely applicable classification system of non-wood forest products (and of the forest resources, which may provide NWFP) is a basis for the assessment of the (biological) potential of NWFP exploitation.

The regional workshops also indicated the multitude of socio-economic and biological factors influencing the exploitation of NWFP. In order to gain a better understanding of these factors, pilot studies were realized in representative African and Caribbean countries (e.g. Uganda, Zimbabwe). In these countries, an assessment of the potential exploitation of selected (important) NWFP was carried out; important socio-economic and biological factors influencing the exploitation of NWFP were identified and analysed, and a proposal for sustainable management was elaborated.

Theory of the Timber Harvesting Based on Forest Function

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The paper deals with problems concerning the timber harvesting based on identification of different forest functions. Firstly- The forest harvesting must be carried on , both as a direct utilization of timber and in the forms which are playing important values - the spiritual and esthetic and several other values. It means that all the benefits from the forests are irreplaceable for man together with material and other (spiritual) values. Secondly - Destruction caused by felling single trees, many trees,many ha of the forest etc. Which causes of definite forest ecosystem destruction could be minimized, and have all accessible methods really been used? Thirdly - To ensure the sustainable and multifunctional forest harvesting, proper methods of forest regulations must be used. The possibilities of solving all these problems could be seen only through properly applying a synthesis of theoretical and practical knowledge in compliance with several scientific disciplines, often far away from forestry sciences.

3.11.00 Forest operations and environmental protection

Restorative Planting of Degraded Sites In a Logged Hill Dipterocarp Forest Using New Approach And New Method

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Keywords: logged hill forest, silviculture treatments, rehabilitation, enrichment planting, degraded sites, wild-boar attack

Currently, the harvesting technique used in the hill dipterocarp forests in Peninsular Malaysia is the crawler-tractor. This technique results in excessive opening of the forest canopy and causes much of soil disturbance due to construction of logging roads, landing sites, a maze of skid trails and tree fall gaps. Normally these degraded areas are highly to moderately compacted and have poor regeneration. To increase the productivity of logged-over dipterocarp forests and to ensure enough resource for the future crops, therefore, restorative of the degraded and poorly stocked areas using dipterocarp and other commercially indigenous species through enrichment planting is required. Current enrichment planting practice was associated with low survival, high maintenance cost, and poor performance of planted plant. Subsequent treatments were impeded by difficulty in accessibility to the site. Thus, a new semi-mechanized planting method is introduced and examined. A conducive planting condition for the early establishment is provided. The method emphasizes on using big healthy planting material, big planting holes, suitable species, and adequate light. The soil physical properties and soil fertility of the planting point were improved at the time of planting. Performance of the planted plants will be discussed. Preliminary results showed high survival. The new technique is expected to produce better growth and minima tending after planting as the planted plants can be left to establish on their own. A feasibility study on the time taken, manpower involved and type of machine used in the planting operation will be discussed. The initial problem due to wild-boar attacks was successfully overcome by introducing a deterrent guard.

Effects of Superposition of the Tractor Tire Tracks on the Level of Forest Soil Compaction

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This work was carried out using forest tractors Feller-Buncher (411EX HIDRO-AX) and Skidder (CAT 525) in a *Eucalyptus* timber harvesting operation of charcoal producing company, located in Itamarandiba, State of Minas Gerais, Brazil. Its objective was to evaluate the level of soil compaction as a result of tractor tire tracks superposition in stands of *Eucalyptus*, according to the cutting module adopted by the company. The following physical properties of the soil were considered: bulk density; particle density; total porosity; water content; saturated hydraulic conductivity and soil resistance to penetration. The following conclusions were made: The average pressures applied to wheel surface were 90.6 and 73.9 KPa for Feller-Buncher and Skidder, respectively; saturated hydraulic conductivity had a greater change at 0-10 cm depth, among the soil's physical parameters; the cone index curves at the four depth levels showed an increasing change in soil resistance to penetration, due to traffic on the tracks. The effects of the superposition of tire tracks on the crop area became more evident at the depth of 0-10 cm, for all the physical parameters used; the total increment in bulkdensity of the soil before traffic and after log skidding was of 19.56%, at a level of 0-10 cm of depth; the effect of the traffic of the tractors on the soil was greater in the first travel and it was related to the Feller-Buncher operation. Its movement several times in the same place with the head loaded contributed to a greater mechanical compaction of the soil.

Effect of Forest Harvesting on Soil Physical Properties and Productivity: A Global Perspective

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Keywords: soil disturbance, soil structure, bulk density, porosity, tree growth

The deleterious effect of forest harvesting on long term site productivity has been documented in several countries. Decreased productivity has been

attributed to lowered soil fertility caused by removal of harvested biomass components, leaching, erosion, and chemical and biological transformation phenomena. Site productivity decline also results from soil structural degradation that occurs when harvesting takes place under unsuitable conditions. Repeated traffic by forestry equipment during logging, causes soil disturbance and, depending on texture, wetness, type of equipment, and traffic intensity, may result in displacement, compaction, rutting, and puddling. Under partially saturated conditions, soil strength decreases as soil water potential decreases (soil becomes wetter) and fine textured soils are more susceptible to compaction because they dry more slowly. Compaction results in increased bulk density, and capillary pore space (micropores) but there is a decrease in non-capillary pore space (macropores), infiltration rate, and permeability as soil particles are forced closer to each other. The resulting impairment in soil-air-water balance and the physical impedance presented to roots reduce their elongation and hence plant growth, and inhibit production of suckers in aspen (*Populus tremuloides* Michx.). Tree species differ in their tolerance of changes in bulk density and macroporosity, and management in each jurisdiction should define the level of soil wetness that is commensurate with significant compaction, given the logging equipment that is being used. Critical soil water potential in the range of field capacity can be measured with instrumentation, or can be estimated by observing the ease of breakage of a molded clod that is squeezed between the fingers.

Deterioration in soil structure may last a few months or several decades, depending on soil texture and the severity of disturbance and it is incumbent on forest managers in all climatic regimes to be proactive in developing a rating of compaction risk for their soils. Cyclical phenomena such as wetting and drying, and freezing and thawing (in north temperate and boreal climatic regimes), act as ameliorative processes on compacted soils, but their effectiveness depends on the presence of expandable-type clay minerals, and the soil moisture content when freezing occurs. Amelioration through plowing, disking, and bedding have been used successfully but subsoil tillage operations have not always been effective, despite the high cost of specialized equipment that is necessary.

Strategies to minimize soil disturbance during harvesting and restrict disturbance to acceptable levels include a) developing a rating of disturbance risk for managed areas and mapping the soils accordingly, b) traffic avoidance until soil water potential is above the critical point for significant compaction, c) use of larger and wider rubber tires at reduced inflation pressures, d) use of rubber-tired or tracked equipment capable of articulation and extension, e) use of a traffic mat comprising tree branches, foliage, and harvest residues, f) use of designated skidtrails (machine corridors) commensurate with an acceptable level of disturbance, and g) in boreal climates, harvesting aspen and other poplar species in winter only, to take advantage of greater soil strength offered by frozen soil.

Research of Forwarder Performances on Hard and Soft Soil

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Keywords: wood extraction, forwarder, soft soil, hard soil, penetration characteristic, rut formation, wheel slip, productivity

This paper deals with the investigation of the impact of forwarders on soil, their tractive performance and productivity on hard and soft soil. Heavy, six-wheel forwarders with a capacity of 14 tons are the most frequently used vehicles for wood extracting after reproductive and final cutting in low-land oak forests in Croatia. Since this transportation is mostly carried out during winter with unfavorable soil conditions, the impact of the forwarder on the soil and its productivity represents an essential technological parameter.

The measurements were carried out in two ways:

1) The investigation of the impact of forwarders on soil was performed under controlled conditions on 2 testing skid trails: soft and hard. At the same time granulometric composition and soil moisture were determined and the measuring equipment in the laboratory vehicle was used to measure:
- soil penetration resistance before and after the pass of the vehicle with cone penetrometer
- rut formation
- wheel slip curve (gross tractive coefficient vs. slip)

2) Productivity investigation was carried out by work study methods during the transportation of wood from an oak stand without influencing the forwarder driver. The soil was divided in two categories: hard and soft. 207 transportation samples were recorded on hard soil and 163 on soft

soil. The differences of mean load volume, traveling time and productivity depending on soil conditions were defined.

Sediment Yield of Hill Forest Watersheds in Peninsular Malaysia

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This paper reports on sediment yield of several hill forest watersheds assessed for logging impact. The discussion includes suspended and bedload transported from four steep gradient streams draining the headwaters of the Main Range in Selangor. Although the Batangsi, Chongkak, Lawing and Pangsun watersheds were monitored at different times, interesting characteristics in sediment yield were detected. Sg. Batangsi was monitored between 1987 to 1989 when logging was on-going, while in Sg. Chongkak, logging ceased. Suspended loads from Batangsi were then about fifty times higher than natural watersheds. The Sg. Lawing, where about 40% of the lower basin was logged in 1993, produced loads about twenty times higher prior to timber harvest. While exposed areas are primarily responsible for much of the sediment transported, hydrometeorological events also determine, to a large extent, the sediment loads evacuated. The undisturbed Sg. Pangsun, intensively gauged in 1997 through 1998, for example produced rathed low suspended load because of a period of severe dry spell.

Soil Compaction by a Small Sized Processor, Forwarder, and Skidder inTimber Harvesting

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Keywords: Soil compaction; Bulk density; Processor; Forwarder; Skidder

Various kinds of forestry vehicles are used for logging operations in forests. Soil compaction is a concern because of the increased use of heavy equipment. Soil compaction reduces macroscopic pore space in soil, aeration, water movement, water holding capacity, and it prevents root penetration. We investigated the soil compaction of skid roads by a small sized processor and a forwarder which were developed especially for thinning operation, and also the recovery of bulk density and organic matter in an area where logging operation had ceased several years earlier.

Investigation areas were at a forest in Matsuida, Gunma Prefecture, and Tokyo University Forest in Hokkaido, Japan. Cone penetrometer was used to measure the soil hardness. In Matsuida, soil hardness was measured from the surface until 50 cm depth of the soil at the skidding trail and center of the skidding road, and undisturbed area. The forest consisted of artificial forest of Japanese Cedar and thinning was operated in 1996 by a processor and a forwarder. At the Tokyo University Forest in Hokkaido, soil samples were taken from sites where logging operations had terminated 1, 5, 8, and 12 years prior to sampling. Bulk density and organic matter were analyzed for soil at the surface and at 20cm depth in each main and branch skidding road, landing area, and undisturbed area. The forest was covered with natural forest and selective cutting was performed with a crawler type tractor.

In the Matsuida forested area, hardness of soil at skid trail and center caused by only a processor was not different from the undisturbed area. The soil became more compacted at the skidding trail of entrance section by the traffic of forwarder, especially at the surface of skidding trail. The existing condition of soil hardness in the investigated area was originally hard. The skidding distance was kept shorter by the density of the forest road. The percentage of opening up forested area was only about 3.25%. Even though soil hardness at the permanent skidding road was higher than that of the undisturbed area, damage did not increase seriously at the processor site. The small percentage of the disturbed area in thinning operation will not cause serious problems of soil compaction in an area such as Matsuida forest.

The organic matter at the surface down to 5 cm tended to increase in several years after logging operations. The surface of the soil at the branch skidding roads which were not intensively disturbed had apparently recovered to the original conditions of such as in the undisturbed area. Several years after logging operations, bulk density showed some recovery as indicated by a decrease in bulk density. The bulk density of the surface of the branch road showed some recovery 5 years after logging, though to the original condition represented by the bulk density of the undisturbed area. At the main skidding road, the bulk density did not recover during 8 years after termination of logging but the density decreased 12 years after logging operations ended. At the landing area, the bulk density did not

recover to the same conditions of the undisturbed area even 12 years after logging.

EXPLORE: Expert Systems for Predicting the Effect of Logging Roads on Environment

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Logging roads are crucial for transportation and forest management and a major cause of negative impact toward sustainable forest management. This paper presents an expert systems for predict effect of logging roads on environment based on knowledge acquired from the experience expert. The rule-bases of the system is developed using wxCLIPS 1.64, an Expert System Shell which is designed by Artificial Intelligence Application Institute, University of Edinburgh, The prototype of EXPLORE is to provide users with as much related information as possible to provides an understanding of effect of logging roads on environment.

Keywords: Expert System, Prediction, Logging roads, Impact.

Roots Under the Impact of Logging and Hauling Machinery. Application of New Field Techniques.

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Keywords: Heavy machinery, Soil compaction, Tree roots, Mechanical damage, Spruce

Aim of the research is to estimate objectively the impact of mechanical perturbations of soils and changes in water capacity along skidding trails and roads in forest stands caused by movement of heavy logging and hauling machinery on tree roots, especially their health as reflected by water absorbing functions. Present measuring electronic techniques available on the field of tree eco-physiology and structure allow to detect the impact immediately, to quantify its harmful effects on the individual root and the whole tree level and to specify, which are the most important features of the injury. Heavy forest machinery with defined tires and specific load moves along skidding trails during experimental load. Pressure caused by the machinery in different soil depths is measured by flat plastic sensors connected by flexible tubes to tensiometric devices, which are connected to dataloggers. The important changes in the soil water capacity are measured in addition. Studies include the most widespread coniferous species, particularly Norway spruce (*Picea abies* (L.) Karst.) and forest stands growing on different soils. Sap flow is measured in different depths along radii of selected coarse roots and stem basis by the heat field deformation method before, during and after the experimental load (just after the load and repeatedly after longer periods of time to check for eventual root regeneration). By comparing response of sap flows of experimental and control trees we can specify the extent of functional damage. Repeated measurements show how long time the effect of root perturbation persists. Root systems of trees are finally excavated by the harmless air-spade (ultrasonic air stream) technique and photographed in details to check for a structural extent of eventual damage. Ground penetrating radar technology can be optionally applied for this purpose. On the basis of such studies we can recommend the maximum load along a skidding trail in a particular soil and environmental conditions (number of movement of heavy machinery under a specific load), still not causing erosion and damage to tree root systems.

Logistics of Ash Recycling in Boreal Conditions

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Wood processing in pulp mills cause large amounts of wood wastes, which can be combusted in energy plants. This combusting causes considerable amounts of ash, which contains nutrients useful for trees. Instead of dumping the ash it can be used as a long term fertiliser to forests. Spreading of normal ash to forests has drawbacks such as loose structure, which means ineffective logistics and dust problem. Normal ash is also easily washed away by spring floods and rains. In order to solve aforementioned problems, the granulating system has been developed. This study concentrates on logistic systems from millyard to forest. Granulated ash is spread either by a helicopter or by a forwarder-mounted centrifugal spreader. Preliminary tests of forest spreading of granulated ash have been started in Eastern Finland. Problems faced so far are i) helicopter spreading is remarkably more expensive than forwarder spreading, ii) helicopter spreading is very much weather dependent whereas forwarder spreading requires thinning cutting made

beforehand, iii) moist soils can not carry forwarder except when frozen.

System design includes organising of millyard-forest transportation and the spreading of ash in forest as well as identifying of potential spreading areas as a part of the normal timber procurement process. Time studies were done for forwarder and helicopter and other collaborative apparatus like trucks and loaders. Logistic systems will be evaluated with discrete event simulation technique.

The most competitive and cost effective logistic system with annual production of 6 000 tonnes of ash included 1) Large ash storage on the millyard far enough from the pulp mill in order to avoid the harm caused by ash in the pulping process. 2) Transportation from the mill to forest by trucks made for sand transporting. 3) Small operative ash buffer in the forest. 4) Spreading by forwarder mounted centrifugal spreader. Especially in winter ash cannot be stored in open air in the forest more than a couple of weeks without quality problems.

Unit costs of transportation and spreading with the most competitive millyard logistics and transportation alternative were USD 14.8/t with forwarder spreading (average spreading distance, ASD 0.5 km, distance from the forest storage to the spreading area) and USD 55.4/t with helicopter spreading (ASD 0.8 km). When the unit costs of oneha of spreading (transportation excluded) is considered with the recommended spreading amount of 3000 kg/ha, unit costs with forwarder were USD 26/ha and with helicopter USD 128/ha. (ASD 0.5 km). Because of the considerably lower unit costs, the forwarder mounted centrifugal spreader has to be considered as a primary spreading method. In boreal conditions storages in the logistic chain have to be placed at the beginning of the chain and transportation and spreading should be organised as a "hot chain".

Effects of Slash Disposal Methods on the Physical and Chemical Properties of Soil on Harvested Sites

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According to the Stipulations of Forest Harvesting and Regeneration issued by the Forestry Ministry of China in 1987, there are three methods of harvesting slash disposal, piling, burning and spreading. The burning method was restricted in the dry season in recent years due to forest fire. Field survey for effects of slash disposal methods on soil properties was carried out in Dailing Forest Experiment Bureau, Heilongjiang Province, China. The test sites are located in Dongfanghong Forestry Farm, 128°47'32" E and 47°13'10" N. Forest stands before harvesting are mixed stands of conifer and broadleaf trees, 70% to 30% in proportion. Average slope on test sites is 16-22°. Forest soil is dark brown soil. Clear cutting and selective cutting systems with ground crawler skidding were employed in the harvesting. For each small block of test site, there is another small block with the mostly same conditions (time, space, and operation) taken as the reference block. The small test block for burning and spreading methods was 100 (100m^2 which contents 9 small sample squares evenly distributed. And for piling method, the small test block was 300 (300m^2 which contents 25 small sample squares unevenly distributed. The soil samples taken for piling and spreading method are from the year of 5, 10, 15 and 20 after harvesting and slash disposal operations. And those for burning method are only from the year of 1986, 1990 and 1996 due to the slash on a few of operation sites disposed by burning.

In order to evaluate the soil physical property changes, bulk density, saturated water retention capacity and total porosity of soil were measured. The results of laboratory analysis showed that, compared with its own reference site, (1) the bulk density on spreading, piling and burning site is changed with a rate of 1.3% of decreasing, 3.2% of decreasing and 5.2% of increasing respectively; (2) the saturated water retention capacity and the total porosity of soil on these three test sites were also changed with changing rates mostly below 10%, and changing trend just opposite to bulk density.

The parameters of soil chemical properties, pH, organic matter, total N, total P, total K, hydrolytic N, available P and available K, were taken as the evaluation criteria and they were measured. The chemical criteria above on spreading site were changed within 7%, compared with those on reference site There is no significant difference between pH values of soil on piling site, but not the burning site (increasing 9%), and on reference site. The organic matter content of soil on piling and burning site is significantly higher, 24.6% and 13.2% respectively, than that on reference site. The contents of nutrient elements of soil on piling site are also higher than those on reference site with the increasing rate mostly over 10%. But these on burning site are significantly lower than those on its reference site, mostly changed up to 30% or even lower.

Conclusions of this study were derived from the results above. (1) Both piling and burning methods do not affect the soil physical properties significantly. (2) Piling method is quite helpful for the site to maintain the productive soil. (3) Burning method is useful for soil acidification improvement, but it is easy to lose nutrient elements. (4) Spreading method does not change much the soil properties, but high cost for planting after harvesting.

Environmental Impact Caused by Forest Operations

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Keywords: environmental impact, soil disturbance, compaction, root damage, ground pressure

Environmental impact caused by forest operation makes land productivity less. Especially forest vehicles cause forest floor disturbance including soil degradation and root damage on residual trees. It must be reduced for sustainable forest management. It is necessary to obtain knowledge of environmental impact to reduce it.

Two studies on environmental impact had been done. The first is an investigation of soil properties on a harvested site in tropical rain forest in Malaysia.

In Malaysia, ordinary logs are primarily collected by bulldozers and are secondarily transported by large sized forwarders. Bulldozers enter into forests over long distances; therefore much forest floor was occupied with bulldozer trails. Bulldozers repair the surface of logging trails so many times that surface soil is hardly removed. The logging trails were classified in 2 categories: main logging trail and sub logging trail by travel times of bulldozers and whether surface soil had been scraped or not.

Soil properties on main logging trails, sub logging trails and the natural forest floor as control were investigated. The result shows that soil on main logging trail is very dense because of many travels and surface soil scraping. Soil on sub logging trail has medium density between main logging trail and natural forest floor. It is decided that surface soil on main logging trails had been lost, and that surface soil on sub-logging trails remains, through the measurement of organic mater contents of surface soil comparing with natural forest floor.

The second study is the trial to measure the tension on root caused by the ground pressure of forest vehicles. It is difficult to observe the process of root damage directly because root system exists underground. And it is difficult to do reproducible experiment because roots are fragile and of varying shape. Therefore dummy roots made from wire rope were used in experiment of root damage by ground pressure of the forest vehicles.

Before the experiment, the diameter of the real cypress root equivalent to dummy root was guessed through the measurement of pulling resistance of cypress root and dummy root. A regression equation between diameter and pulling breakage strength was obtained by measuring pulling breakage strength of various diameters of real cypress root. Ground pressure and tension on dummy roots were measured while a vehicle travels on buried dummy roots 50 times. Though the ground pressure decreases after the vehicle passes, tension force on dummy roots decreases slowly after the vehicle passes. Therefore tension force on the dummy roots was integrated. The result shows that maximum value of integrated tension force was superior to the breakage strength of real cypress root equivalent to the choking point of the dummy root. It is guessed that real cypress root would be broken by short interval travels of forest vehicles.

Observation of Soil Erosion in a Logged-over Tropical Forest in Pasoh Forest Reserve, Negeri Sembilan, Malaysia

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The study was conducted in the area of a logged-over tropical forest in Pasoh Forest Reserve, Kuala Pilah, Negeri Sembilan, Malaysia. The attempt of this study was to investigate and observe soil erosional characteristics of a logged-over tropical forest. Soil erosion was monitored by using erosion pins at five unbounded 10m x 10m research grids in a 100m x 100m research plot. The occurrence of soil erosion and soil deposition were observed. Among the research grids, the maximum soil erosion was 14.6mm and the maximum soil deposition was 7.2mm. The form of soil erosion that occurred consisted of sheet erosion and splash erosion. Generally, the pattern of soil erosion varied significantly between locations within the plot.

However, the pattern of erosion did not show any significant difference with time of sampling.

An Information System for the Soil Protecting Use of Forestry Machinery

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To avoid damage of the forest soil caused by forest machinery when driving on the forest ground, an information system is introduced to enable soil protecting machine operations. The key for this tool is the knowlege, that there is for every siteclass and for every soil water content a limiting maximum soil pressure, which must not be exceeded to avoid damage. The specific soil pressure depends on machinery parameters of the equipment used and it's type of tyres.

The siteclass, and geology where applicable, are widely available through site classification maps

The information system uses a database, which is filled with information concerning these stratums: data on (forestry) machines, tyres and site information.

Thus for a given site class and the equipment to be used at that site the infomation system is able to calculate the soil water content, which must not be exceeded when a soil protecting operation takes place.

With this prediction-which is specific for a forest stand, the planned operation and the equipment configuration to be used - for the first time a precise instrument exists, which makes a truely soil protecting machine operation possible.

Division 4
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4.00.00 Division 4 Meetings

Structural analysis and crown modeling of tree population relics in coastal lomas (Mejia, South Peru)

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In central and southern Peru the coastal vegetation is semi-arid, or steppe like, with the presence of scattered trees. This so-called lomas (hills) vegetation can be divided into several physiognomic types on the basis of the dominant species, i.e. from herbaceous to shrubby and tree lomas. The area has a very low annual average rainfall of 20mm. The vegetation depends on fog and mist interception for its water supply, and moisture intercepted by leaves and branches can contribute up to the 80% of tree transpiration. The region is also strongly affected by man's historical activities. In the Department of Arequipa, a few of the endangered ecosystem relics include tree lomas. Up to present, grazing is rather intense in the region.

The specific objectives of the research are to (1) study the magnitude and dynamics of site degradation factors, (2) describe the spatial structure of tree populations, and (3) characterize the morphological features of relic trees for crown parameters related to fog interception and throughfall. The study was carried out in the Lomas of Mejia, Valdividida district (La Curva). The lower limit of the fog is between 200-300 m a.s.l., while the upper limit coincides with the base of the thermal inversion between 700 and 1000 m. Eight plots in a transect were selected in two distinct valleys with differing grazing pressure, average elevation, and slope exposure. In each plot the presence/abundance of shrubs and herbaceous species, structure of trees, DBH, height, crown intersection and projected areas, number of cut shoots, number of clustered buds and sprouts, and the type and positioning of tree damage were recorded. Fifteen trees where sampled at altitudes ranging from 450 to 750 m a.s.l to characterize morphological parameters, including crown shape and size, and branch volume and pattern. Throughfall distribution was investigated by placing rain gauges under the crown projection of trees. The spatial distribution of throughfall was analyzed by means of the Blackman's Dispersion Index. Evaluation of tree damage was carried out by counting cut scars, fire signs, and bud/shoot proliferation nuclei. The polycormic structure of trees was noted as well as reaction to past logging. Crown shape and volume, branching pattern and density were processed with Autocad software. Discriminant and multiple regression analyses highlighted relationships within state factors, morphological parameters and throughfall.

Caesalpinea spinosa trees form single-layered and even-aged stands. The crown cover index of these trees was 10.4%, and the average basal area was 1.3 m^2/ha. Signs of utilization were seen on 56% of trees. Regeneration of trees is absent. Tree density is higher on slopes facing the main fog stream. Leaves and seeds are mostly located in the leeward part of the crowns, very likely in relation to the sulphuric acid pollution produced by a copper refinery 50 km south of Mehia. Crowns project toward the prevailing wind direction and have high efficiency for moisture capture. Rather high total and daily throughfall amounts were measured in relation to the crown volumes and tree branching patterns. Tree diameter and crown volume appear to correlate well with water capturing ability. Despite the low total leaf area and leaf location opposite to the prevailing wind direction, high capturing efficiency of the branching patterns was verified. Nevertheless, the estimation of the water available for trees from these results is difficult due to the need to account for infiltration and runoff associated with hillslopes and physical modification of soils.

Economic and ecological sustainability of neotropical rain forest management: results from one decade in Central America

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The new paradigms governing sustainable forest management in the neotropics are examined, particularly those related to keeping an appropriate balance between the continuous flow of economic benefits derived from forest management and the maintenance of the ecosystem integrity. The paper specifically assesses the sustainability of managing natural rain forests in Central America, based on one decade of research results regarding the effect of forest harvesting operations and post-harvesting treatments on the economic feasibility, forest growth and plant biodiversity. This study provides a close analysis of the possibilities of natural forest management in the neotropics and how far we are from achieving sustainability in these types of forests.

It was found that at least 30 ha of forest and 10-15 m^3 ha^{-1} of commercial timber should be harvested in order to make natural forest management economically attractive in conditions similar to those found in the region where this study was carried out. Post-harvesting treatments significantly increased growth, especially for commercial species; these operations, however, affected negatively the economic feasibility of the whole management scheme. Some kind of financial compensation, such as the innovative payment of environmental services prevailing in Costa Rica, would be required to make post-harvesting treatments economically feasible. Tree species that colonized disturbed sites were favored in areas directly affected by forest operations.

Simulations tested using the SIRENA II model for scenarios combining different forest harvesting intensities, cutting cycles and post-harvesting treatments, suggest better possibilities for achieving sustainability in managing natural rain forests when: a moderate harvesting is implemented (approx. 60% of the commercial volume); post-harvesting treatments are prescribed in order to maintain an appropriate composition of commercial species; and a cutting cycle of at least 20 years is selected. Under these conditions, it would be possible to harvest a sustained yield of 15-20 m^3 ha^1 of commercial volume.

These results could serve as a reference for future actions to improve forest policies that aim at promoting sustainable forest management as a conservation tool in neotropical countries, such as the ongoing processes of development and validation of criteria and indicators for the sustainable management of natural forest in some Central American countries.

Effect of different spacing on storm-resistance and volume of young *Eucalyptus urophylla*

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Key words *Eucalyptus urophylla*, spacing, volume, storm-resistance

Most of the eucalypt species are planted around coastal districts in southern China for pulp and paper. Eucalypt plantations especially young plantations are strongly damaged by the storms which happened 3-4 times in these regions each year. Storm is the main obstacle for the development of eucalypt plantation in south China. An *Eucalyptus urophylla* spacing trial which included 5 planting densities of 3m/1m, 4.5m/1m, 3m/2m, 4.5m/1.5 m and 3m/3m was established in Leizhou Peninsula, Guangdong Province where 20%-50% of young eucalypt plantation were damaged by the storms every year. The design was a randomized complete block. The area of each block was 0.169 hm^2. All areas were ploughed with the Shearer Majestic disc plough followed by a single run with the Shearer offset discs. Study on the effect of 5 different spacing on storm-resistance and volume of young *Eucalyptus urophylla* plantation showed that: (1) The more the planting density, the stronger the storm-resistance in 5 spacing of the trial. The percentages of damaged trees of 5 planting densities from 3m/1m to 3m/3m were 9%, 12.5%, 16.6%, 19.2% and 27.9% respectively at one year. (2) The more of planting density, the bigger is the stand volume. The volume of 5 planting densities from 3m/1m to 3m/3m were 139.8 hm^2, 136.5 hm^2, 108.1 hm^2, 101.4 hm^2 and 81 hm^2 respectively at the age of 3.5 years. Planting density may be increased up to 2500-3000 trees/ha instead of 1667 trees/ha which is the popular spacing in forest practice in south China. (3) The spacing of 3m/3m is the worst one.

Harvesting plan - a case study in producing a good quality map for harvesting in tropical hill forest.

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Malaysia had formulated and operationalised the Malaysian Criteria and Indicators for Sustainable Forest Management (MC&I) using the (International Tropical Timber Organization) ITTO guidelines for the Sustainable Management of Natural Tropical Forests and ITTO Criteria for the Measurement of Sustainable Tropical Forest Management. Malaysia has further developed a set of MC&I for purposes of forest management certification at the Forest Management Unit (FMU) level.

A total of 71 activities and 164 management specifications covering six criteria and 28 indicators have been formulated. Following the formulation of MC&I, a number of assessment, both internal and through independent external assessors, have been conducted to assess the implementation of all prescribed activities at the FMU level. The first internal assessment for Peninsular Malaysia conducted in 1996 produced some valuable feedback for the improvement and refinement of the MC&I.

Well-documented forest management has been developed in Malaysia over a very long period, within the Permanent Forest Estate (PFE). A good system of Totally Protected Areas and Virgin Jungle Reserves was being extended further. The main concerns had been over the effectiveness of implementation and logging contracts, and involvement of local people.

With respect to the concerns above, further assessment on current forest management practices especially implementation of a forest harvesting plan was undertaken by the Forest Research Institute Malaysia (FRIM) in collaboration with the Kumpulan Pengurusan Kayu Kayan Terengganu Sdn. Bhd. (KPKKT). The findings from this study may result in the possible revision and improvement of the MC&I. The study was done in Block Beta of Compartment 51, Jengai Forest Reserve, Terengganu. The area for this study covers 42 ha.

This paper explains the procedure and some of the costs involves in producing a good quality map for the purpose of harvesting to extract commercial trees. The boundary and streams within the block was first surveyed to produce a base map of scale 1:1000. In the MC&I the scale for the map stated was 1:5000. So, causes for the scale 1:1000 chosen are stated too. The location of the Base Line was decided on the map and then the base line was demarcated together with the 30 meters apart strip lines on the ground. The strip lines were used to gather data for topography and trees marked for felling (tree mapping). The height of every 30 meters (horizontal distance) on the strip lines are recorded from the inclination readings obtained by using either clinometer, Impulse or Criterion.

The Impulse equipment was used for the boundary survey and the Criterion Laser 400 equipment was used for the stream survey. Errors encountered during boundary, streams and strip lines surveys are explained in this paper and mitigation measures stated to minimize errors in the future. The initial stage of producing the base map was totally done manually. Hence the time consumed are noted for improvement if computer software are used to produce the map. The possibility of using better equipment for producing a good harvesting plan are discussed further. These include equipment such as Trimble Pro-XR, Geoexplorer and software such as Roadeng, Forest Low Density Road System (FLDRS) and Earthwork.

Last but not least this paper explains the perception of the present logging contractors on the MC&I and steps taken to convince them of the usefulness of advanced technologies for the use in the forestry sector especially for harvesting.

Long-term financing as a determining factor to investments in reforestation: the case of *Pinus* spp. in Paraná State

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Brazilian annual consumption of roundwood is around 350 million m^3. Forestry sector annual product is around US$17 billion or 2.2% of Brazilian GNP and it generates 700 thousand direct and 2 million indirect jobs. Exports reached US$4.1 billion in 96 and US$3.3 billion in 97. The industrialization of urban areas and the mechanization of agriculture where causes of deforestation in South and Southeast Brazil. In the 70's, Brazilian government implemented some tax incentive measures to foster reforestation with fast growing species. In South Brazil, most of incentives became Pine plantations, which supplied pulp and paper industries. This successful policy, together with investment in research and genetic improvement of pines, led to a tremendous growth of the pine-based industry in South Brazil. The 80's and 90's were marked by a strong economic crisis in the country with an inflationary process and bankruptcy of public budgets. Tax incentives were interrupted and since that time forest sector does not have any public policy, which can promote reforestation. Forecasts of production based on modeling the production of stands planted and on a near stable demand of pine roundwood shows that a shortage of pine wood will occur by the year 2013. To avoid that, an annual reforestation program of 12,000ha must be established.

Considering that all tax incentives were extinguished and that existing plantations were poorly managed, there is a strong need of establishment of a set of policies aimed at promoting industrial reforestation, research and defining a program directed to small land owners.

Growth and modernization of Paraná's Forest Sector depend upon a financing policy which takes into account local specific conditions of production, profitability, yield, costs and technological level.

This work was developed through the analysis of the productive system of pine in South Brazil, with emphasis in Paraná State. The methodology allows the definition of main elements of the productive system and the quantification of their economic efficiency. Main bottlenecks of the productive system and basic conditions of its development are also identified.

Two methods of selection cutting systems for sustainable management of natural hiba (*Thujopsis dolabrata* var. hondai) forest

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Two plots were made in Kansuizawa experiment forest in 1927 to develop the selection cutting system for sustainable management of natural hiba (*Thujopsis dolabrata* var. *hondai*) forest. Strip clear-cutting system (the width of every strip was 15 m) was applied to one plot (plot A) and 28 percent in volume was logged. To the other plot (plot B), single tree selection cutting system was applied and 36 percent in volume was logged. The dbh and height of trees were measured in 1997, 70 years after selection cuttings, and stand structure of each plot was compared with that of 70 years ago. In plot A, population of *T. dolabrata* in middle class (22 cm <= dbh < 52 cm) decreased though population of *T. dolabrata* in small class (6 cm <= dbh< 22 cm) increased greatly and that in large class (dbh >= 52 cm) showed a slight increase. It is considered that the growth of young seedlings of *T. dolabrata* was urged by strip clear cutting and the growth of *T. dolabrata* in sub tree layer in reserved belt area was restricted by the coverage of tree layer. The annual growth rate of *T. dolabrata* in small class, middle class and large class in 70 years was 0.2,0.1, 0.2 m^3/ha/yr, respectively. In plot B, the increase in population of small class was not so clear compared with that in plot A. The stand structure of plot B showed little difference from that in 70 years ago. The annual growth rate of *T. dolabrata* in small class, middle class and large class was 0.8, 2.0, 0.6 m^3/yr/ha, respectively. In these 70 years, these two plots had been logged four times. And from the second time of logging, single tree selection cutting system was applied to plot A, especially to the reserved belt area. The total harvest volume in 70 years is 270 m^3/yr/ha in plot A and 363 m^3/yr/ha in plot B. Judging from these results, we concluded that single tree selection cutting system should be applied to natural *T. dolabrata* forests in selection forest type to earn more harvest. And in the *T. dolabrata* forest in uniform forest type where the populations of young seedlings are small, clear-cutting system should be used in order to urge the regeneration of *T. dolabrata.*

A Sustainable Forest Management in Devastating Land by Typhoon

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Japan forests in the northern Kyushu were severely damaged by typhoons 9117 and 9118 (Vmax = 61 m/s) in 1991. Especially in Sugi forest (*Criptomeria japonica* D. Don), the trees were completely destroyed in the various types of wind damage, such as the stem breaking, overturning, bending and branch breaking etc. Even in the residual forests, the growth level and wood quality were clearly reduced by the internal damages with cambium zone. In addition, the secondary disasters (landslide and floodwood) began to occur since then. From the results of actual condition research and experimental analysis for silviculture and strength of wood material, several counter plans for waste management, reforestation plans and hazard assessment were done and the following matters were suggested;

1. Damaged trees will be used for the pulpwood and logs with low quality.
2. Slightly damaged trees will be still remained as a long rotation trees because of the rehabilitation of wood quality.
3. Environmental forest management is superior to the economic efficiency in Japan because of the climate and topographical conditions.
4. Mixed and multi-storied forest should be planned to promote the functions of ecosystem and soil and water conservation.
5. Coniferous trees should be planted at the suitable site condition, for example on a slope between mountain ridge and valley.
6. Native trees, such as broad-leaves ones, should be planted on a ridge and along valley because of their dominant characters.
7. Hazard assessment, such as prediction for criteria of rainfall intensity with landslide and how to reduce and evacuate from disaster, is the significant project to maintain the mountain and keep a human life and their properties in Japan.

Revenue Losses Arising from Inadequate Market Information: A Case Study of the Local Extractors and the Forest Department-Kakamega Forest in Kenya

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Kakamega Forest is refereed to as the eastern-most tropical rain forest in Africa. It covers an area of about 23,000 ha. About 16,000 households, for their various needs, rely on it. As the people extract products legally or otherwise, some of the products enter the market. Mainly, wood products, namely, timber, poles, posts, charcoal and firewood are marketed. Other non-timber products are also marketed but this paper will only review the case of wood based products. These products then undergo what is called marketing. This can simply be refereed to as the process that involves production and all the practices that the product undergoes, till it reaches the final buyer or consumer. The marketing process requires that there is information. This is what is called marketing information. Marketing information must posses certain characteristics if it is to be useful for decision making. That is, it must be accurate, current, sufficient, available and relevant. Any market that operates without proper information is therefore likely to be imperfect. For the case of Kakamega forest, there is a general inadequacy of information in all the characteristics.

The local extractors do not have the right information on which to base their decisions. Middlemen collect information from the markets or create it when there is need, "analyze" it and then use it for their own benefit. Pricing, which is very important in any production and marketing practice is the preserve of middlemen. They set the base price on which the local people then base their producer price. Issues concerning far off markets are beyond the reach of the extractors. They thus rely on middlemen to provide some information. In so doing they are exploited by the middlemen. Middlemen may set prices that are low and later on, sell at higher prices. They are also capable of buying on credit to the disadvantage of the extractor as they create a situation where the extractor is not sure of whether the middleman will pay or not. The government or forest department, on the other hand, by not collecting and providing information looses a lot of revenue. The local people are engaged in extraction for sale under the guise of home consumption. As the products leave the forest and get in to the homesteads, and eventually on to the market, the government looses revenue. This is because home consumption products are obtained free of charge. The government can not benefit from license fees that are applicable to commercial dealers nor from royalty fees. At a higher level, if the products get in to the formal market, the government or forest department loss value added tax. The losses can be worked out and given a monetary value. Preliminary studies show that the revenue looses may be much higher than the revenue that the forest department officially collects.

Crown Condition and Increment

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Due to well-known drawbacks, crown condition is only conditionally suited as indicator for the condition of forests. However, because of increasing doubts about its suitability, it became necessary to search for another indicator. Various increment parameters seem to be more useful, mainly owing to the higher objectivity of measured data. In 1992/93 it was for the first time possible to analyse increment data and timely corresponding crown condition data from the Forest Damage Monitoring System of Austria (Waldschaden-Beobachtungssystem, WBS). Increments were found to decrease considerably with increasing defoliation, notably in the case of needle losses of more than 25%. Especially the two parameters basal area increment and basal area increment related to crown diameter have clearly shown increment losses.

Growth of the Trees in the Mixed Stands of Black Pine (*Pinus nigra* Arn) and Beech (*Fagus moesiaca* M) Depending on the Type of the Mixture

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The practice of raising monocultures is being abandoned in modern forest management, in favor of mixed-species forest. This trend is of particular interest for management of forest of heliophyte species, such as *Pinus nigra.* Raising mixed stands composed of heliophyte and sciophyte species can increase productivity, stabilize the forest ecosystem and eventually these stands might evolve in permanent mixed forest stands of coniferous and deciduous species.

This is the fairly new trend and there is lack of long-term data and information, so many questions remain unresolved on the development structure of mixed forest stands. As a result of this, the management of mixed forest stands utilizes no long term concept or concepts valid for single-species stands (monocultures) are being used. This results in inprecise evaluation and assessment.

In order to reach the basic concept for the development model in such forest, apart from investigation of their structure and productivity at various ages, a very important can be achieved by stem analysis. This would generate retrospective data on the growth of single trees.

In the complex investigations in order to determine the dependence of productivity of participation in species, of mixed stands of black pine and beech we have established experimental plots in stands of three different ages with different participation of both species. The stands are at of 80,100 and 120 years. Our purpose is to observe the development of the stands in a long-term period. A medium basal area model tree of black pine and beech from the vicinity of each experimental plot were cut off and analyzed, which is the subject of this paper.

Biodiversity and Stability of a Mountain Beech Stand where Cleanings of Different Intensities were Performed

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The research focused on the influence of cleanings of various intensities on stand biodiversity and stability. The fieldwork was carried out in a 30-years old beech stand where extraction racks had opened in 1991. In 1992, an experimental block with three variants of cleanings (high, moderate, as well as non-intervention variant) was established. Two cleanings (a high intensity in 1992 and a moderate intensity intervention in 1996) were carried out in the high intensity intervention variant, while only a moderate intensity intervention was carried out in 1994 in the moderate intensity variant. The inventory of shrubs, seedlings and ground vegetation was carried out in 1998.

After cleanings, the stand composition has improved (the beech proportion increased with about 20 per cent, while hornbeam proportion decreased with about the same value)

The intensity of cleaning in the high intensity plot was 80% per number of trees (N), 48% per basal area (G) and 37% per volume (V). In the moderate intensity plot the cleaning intensity was 43% per N, 20% per G and 14% per V.

The light intensity within the stand represents 4% of that on open land in the high intensity plot, 2% in the moderate intensity plot and 1% in the non-intervention plot. The monochromatic light penetrates the stand canopy in uneven proportion, so that the proportion of red and infrared waves is higher than that of blue waves.

The slenderness index of trees is 125 in the high intensity plot, 148 in the moderate intensity plot and 158 in the non-intervention plot. These values show that trees are vulnerable to snow and wind damages, especially in the latter two variants.

The tree distribution on diameter classes in the non-intervention plot is an irregular (uneven) one. As the cleaning intensity increase, the distribution approaches a regular, even (Gauss-type) one.

The highest number of shrubs (0.6 samples/m^2) was recorded in the high intensity plot, followed by the moderate intensity plot (0.2 samples/m^2). In non-intervention plot 0.1 samples/m^2 were recorded.

Although the stand is young (30 years old), trees are already mature so that 0.4 seedlings/m^2 were recorded. The highest seedling (1-3 years old and 5-15 cm tall) density was found in the plots where cleanings were performed.

The density and amount of ground vegetation species, as well as the surface occupied by these species, were highest in the high intensity plot (24.4 samples/m^2), with 26 species spreading over 35% of the surface The lowest values were recorded in the non-intervention plot: 6.4 samples/m^2, respectively 9 species spreading on 15% of the analyzed surface.

Tree stability was not affected by cleanings. On the contrary, such detrimental effect was recorded in the non-intervention plot, where about 20% of the trees of 2-4 cm diameter were bent over, as well as in moderate intensity plot, where about 10% of the trees were bent over. In conclusion, the plant diversity and tree stability are higher in cleaning stands than in the non-cleaning ones.

4.01.00 Using growth models for better forest management in the tropics

A Process-based Model to Assess Forest Management Strategies in Tropical Rain Forests

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Until now, attempts to model and simulate tropical rain forest are very few. The approach we present here is highly focussed on available field data, their analysis and the state-of-the-art knowledge on rain forest tree growth. Our model FORMIND is an individual-oriented and process-based rain forest growth model with special emphasis on dry matter dynamics. To predict tree growth, we model photosynthesis and overcome the problem of estimating respiration - where normally data are not available - by integrating diameter increment data from field observations in the model. Together with precise tree geometry information (incl. relation between diameter, height, leaf area, crown extension, aboveground biomass) single tree growth can be determined very accurately. Modules for light competition on patches of 20m x 20m in size, mortality (incl. falling trees creating gaps) and establishment enable FORMIND to simulate forest stands up to a size of several tens of hectares. Tree species are aggregated based on a generalized approach to derive typically 5-10 plant functional types with respect to their light demand (shade tolerance) and their potential maximum height. Because of the general formulation of basic processes, sites in different world regions can be simulated. Including typical environmental factors like dry seasons of various lengths, rain forest stands in South-East Asia and South America were simulated with a satisfying precision.

As one of the most urgent model applications, the impacts of different management scenarios on tropical rain forest are discussed in detail. Due to a lack of field data it is still not clearly known how management of tropical forests influences tree mortality, forest regeneration potential and its time scale. We therefore simulate the huge variety of possible impacts of different logging strategies and compare simulation results with field observations to identify those impacts, which might be of major importance for forest growth. This analysis has a special focus on establishment processes and how their changes due to logging impacts are responsible for future forest development.

The results show that even with an optimistic constant seedling input logging intensity and the length of logging cycles have to be on levels which are not observed in practice at the moment. If highly likely impacts of logging on seedling input and survival rate are taken into consideration it becomes very clear how far common logging practices are away from sustainability.

The Influence of Age on Forest Site Productivity: A Case Study with Suppressed Black Spruce Trees

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Keywords: site index; productivity; stand age

In forestry work the age of a tree, as indicated by the number of annual growth rings at the base or at breast height, is generally the only age considered. Studies related to the phenomenon of tree suppression in juvenile age of black spruce trees (*Picea mariana*) have raised doubts as to whether the total age of a tree is the best indication of its true physiological or economical age on a given site. Tree suppression usually occurs when black spruce advance regeneration suffers from competing, taller trees. Tree growth is then severely limited, and these trees have distinct, slow growing annual rings. This slow accumulation of diameter growth during the juvenile years leads to a sigmoidal pattern of diameter increment over age. By considering this, our aim was to develop a method that removes the influence of the initial suppression years, and provides an estimate of the "economical" age of a tree.

To achieve this goal, we sampled three black spruce sites (6 plots per site) growing in north-east Québèc, Canada. On each site, all merchantable trees were tallied and tree height as well as tree diameter at 1 m were recorded. In addition, an increment core was taken at 1 m for patterns of diameter growth accumulation. Traditional site index determinations were calculated using the 4 biggest trees per hectare using total age at 1 m. With these data, a method was developed using a logistic nonlinear regression model of cumulative annual ring widths regressed against age in order to determine the "economical" age of a tree. This was done by extrapolating the linear portion of the logistic curve down until the tree diameter equals zero, assuming that the pattern of cumulative annual ring widths with age of non-suppressed trees is generally linear.

By using the "economical" age as a replacement for total age, site index estimates were shown to increase by as much as 1-2 m (site index based on age50 at 1 m). Since tree age is an important factor in determining site productivity of black spruce stands, the use of the "economical" age is recommended since it yields more realistic and less conservative site productivity indices. The use of the "economical" age as a replacement for total age had, however, slightly less impact on plot merchantable volume determinations since plot volume is not only dependent on age but also on other plot variables such as density and mean quadratic diameter.

Nutrient Cycling in Tropical Tree Species on Semi-arid Region.

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The processes of soil nutrient uptake by vegetation, litter nutrient return to the soil and nutrient release during litter decomposition maintain the nutrient flux between biotic and abiotic systems. The rate of nutrient cycling determines the sustenance of vegetation on the soil. The present study reports nutrient cycles (N,P,K, Ca and Mg) of *Acacia auriculiformis*, *Acacia holocericea*, *Casurina quisetifolia*, *Eucalyptus tereticornis* and *Leuceana leucocephala*, plantation on semi arid region. Leguminous species such as *A. auriculiformis*, *A. holocericea* and *L. leucocephala* had the higher concentration of nutrients than non legumes such as *Casurina equisetifolia*, and *Eucalyptus tereticornis*. The ranking of species with regard to nutrient storage was as *E. tereticornis*> *Leucena leucephala*> *Acacia auriculiformis* > *Acacia holocericea* > *Casurina equisetifolia*. The turnover time of nutrients in the vegetation of *A. auriculiformis*, *A. holocericea*, *C. equisetifolia*, *E. tereticornis* and *L. eucephala* were comparatively much lower. The loss of N, P, K, Ca and Mg during decomposition were significant during initial months. The turnover time (based on litter decomposition) of anions like N and P were longer than cations like K, Ca and Mg. The five species aligned with regard to efficiency on nutrient cycling of *E. tereticornis* > *A. holocericea* > *A. auriculiformis* > *L. leucocephala* > *C. equisetifolia*. The architecture, N economy and a higher utilization efficiency of nutrients allowed *E. tereticornis* to emerge as the best among the five species.

4.01.04 Using models for forest growth and stand dynamics to evaluate sustainability

Sinergetic Theory of the Forest Stands Growth, Structure and Stability.

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The theory allowing to describe and explain the process of formation of the size structure of various forest stands is elaborated on the basis of synergetic approach. The structure in question generally is formed under influence of two sharply different kind of the processes, first is the process of strictly deterministic trees size growth, second is the process of non-regular, due to a lot of external (ecological) and internal (genetic and physiological) factors, trees size differentiation. For the explanation of the mechanisms of forest stands structure formation both this processes must be taken into account and analyzed simultaneously. Such a possibility is offered namely by synergetic approach. The analysis of the growing and at the same time differentiating forest stand was done using the Fokker-Plank equation. As a result of analysis the forest stand size structure under stationary condition may be described by following equation:

$$n(x) = n0 \exp(-V(x)/B)$$

where x is individual size, n(x) is a share of trees with size x, n0 is a constant

$$d/dx(V(x)) = -A(x)$$

A(x) is an expression describing deterministic growth rate of forest stand, B is a parameter describing the intensity of random non-regular differentiation of trees within the stand. The type of forest stand structure is determined first of all by the type of trees size growth. Different size structures are studied by using growth functions most common in quantitative ecology, such as linear, Hompertz, J-shape, S-shape and several modifications of the logistic curve. This analysis is resulted in 7 types of forest stand size structures covering all principal cases known from literature. A correspondence between growth and statistical characteristic is established for some of the most common types of the size structures. The synergetic approach to forest stands growth and structure allows introduce and investigate the stability features of the forest stands equilibrium state. Stability attribute of the forest tree stand is understood as an ability for restoration after some disturbances, it is described by the time needed for returning to initial state. Special macroscopic characteristic functions of forest stands are introduced for holistic description of the size structure, such as entropy, free and average growth energy. Their mutual relation is established. This part of the analysis offers a new facility for evaluations of forest stands growth dynamics and sustainability. The developed theory was checked using the data on distribution of the trees over thickness classes for Scots pine and Norway spruce tree stands of different ages and forest types from Sankt-Petersburg Forest Technical Academy experimental and training forest enterprise.

Growth Trends in Pedunculate Oak Stands in Croatia

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In Croatia, the growing stock of Pedunculate oak (*Quercus robur*, L.), is the second largest with contribution of 14% and also takes first place in total market value of timber.

In researching ecological-managerial forest types in Croatia, for the past 40 years, the Forest Research Institute Jastrebarsko has established approximately 3000 sample plots in 500 dry (II-G-10) and humid (II-G-20) Pedunculate oak stands. The EMFT II-G-10 is represent with associations of Pedunculate oak and common hornbeam (*Carpino betuli - Quercetum roboris*), while the EMFT II-G-20 are associations of Pedunculate oak and great green weed (*Genisto elatae - Quercetum roboris*).

In compiling all parameters for evaluating the population structure of each sample plot, 1-3 mean stand trees were felled, dependent on the age of the plot and the number of trees. The data was recorded in the EGTRH database and in the CANASTA sub-database, and the stem analyses were carried out.

The ecological-managerial forest type is considered to be a specific area of the forest and a forest land that has similar ecological and managerial factors that normal forest management depending upon. The ecological - managerial forest type can be determined by its geological structure, phytocenosis, soil type, climate, sylviculture characteristics, production capabilities and stand value. For each ecological-managerial forest type and forest land, the most favorable stand form, rotation, felling maturity, normal production and its value are determined.

In examining the measured data and in calculating the width, height and volume increment of the analyzed trees stem, one can obtain an understanding of the growth trend of the Pedunculate oak trees as a representative of its stands.

After 20-30 years on these plots (however, fewer in number than previously), a number of trees were felled and analyzed. The obtained results were compared with the first measured results. This was done so as to compare them with the estimated growth trends therewith.

Quantic Hypothesis of Growth and Development

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The wood is the most complex natural macrosystem and its growing is the basic property of nature. The periods of growing and developing of wood, the oscillations of increasing by growing are not completely congruent with axiom in the biotechnical science. Axiom with one culmination of increasing by growing and two points of inflexion suggests unperiodical motions in nature. The cause of unperiodical motions is a strong force of the resistance that prevents the system to attain to balance position. The essence of the modern biotechnical science is its foundation on the quantum mechanical principles and without them is impossible to explain periodical phenonema in nature. Cognition of quantum mechanical laws, necessity of knowing behavior in microsystem is necessary for explaining macrosystem behavior. For quantum mechanical observing of the growth and development woods system is necessary to understand and to know the wood. It is needful to study its biological essence on its basic phenonema in order to understand its micro and macro system. The basic characteristic of material is wave property and this is a fact. The wave notion about material leads naturally to general procedure quantifying. Explaining the phenonema in the wood that couldn't be explained in classical manner the another sets quantic hypothesis using classic differential equation of the suppressed sinusoid oscillations law. Here using universal quantic relations and intuition, the author sets wave equation of growth and development woods:

Diameter growth – $D'' = Ae^{-kt} \sin(w_0 a t - j)$

with reference to

$$Height\ growth - H'' = Ae^{-kt} \sin(w_0 a t - j) + A_1 e^{-kt} \sin(w_1 a t - j_1)$$

In equations some symbols are:
D" – derivating of derivations of diameter growth; H" – derivating of derivations of height growth; A, A_1 – amplitudes of growth; e – natural logarithm; k – resistance coefficient; t – time; w_0, w - elasticity coefficient; a - fine structure constancy; j , j_0 - phase.

Elasticity coefficient respectively frequency of motion w in wave equations speaks to us about the speed periodical phenonema in nature and constant of fine structure, a is its multiple. Constant fine structure α introduces us in the world of quantic phenonema in nature. Supposition is that fragment wave description satisfies the separate relativity principles, that means the connection between wave vector and frequency wave, impulse and energy fragment must be the same in every inertial system. With quantic hypothesis meaning the hypoothesis about discretion physical magnitudes with the hypothesis that the wood cellules are oscillators making ansamble, the author demonstrates growth continuance and enters in trace to universal law of growing.

Let us suppose that macrosystem, as well, as microsystem have wave properties then for the wood may be set wave equations, and so by then may be foreseen phenonema being observed experimentally. Setting up of such wave equation and foreseeing of experimental results enable the basic tasks of the quantic theory field. The waves in hyphotesis are described by quanticmechanical fields and in certain point of view they are quanticmehanical generalising of the classic wave function. Quantic theory of field is actually a theory of many fragments making a unique method suitable for condition describing by voluntary number of fragments of determineal sort.

The wave equations of growth and development woods everywhere disappear identically, meaning that they are producing a complex vector space. Graphic resolving of the wave equations make a complex vector space of growth and development woods. Its vectors are determined complex functions of space and time. Increment and prognosis of developing diameter growth and height growth of the structure may be established by great punctuality using wave equations.

Dendrochronology of the trunk growth or its component barts may be detected and quantified by resolving wave equations of growth. By using wave equations of growth and development woods the construction of standard quality tablet is simple.

Quantic hyphotesis of growth and development woods reflects the deepest nature laws, by the way, they are great advancing to the right fundamental theory of growth.

Keywords: growth and development of woods, micro & macro system, quantic theory, complex vector space

Calibration of the Prognosis BC Regeneration and Small Tree Models

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Models for predicting natural regeneration and small tree dynamics are essential components of any growth simulator used in projecting partially-cut stands. PrognosisBC is an adaptation of the Northern Idaho (NI) version of the Forest Vegetation Simulator (FVS), to the Southern Interior of British Columbia. In this poster, we will summarize the sampling methodology, data collection, and calibration approaches used to calibrate the regeneration and the small tree height increment models in PrognosisBC, for the Interior Cedar Hemlock, warm, moist sub-zone (ICHmw2). The ICHmw2 is one of the most extensive and productive sub-zones in the southern interior of BC. Fifty-eight stands were selected. Eighty percent of the plots were in stands that were disturbed (partially cut) in the last 20 years, 10% in undisturbed stands and 10% in stands that were clear cut. An attempt was made to cover a wide range of elevation, aspect and slope, within the geographic range of the sub-zone. A total of 186 temporary sample plots were measured. Plot centers were systematically located in selected blocks. At each sampling point, a fixed-area main plot of 0.04 ha was established and two smaller nested sub-plots of 0.005 and 0.00135 ha, were used to collect small tree 5-year height increment and regeneration data, respectively. In addition, four satellite regeneration plots were established at the edge of the main plots in the four cardinal directions. The regeneration plot size was determined for consistency with the original design used to develop FVS, to reduce differential design errors. Initial summaries of the regeneration data confirmed the inadequacy of the regeneration model in FVS for the southern interior of BC. Similar problems were identified in other studies using regeneration survey data. Preliminary results from the 5-year height growth of trees < 7.5 cm dbh showed that the small tree height increment model in PrognosisBC, significantly overestimated growth. A significant trend over stand density was observed. Further analysis will be conducted to calibrate the model components that predict probability of stocking and the occurrence of advance and subsequent regeneration. A small tree 5-year height increment modifier will also be developed. Final results, conclusions and recommendations, will be available prior to the meeting.

The Development of Young Beech Stands and Environmental Effects

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Oriental beech (*Fagus orientalis* Lipsky.) forests consist of %8 Turkey' s forest area. Beech wood very important for forestry industry (furniture, parquet etc.). In this study, it was investigated the relationships between site quality and some marks of site (main rock, distance from edge, slope, exposure, lime content of main rock, elevation, distance from the sea) of even-aged oriental beech forests on West and Middle Black Sea region in Turkey. For this purpose, temporary plots were chosen different of site. Oriental beech forests located on very different main rock in research area. It was seen that best growth of these forests on andesite main rocks and also worst growth of this forests on quartz main rocks. Slope is estimated as an important works of site on growing of oriental beech forests. Exposure and main rock (magmatics, sedimentary and metamorphoced rocks) explain variation of site in %51 ratio (R2= 0.509).

The models were developed predict periodic (5-10 year) increments which are diameter at breast height, height, basal area, volume. Tree, stand and site factor information was recorded at 116 randomly located sample sites. Corresponding diameter growth for the past 5-10 years was measured from increment cores of the individual trees. Correlation between the latter and independent environmental variables was tested by regression analysis. Least squares regression techniques were used to obtain estimates of the required parameters. Information needed to predict volume and other volume elements increment of individual trees on a given site includes diameter of each tree, stand density (basal area per hectare), elevation, latitude and percent slope. Slightly better predictions can be made when site index information is available for a given species on a particular site.

Simulation of Increment and Growth in Even-aged Oriental Beech Stands

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A model was developed to simulate the increment and growth of even-aged *Fagus orientalis* Lipsky.(oriental beech), forests in this research. In this study, even-aged, oriental beech natural stands of normal canopy closure in Turkey were examined. For this purpose, a lot of measurements were carried out in 116 temporary sample plots selected from West and Middle Black Sea region.

In this research, increment and growth relations of beech for single tree and stand according to age and site conditions were investigated separately. Volume and other elements in single tree were related to age and site quality degree. Then, optimal stand density, which can maximize the stand volume and increment for every ages and site index was researched.

SARACOGLU's (1988), method which is different from known methods was used to determine the site index in temporary plots. Arithmetic mean height of stand which is affected smallest by technical treatment and arithmetic mean diameter of stand in plots were used as a measurement of stand productivity in determining of site index.

After the trying of different models according to least squares method, data of single tree and stand were balanced. Computations were realized by using of SPSS version 5.0.1, and some statistical programs written in QBASIC programming software.

Beech shade-tolerant characteristic, number of trees diameter classes distribution aren't figure normal distribution which is right skew shape. Stand of basal area and volume diameter classes distribution are alike diameter distribution. The alteration of the diameter, volume and basal area diameter classes distribution by site quality and age, present by the actual structures of even-aged oriental beech stand, related to the models constructed by basing on the distributions of Gamma, Beta, Weibull and Normal. A linear model has been constructed for each distribution, and the coefficients in the model have been computed with the help of regression analysis. Gamma model seems to be more suitable than the distribution models.

A model was developed to simulate the increment and growth of even-aged beech, forests in this research. Model was growth diameter distribution and stands during one period (10 years), to determine the volume increment, stand volume, basal area, mean height and basal area increment beginning and end of period. In this simulation model, stand density, which can maximize the volume increment with respect to stand age, and site quality degree was investigated. This model was tried for every ages and site index.

The relations found in the investigations of increment and growth of stands have been used to determine the optimum stand structures even-aged oriental beech, by means of the iteration method. The method was applied so as to maximize the stand volume annual increment, by the computer program named AYNI_KAYIN, which he developed in the QBASIC programming software. The program determines the optimum stand structures, according to the desired age and site quality degrees. The basal area of the optimum stand structures was limited between 20 to 80 m^2/ha. Diameter distribution was limited dmax (maximum diameter), according to the age and site quality degrees. The stand volume increment has been thought of as a function of the density degrees (SD) in the approximation.

By the inspection of the optimum stand structures, it has been recognized that the stand volume increment would increase as long as the density degree (SD) would increase. Volume increment indicated relationships site index, basal area and age. Stand volume increment young (50-70 age) maximum rise up, forward ages together happens decrease.

In this program (AYNI_KAYIN) for periodic mortality to take not predictor is not obtainable from any sampling scheme which results in a list of diameters. dmax is average value, really more than dmax is going to be and in the stands different diameter distributions is going to indicate.

The purpose of production forests for timber is to product the timber raw material in maximum quality and quantity can be generated by site in perpetuity. For this reason, optimal structure of forests must be known and stand structures must be transformed to optimal structure. Results of these tries, it was seen that volume and volume elements of beech forests had to be known to manage them. Yield knowledge on beech will allow the utility of these forests in full capacity. Also, after the research, knowledge, which is needed to compare optimal and actual growth, was ensured.

The Alteration of Stand Height Curve by Site Quality and Age in Even-aged Oriental Beech Stands

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When stand volume is calculated from measurement of diameter of all trees on an area and estimates of height based on a sample of those trees, a common procedure is to relate height to diameter and then to obtain volume per tree by entering a standard volume table with the measured tree diameter and the estimated height given by the height-diameter curve.

The stand height curve is steep for young crops on good sites and near flat and linear for old crops and those on poor site.

In this study, it has been aimed to investigate the natural relationships which the actual structures of even- aged oriental beech (*Fagus orientalis* Lipsky.) stands denote according to site quality and age in the West and Middle Black Sea region.

Temporary plots taken in the pure, even-aged, untouched normal stocked and naturally grown stands of beech. Temporary plots, were scattered according to age class, site quality in the research area to define different beech stands. After the normality control, 116 plots were accepted to research.

A number of stand height curves age- site quality-diameter equations were compared for oriental beech. Most gave similar results within the range of the data. Some appeared undesirable because of unreasonable curve shapes when extrapolated. For remeasured plots, use of a single age- site quality-diameter equation for each plot rather than individual height- diameter curves for each measurement will give more accurate and more consistent estimates of volume, periodic increment and site index. A number of suitable equation forms are suggested. Besides, the stand height curves have also been graphically showed according to site quality and stand age.

Growth and Yield in Sustainable Forest Management

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The mounting global pressure on tropical forest resources and the realization of the need to manage these resources sustainably has propelled accurate determination of growth and yield to the forefront of tropical forest management. This is not surprising as growth and yield is the lifeblood of sustainable forest management and accurate growth estimation is needed to determine the level of sustainable harvest in accordance with the forest management systems applied.

Since the 1970s, the Forestry Department Peninsular Malaysia has embarked on an integrated growth and yield program with the primary aim of studying and monitoring the growth and development of logged-over natural forests. To date a total of 12 study areas and 95 permanent sample plots have been established throughout the peninsula, resulting in the gathering and collection of valuable and informative data on these forest stands.

Stand Dynamics and their Simulation for *Pinus brutia* Ten Forests

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Forest stands are mainly simulated in two ways. One of them is based on the distribution of stand parameters i.e diameter, height and stocking. The second is based on the individual tree growth. In the second method individual tree growth in different conditions (such as site quality, neighborhood relations and age) is predicted by sampling. Stands can be simulated after individual tree growth relationships have been established. In this study the simulation was based on the individual tree growth. Firstly an initial stand was formed at the age of 15. Coordinates of trees in the stand were produced at random. Diameter at breast height (dbh) of trees were produced from the diameter distribution and applying parameters obtained from natural stands. Height of trees in the initial stand was estimated from the height equation.

After the initial stand was simulated, trees were grown up to the age of 120 using the individual tree growth functions. To explain the variation of individual tree growth a distance-dependent competition index (BEN) was developed and used as an independent variable in growth function with the other effective factors. This index can explain 52% of individual tree diameter increment variation. Individual tree growth was based on the dbh increment which was predicted as a function of age, BEN, site index (SI), and dbh. Heights (H) were estimated from the height function which contains dbh, age and SI as independent variables.

Uncertainty Analyses of a Process Model when Vague Parameters are Estimated with Different Methods

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For many process models there are often model parameters for which there is no real data or common knowledge on what these parameters should be. Often traditional statistical techniques can not be used to estimate these parameters. Presented here are some results of a study where the Maximum-Entropy Principle and the Bayesian method with weighted bootstrap sampling were used to estimate unobservable parameters of a pipe model calibrated for red pine (*Pinus resinosa* Ait.). An uncertainty analysis based on the estimated parameters was conducted. Three parameters of this model have been estimated to demonstrate the estimation methods and uncertainty analysis with different amounts of information. The mean values of the estimated posterior distributions based on the two methods applied in this study were very close to those of their corresponding prior distributions. The posteriors estimated by the Bayesian method had less variation than did their corresponding priors. The relationship between uncertainty in posterior distributions of parameters and uncertainty in projections made with the model was assessed.

Studies on Stand and Tree Growth Models in Natural Forest Region in China

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In order to update and predict forest resources on the level of forest bureau and forest farm in natural forest region in China, stand growth models are developed based on permanent plots of forest management inventory in 1997, taking Wangqing forest bureau in Jilin province in China as an example. The stand growth models can be used to update forest resources data in natural forest region. Natural individual tree models are also studied. The main conclusions are as follows:

(1) Combined with integrated stand model, subcompartment forest resource data updating models are developed, which can be used to update

subcompartment in forest bureau and forest farm in natural forest region without human disturbance. The updating factors of subcompartment include mean height growth, site class index, estimation of mean height, basal area per hectare, stand density index, mean diameter, number of stems per hectare, form-height, growth stocking volume, degree of closeness, and volume of open-grown trees.

(2) Given current of situation of a certain subcompartment, the stand measurement factor values of the subcompartment without human disturbance and its composing tree species at any time may be updated and predicted dynamically by the stand growth models. The tested results are good.

(3) By composing tree species of a stand, taking site class index stand density index, and prediction interval as independent variables for updating the data of natural growth subcompartment, the stand growth models are more suitable for updating the data in the natural mixed-species and uneven-aged subcompartment.

(4) With regard to prediction results and practical usage, individual tree models are not suitable for updating the data in permanent plots and in subcompartments. Subcompartment forest resource data should be updated by stand growth models.

Gmelina arborea and *Swietenia macrophylla*: Species-Site Compatibility Assessment Without Establishing Field Trials

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Sample plots were established in randomly selected 3-10 year old plantations of *Gmelina arborea* (yemane) and *Swietenia macrophylla* (mahogany) in different parts of the Philippines. To systematize sampling, the country was divided into 10 zones of equal width from the northernmost to the southernmost part of the country. The plantations sampled were selected at random from each zone. For *G. arborea* a total of 223 sites were sampled. For mahogany the total is 163.

From each sample site data on tree height and diameter, spacing, elevation, slope, aspect, soil properties of the A- and B-horizons, rainfall, temperature, wind speed, and relative humidity were obtained. Climatic data, averaged over a period of 10 years (1988-97) were obtained from the nearest weather stations of the Philippine Weather Bureau.

Data were analyzed using the methods of analysis of covariance, multiple regression analysis, multiple partial correlation analysis, and discriminant analysis. Tables and graphs were prepared as necessary to help in the interpretation of the results. Tree measurements and most of the environmental parameters were found to vary significantly from the northern to the southern part of the country. This jibes with the findings that site conditions that affect tree growth show significant variations from one zone to another. Adjustments for differences in tree age and spacing were made in all analyses involving tree height and diameter using multiple regression analysis. Site classification functions were derived for each species by discriminant analysis using data that have been adjusted to account for differences in age and spacing among sites. The functions, which used environmental parameters as predictors, were tested and found highly acceptable for classifying sites as good, average or poor for mahogany. With the aid of the classification functions it is possible to classify a site designated for planting as good, average or poor for *G. arborea* or *S. macrophylla*. For *G. arborea*, the variables found to have significant discriminating effects were zone number, elevation, temperature, depth and potassium content of the A-horizon, and pH of the B-horizon. For *S. macrophylla*, the variables with significant effects were zone number, wind speed, soil depth (A-horizon), relative humidity, temperature, and rainfall.

Needle nutrient ratios affects Scots pine seedling survival and height growth in Finnish Lapland

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Scots pine (*Pinus sylvestris* L.) has been widely used in the artificial reforestation of both the dryish native pine sites and more moist and fertile native Norway spruce (*Picea abies* L. Karst.) sites in Finnish Lapland since 1950s. The reason for choosing pine has been it’s better productivity compared to that of spruce or pubescent birch (*Betula pubescens* Roth.), and the promising results achieved in reforestation in the 1930s. However, severe *Gremmeniella abietina* [(Lagerb.) Morelet] and *Phacidium infestans* (P. Karst.) epidemics and dieback have occasionally occured in pine plantations during the last three decades especially on spruce sites. Unfavourable physical soil conditions, e.g., excess water and low temperatures, have been suggested to be one of the main causes of this dieback. Thus, intensive site preparation methods such as ploughing has been widely used to improve the growing conditions.

Our aim was to model the survival and height growth of Scots pine seedlings. We followed the performance of Scots pine during 16 growing seasons using a split-split-plot design in randomized blocks. Four of the eight clear-cut forest sites were dryish pine-dominated sites and four were moist, formely Norway spruce-dominated sites. The site preparation methods were prescribed burning, patch scarification, disk trenching, and ploughing. The reforestation methods were sowing and planting with containerized seedlings and bare-rooted transplants. A total of 72 000 reforestation spots were sown or planted in 1975-77 on the 288 plots using the reforestation density of 2500 spots ha^{-1}.

We used the mixed model technique to evaluate explanation models for survival percentages and mean height growth. In the model, the site preparation and regeneration method were fixed treatments, and the plot and regeneration year random effects. With the mixed modelling approach the dependent variables were explained by soil stoniness, topography, inclination, mineral soil nutrients, needle nutrient content, and the experimental design. The estimation method was based on maximum likelihood, in which the variance components adjust the parameter estimates of the fixed effects.

After 16 growing seasons, average survival was 41% and mean height 247 cm. The survival was the higher, the closer the site was to a typical native pine site. *P. infestans* and *G. abietina* were the most common causes of damage. Neither site preparation nor reforestation method showed significant effect on survival. However, both of them influenced significantly on mean height. The mineral soil nutrients showed no significant influence on survival or mean height. The needle nutrient ratios, e.g. N/(Ca+K+Mg+P), affected negatively and highly significantly on both survival and mean height. In addition, the interaction between topography and inclination showed a positive significant effect on survival. Our results indicate that unbalanced needle nutrient ratios are related to the survival of Scots pine seedlings. The results coincide with the earlier published laboratory studies which show that host nutrient imbalances affect, to *G. abietina* the resistance of Scots pine.

Investigation of the Sustainability of some Management Practices of the Rainforests of Ghana Using Individual Tree-Based Simulation Models

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The sustainability of tropical rainforest management is currently the subject of strong concern and interest. GHAFORGROM, a semi-stochastic simulation model is used to predict the growth and yield of the natural tropical high forests of Ghana, using individual trees as the basic unit of growth entities. GHAFORGROM has been used to evaluate the biological sustainability of some management practices currently being used for the rainforests of Ghana. Simulation studies employ felling cycle analysis and yield estimation to demonstrate the sustainability of logging. The studies indicate that for a specified logging rule, selection harvesting could sustain a viable timber harvest of about 0.2133 m^2 ha^{-1} yr^{-1} or 3.4 m^3 ha^{-1} yr^{-1} for a 40-year felling cycle for trees of dbh > 10.0 cm. For trees of dbh > 10.0 cm, 40-year felling cycle is the minimum number of years to ensure sustainability using a specified logging rule. It takes about 80 years for the basal area or volume of trees of dbh greater than specified felling diameter limits for timber classes 1 and 2 species to regain their initial value. Similarly, it takes about 110 years for the basal area or volume of trees of dbh greater than the specified felling diameter limits for timber class 1species to regain their initial value.

Lignum: Towards a (Forest) Scientist's Workbench Using Scientific Visualization.

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When three dimensional tree models become more and more popular one of the questions that rises naturally is how to present the results produced by the model to the scientist. Plotting some characteristics, e.g., the taper curve, on a data sheet is always an option but these often two dimensional ways of presenting data fall short with the three dimensional models like Lignum.

Lignum is a three-dimensional tree model and the natural way of presenting its simulation results to use scientific visualization. This is often the fastest way to understand, analyze and communicate the results. Currently a simple "scientist's workbench" has been developed using industrial standard OpenGL programming library to visualize the simulations of Lignum. Using this workbench scientists can take different views of a tree depending on his or her interests. It is possible to view the general appearance of the tree, examine its architecture or scrutinize the internal structure of it, to study, e.g., the formation of heartwood. Naturally the scientist can interact with the tree or a group of trees by taking different viewpoints in the program.

The scientific visualization of trees generated by Lignum can be taken a step further. Virtual reality (VR) represents computer technology where it is possible experience artificial computer generated environments. The environment is generated by a computer and is presented with an ordinary (stereo) computer display, with special devices like display helmets or in a special virtual room where the images are reflected on the walls, ceiling and the floor. The user can interact directly with the artificial environment with medium that transmits movements allowing feeling things, to touch things and to hear them very much like in the physical world. Regarding Lignum the idea of virtual rooms is worth pursuing with, e.g., CAVE like systems that are becoming popular. A tree generated by Lignum is shown in a CAVE system.

Another (research) problem in the scientific visualization of model trees is how to present large complicated data sets effectively. One approach to solve this problem is to use level of detail (LOD) techniques where alternate representations of an object or a scene with varying levels of complexity can be specified. For example several graphical models with different accuracy can be specified to visualize the foliage. Depending how far or close the scientist is from the tree the appropriate model can be chosen to give realistic image of the foliage. Some examples of LOD techniques in the conjunction with Lignum are shown.

Management of Deciduous Forest in Central Cambodia - A Case Study in Sandan District

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It is believed that one of the key points to ensure the sustainable management of the forests is to understand their population dynamics. The aim of this paper is to provide useful information on the population dynamics of Cambodia's deciduous forest, as a basis for management decision making. Cambodia was one of the most heavily forested countries in the world, but a large proportion of forest has been destroyed as a result of wars and political instability over the past 30 years. Forest management in Cambodia has been difficult because until recently, there has been very little scientific research to provide the required information. The management purpose for deciduous forest is to harvest fuelwood and poles for local use. It is managed on a 12-15 years selective felling cycle. By 1997, deciduous forests covered about 4 million ha or 38% of the total forest area in Cambodia. Under the national forest inventory project, Sandan district, in central Cambodia, was chosen to conduct a forest inventory. With a population of 40,000 people, Sandan has a total land area of 280,000 ha, 92% of which is fully forested. Deciduous forest covers 24,900 ha or 8% of the total forest area. Approximately 131 inventory clusters were laid out on the map, but, due to security problems, only 63 clusters were successfully established in the field. Of this figure, 4 clusters were established in deciduous forest, containing 36 plots or 4.32 ha of forest. Statistical analysis showed that the average density was 596 trees/ha, of which trees with a diameter of 5-9 cm comprised 53%; trees 10-29 cm, 33%; and greater than 30 cm accounted for 14%. In terms of species, 11% of total trees were from the family *Lyrthraceae*; followed by 7% of *Myrtaceae*; 4% of *Dipterocarpaceae*; and 36% of unknown and minor families. The average volume per hectare was 107 m^3, of which the volume trees within DBH greater than 30 cm was 102 m^3. On a felling cycle of 15 years, the mean annual allowable harvest volume is 7 m^3 /ha. There is a need to firmly protect the forests from repeated encroachments by outsiders so that the young trees can naturally regenerate and reach the harvesting size over a period of 12-15 years felling cycle. A further vegetation research is also needed since the proportion of unknown trees is still remained high. All these trees will produce additional wood for the present and future needs. In addition, political will and the cooperation of all parties involved are required to ensure long-term sustainable management of the forests.

Acknowledged Seed Stand (Bald Cypress) *Taxodium distichum* Rich. in Croatia

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In 1933 a culture of Bald Cypress (*Taxodium distichum* Rich.) was raised in the Mirna river valley (in region III and zone Ja in the seed unit "Da") by the planting of plants with seeds from an unknown provenance. In 1960, after phenotypical assessment and determination of site class, they were entered into the Register of acknowledged seed stands in the Republic of Croatia. During the first 30 years the culture of Bald Cypress was not managed, which had a significantly negative consequences on growth and increment of this stand. The first thinning was carried out in 1959, when 61 trees were felled (i=12.87% of the number of trees). The second thinning was performed in 1961, when 63 trees were felled (i=14.32% of the number of trees). The thinning effectively influenced increment in the stand. Since that time no thinning has been carried out. At the age of 30 years the culture had 1100 trees/ha, a basal area of 44.30 m^2/ha, growing stock 265.50 m^3/ha, annual increment of growing stock 29.65 m^3/ha, which at the age of 65 years the culture had 593 trees/ha, basal area of 96.85 m^2/ha, growing stock of 1458.12 m^3/ha, and annual increment of growing stock 35.77 m^3/ha. Mean basal area tree in the 65th year had diameter breast height of 45.31 cm, height 29.6 m, stem length 11.3 m, crown length 18.3 m, crown width 6.95 m, crown volume 231.29 m^3, crown shape (crown width/crown length) 0.3798, crown development (crown length/height) 0.6182 and site index (crown width/diameter) 15.3388. The presence of 6.33% negative trees was determined in the stand. Although, during its growth this stand was mainly left unattended, i.e. no management was undertaken (neither were silvicultural works carried out, tending, clearing and thinning), the measured parameters undoubtedly indicate the significance of the Bald Cypress as a fast growing, allochthonous species. Its site in zone III J suggests that it could, and should, be utilised in this zone and in zone II G, in sites with stagnant or limited running water, such as swampy areas in the vicinity of our large rivers and their estuaries (particularly with regard to the Neretva river and the marshlands of the Drava, Danube and Sava rivers) which are suitable for the recultivation with the above fast growing species, whose wood is valued because of its extremely good quality and versatility.

A Study on *Buxus* Growth in Hyrcanian Forests (Iran)

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Box tree (*Buxus hyrcana*, Pojark) grows in southern part of the Caspian sea from -20 to 1200 meters altitude. It is scattered in small and large area extending from Astara to east of Kordkoey (45 to 54 Longitude). The objective of this study is to indicated the Box tree growth and performance in different forest conditions. The tree height, dbh and under story vegetation were measured in separate plot at each study area. The obtained results were indicated that apart from geographical differences the edaphic factors affected Box tree growth. Soil texture analysis indicated that the loam soil texture is the most desirable for Box tree. However Box tree highly shade-tolerant but more light enhances to its natural regeneration. The vegetation study indicated two types of plant communities in three study areas.

Birch as an Admixture in a Young Pine Stand

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Keywords: pine, birch, sapling, mixed stand, competition

In the Nordic countries, the principal management objective for Scots pine (*Pinus sylvestris* L.) stands is to produce high quality timber. The key quality factor is branchiness, which is mainly controlled by site fertility and stand density. The current stocking levels used in Finland, about 2000 seedlings ha^{-1} at planting, seem far too low for a satisfactory quality development in young pine stands. Stocking levels from 4,000 to 8,000 stems ha^{-1} would be required to ensure optimum quality. This can be achieved in direct seeding. However, the problem is greatest on fertile sites where direct seeding is not a feasible alternative to planting because of intensive weed competition. Increased planting density is not considered an economically feasible solution to the problem either.

The number of pine or spruce (*Picea abies* K.) seedlings emerging from natural seed sources is generally quite small on these fertile sites. Additionally, they can not keep up with planted pine seedlings in height growth. The most promising solution available at the moment seems to be the utilisation of naturally regenerated birch seedlings (*Betula verrucosa* Ehrh., *Betula pubescens* Ehrh.) as an admixture in young pine stands. The admixture of birch should be retained until the pines exceed 7 - 8 meters in dominant height in order to enhance the wood quality of pines. However, pine and birch show substantial differences in their height growth rhythms, causing problems for the regulation of stand dynamics and the competition pattern between the species. Planted pines and naturally emerged birches often differ in age, which further complicates the possibilities to use birch as an admixture.

The aim of this study was (A) to compare the height development of planted pines and naturally emerged birches within stands, (B) to describe the competition between pine and birch using the distance dependent competition model approach (C) to evaluate the possibilities to enhance the external quality of pines with a birch admixture in practical forestry. The average number of naturally emerged birches and its variation in young stands planted for pine were studied in a field survey data in Southern Finland. A data set from temporary sample plots with mapped trees was used to study the height development and external quality of birch and pine saplings. Individual tree height and diameter increment and branchiness were predicted using distance and size dependent models. A set of permanent plots with varying competition situations has been established in order to monitor the dynamic competition patterns of the species.

Site Factors Effecting on Growth of Oak Coppices in Turkey

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Turkish forest area occupies about 26,6% (20,7 million ha) of entire land area. Of which 48% is productive. Productive high forests cover about 39.4% of total forest area and 10.5% of total land area. Estimated total annual wood increment in Turkish forests is about 34 million m^3. Annual total wood production including private is about 28 million m^3, of which 63% is consumed as fire wood.

Coniferous species make up about 54% and broad-leaved species 46% of designated forest area. Among coniferous pine, fir, spruce and cedar and among hardwoods oak, beech, chestnut, hornbeam and alder constitute the major tree species. Among broad-leaves species oak with 34 subspecies has 6 million ha forest area. Therefore Turkey is known as an oak paradise. In terms of biological diversity, Turkey is one of the richest countries in the world too.

This research was carried out in Bartin region at north-west of Turkey in order to determine the site factors effecting on growth of oak species. 31 sample plots were laid out in this region. One year old and six years old heights were measured on three dominant shoots in each sample plot. Physiographic characteristics of sample plots were determined. Soil samples were taken from digger soil profiles. By soil analysis in laboratory, data related to soil properties will be obtained for sand, clay, dust, N, Ca, K, Mg, Na, CEC.

Simple and multiple regression analysis were used to evaluate the data. In regression analysis, the six years old shoot heights were used as dependent variables and the effects of different site factors on it. The main results of this research are as follows: For the upper layer (0-10cm) and lower layer (30-40cm) of soil sand, dust and clay factors are more effective on growth of shoots than others.

An Inquiry For Estimation Of Stand Density At Biological Optimum

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Stand density is a significant variable in determining the productivity of forest crops. Biologists, particularly foresters find estimation of optimum density of crop an evasive issue. Nevertheless the relationship of a rectangular hyperbola between density and crop-diameter has been used to search for the existence of any natural law which determines biological optimum density. Finally an indication of the existence of such a biological law has been discovered and reported herein. The law suggests that the aphotosynthetic living surface, in other words the cambial area of a stand reaches the biological maximum, which equals the land area occupied by the crop. The under-bark bole surface area is a good proxy to the cambial area. Area of bole surface is easily measurable in the field.

Cyclic and Morphological Aspects of Relationships between Growth and Cone Production in Stone Pines of Eurasia

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The dynamics of the reproductive activity (cone production) and radial growth (tree-ring width) were studied in 3 species of stone pines (*Pinus sibirica*, *P. cembra* and *P. koraiensis*) in several localities of West Siberia, Khabarovsk Region, Northeast China, and Altai and Carpathian Mountains. To investigate radial growth dynamics, we use the standard procedures (Stokes and Smiley, 1996). To examine the entire cone production dynamics, we use the original methods of identification of the seed cone scars and traces on the bark and cross-sections of annual shoots of cone-bearing branches (Vorobjev et al., 1994). Methodic difficulties for the identification of the scars and traces in *P. koraiensis* were determined by its too long summer shoot and scaling the bark of shoots over 20-25 years old. The following reproductive time series were built for up to 100 years before the present: the number of initiated seed cones per one shoot, the number of 1-year (pollinated) seed cones per one shoot, and the number of 2-year (normally mature) seed cones (cone crop) per one shoot. We also built growth time series (ring width). Both the reproductive and growth series were converted into index ones and averaged to obtain local chronologies (Graybill, 1983). The number of xylem and cambial cells were calculated and their sizes were measured on tree female shoots which produced and did not produce the 1-year and 2-year cones. The structure of cyclicity of the radial growth and reproductive activity in 3 stone pines in-cludes 2.8-3.6, 3.3-3.7, 4.2-4.7, 4-5, 5.1-5.6, 6.5-7.2, 7.5-8.4, 10-11.5, 12-14, 16-18, 20-25, 26-29, 32-34, and 58-68-year cycles. Each pine has itself cycles of the cycle set. The uncoincidences of the curves are explained by regional and local conditions (first of all, climate). The fundamental differences between growth and reproductive processes are found in little cycles (up to 5-10 years). Smoothing the curves of radial growth and reproductive activity indicates on negative correlation between them. The aborted initiated, unpollinated and immature cones disturb the cyclicity of cone crop in all pines. In *P. koraiensis* the heavy crops, great cones, thin latewood in summer shoot are causes that the tops of the cone-bearing branches are broke off. New branches instead of broken ones do not produce cones for 2-4 years. This process also disturbs the crop cyclicity. The cyclicity of reproductive activity of the first-order branches determines that of a tree. Annual fluctuations of the number of the initiated cones have less amplitude than those of the number of mature ones. In the growing female shoot axis the size of cambial zone decreases by 15-20% during flowering before and increases by 20-28% during flowering after development of the 1-year cones. Xylem dimension increases by 45-50% for the same period of time. Influence of the 2-year cones at the status of cambial zone is the same as 1-year ones. The differences are only in varying degrees of size changes. The size of xylem decreases by about 15-20% in time of linear growth of the shoots and development of the 2-year cones when the 1-year cones are absent. The xylem size increases by 30-40% at the same time when the 1-year cones are present. Thus the size of the xylem and a degree of growth changes depend on reproductive load. The size of the cambial cells increases also. So development of the 1-year cones is favoured to rise the cambial cell division activity and xylem cell differentiation. The number of the xylem cells and the size of the cambial cell reduce during growing season under conditions of 2-year cone nutrition. These changes and differences above allow to propose that the decrease of the cambial cell differentiation activity is a cause of the xylem growth diminution.

Height Growth Pattern of Dominant White Spruce in Relation to Natural Regions in Alberta

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Based on provincial stem analysis data of 1018 felled dominant and codominant trees, the height growth pattern of white spruce (*Picea glauca*) were compared among the five major natural regions (1-Central Mixedwood, 2 - Dry mixedwood, 3 - Wetland Mixedwood, 10 - Upper Foothills, and 11 - Lower Foothills) in Alberta. The comparison used the ratio of height at 70 and 30 years of breast height age (Z ratio) as a quantitative measure of height growth pattern (i.e., the response variable), site index (height at breast height age of 50 years) as the covariate, and natural region as the factor. The result indicated that (1) the height growth pattern in Wetland Mixedwood was significantly different from other natural regions and (2) no significant differences in height growth pattern were found among other four natural regions. Two reference-age invariant polymorphic height and site index curves were developed for the Wetland Mixedwood region and the rest four natural regions, respectively. Comparisons between the two curves indicated that, for the same site index, trees in the Wetland Mixedwood region grow slower (when site index 15 m) or faster when site index <10 m) after site index age depending on site quality. It was recommended that these natural region-based curves should be used for predicting white spruce site index or height at any age in Alberta.

4.01.04 Modeling regeneration and the development of young forests

Effects of Global Change on Forest Disturbance and Regeneration: A Gap Model Study in the Netherlands.

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Numerous different patch or gap models have been used to estimate the effect of global warming on forest ecosystem functioning (e.g. Shugart & Smith 1996). In gap models (Jabowa-Forêt type) forest processes (like establishment, growth, and mortality) are simulated on a relatively small patch ("gap"). In general the gap size is determined by the area which is occupied by a mature tree. Key processes in most models are growth, recruitment and mortality of individual trees.

Modeling of growth in most gap models is well advanced. In the new generation gap models, growth is described by physiological processes at tree level, as opposed to a more descriptive approach of plant growth in the old generation gap models. However, recruitment and mortality are not that easily described and thus modelled. Seed dispersal patterns and early seedling growth and survival are greatly affected by stochastic processes and therefore hard to predict. Tree mortality is poorly understood and stochastic events like storms, insect outbreaks etc. play an important role. As seedling establishment is a fundamental step in forest regeneration and succession, the processes in gap models simulating tree mortality, canopy gap formation, and seedling recruitment will have to be improved.

In this study functional relations in recruitment, (seedling) growth, and mortality are further refined to improve an existing gap model. This improved gap model will be used to investigate whether and how different climate change scenarios affect patterns of tree mortality (gap formation) and recruitment (establishment & seedling survival to 2m tall) for three forest-types in the Netherlands. Consequences for long term forest development will be discussed.

4.01.08 Environmental effects on forest growth and stand dynamics

Evaluating Growth and Stand Dynamics under Climate Change and New Management Strategies. Model Studies with the Forest Succession Model 4C

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We use a new forest gap model 4C (*Fores*t *E*cosystems in a Changing *E*nvironment) to evaluate growth responses and stand dynamics under climate change conditions. The current generation of forest gap models can be classified into two broad categories: On the one hand, there are fairly simple models that largely ignore ecosystem functions like biogeochemical cycles and concentrate on structural effects. On the other hand, there are quite complex, "mechanistic" models that attempt to link structural and functional aspects of forests within a single framework, but those models can deal with few tree species only or are restricted to short-term investigations. We propose a new approach to simulating long-term forest development that is based on ecological and evolutionary theory about the functioning of plant communities. The resulting model is considerably more "mechanistic" than classic models, but less complex and thus computationally less demanding than the existing "mechanistic" models.

4C does not only describe the succession dynamics in natural forests but has been complemented by modules which allow for simulation of management practices and initialization of stands from inventory data. Currently the model is parameterized for temperate forests in Europe.

Results from simulation experiments under scenarios of climatic change and future CO_2 levels will be presented. The development of current forest vegetation on regional scales will be investigated. In many European countries new forest management strategies are discussed. Specific objectives are species composition more close to natural forest vegetation, minimization of risks due to climate change, cheaper regeneration practices, and enhancement of recreational and ecological services of forests. Forest management strategies based on different weights assigned to yield, risk minimization and non economic services will be studied. The discussion focusses on the impact of climate change on multi-functional forestry in Central Europe. Possible response strategies are elaborated.

European Forest Ecosystems: Building the Future on the Legacy of the Past.

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The viability of the many civilisations of Europe has depended, to a very large extent, on an adequate supply of wood. In the Ancient World, this supply was secured through the exploitation of forest reserves, the conquest of new territories and, when these opportunities no longer presented themselves, through the conservation of diminishing resources. Ultimately, civilisations collapsed because of the shortage of wood. Although some silvicultural techniques were known in the pre-Christian era, the scientific management of forests was not widely practised until the late eighteenth century. It is argued that the controlled exploitation of "nature", on sustained yield principles, only became possible when men came to view the forest, not as a nuisance, an Arcadia or a pagan horror, but as a centre of wood production, a biological factory.

The emergence of scientific forestry, however, did not put an end to the exploitation of forest resources. Unregulated felling and traditional practices such as litter raking exerted an insidious, negative influence on the fertility of the soil. The impact of human exploitation has often been underestimated by scientists, in recent decades, in particular, in the context of forest decline.

While sustainable management, seen as sustained yield of wood supply, has been practised in forestry for centuries modern ideas of sustainability are broader in scope, embracing all the goods and services of the forest. Increasingly, forests are being managed as multifunctional ecosystems, often for amenity purposes.

Forest ecosystem research, which developed from a range of traditional, highly focused disciplines, requires, if it is to make a meaningful contribution to forest management, long-term interdisciplinary studies. It provides the basis for ecologically intelligent management decisions and as such, is central to the development of sustainable forestry management. Central to the successful implementation of research findings is their efficient transfer from the researcher to the manager. If the research community identifies such an interchange as an important part of their duties, it will be a decisive step towards the better use of forests in Europe.

It is only by deepening our knowledge of the past, accepting the challenge of the present and acknowledging that, as researchers, we have also a responsibility to communicate with users, that we can foster the growth in wisdom which is fundamental to the wise use of Europe's forests in the next millennium.

International Ecological Collaboration in Russian Far East

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Current scale and the acuity of the ecological problems determine the necessity of their solution by joint efforts not only of individual scientists but institutions, countries and international community en masse. The banding of endeavors and resources provides the opportunity to soften, solve and forecast ecological problems with a greater effectiveness. Russian Far East, due to its huge nature resource potential, degree and possibilities to influence the climate change and other ecological problems of global-regional interconnection increasingly attracts the attention of international scientific community first of all as the source of getting information in the extreme conditions, test range to drill the methods, experiment ground, monitoring and check and exploitation of the advanced equipment. Today, on the territory of the region there are not less than 50 international ecological programs with sufficiently large financing are fulfilled. The analysis of main research directions shows a mammoth scale of works implemented by the international scientific community inside Russia. Practically, the projects are formed and actively developed on ecosystems disturbances generated by natural and anthropogenic causes; trace gasses fluxes; aerosol emissions and their transportation; carbon modeling: hydrology; permafrost; the history of climate and land cover disturbances; remote registration of the events and their modeling, etc. However, the leading field of collaboration is the forest complex. The Far east has 3% of world's forests. These forests represent a mammoth potential for carbon sequestration plus a possibility to maintain terrestrial ecosystems stability of the neighboring countries of the Pacific region. In spite of the fact, that in overwhelming number of research directions Russian science has a significant backlog, it is presented in many international programs insufficiently, not fully presented in international turnover the available Russian scientific data already published in the domestic literature. The program and projects diversification gives the foundation to talk about the necessity of rapid work coordination development, their management improvement, compatibility of results elevation using a wide range of discussions and publications. Russian party coordinative efforts are bringing recently some results: such important research directions as 90 and 135 meridians are admitted worth to arrange works and International Steering Committee of International Geosphere Biosphere Program is discussed for these purposes with a wide representation of Russian specialists. And regional interested institutions could be used as infrastructure bases for international projects realization with the assistance of local scientists. The prospects of further international ecological collaboration development are increasingly depending not only on the goodwill of the representatives of the scientific community, but also on the ability of many cooperative parties to work jointly and solve arising problems.

Carbon Sequestration in Forest Ecosystems: Presentation of a General Evaluation Tool and Generic Case Studies Using the Model CO2FIX

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Carbon sequestration rates in forest ecosystems can be derived from biomass growth rates, combined with understanding of soil organic matter dynamics, and an analysis of the amount of carbon in woody products removed during timber harvest. In this paper, an overview of the main aspects influencing forest ecosystem carbon balances will be given, and a general model (CO2FIX) will be presented together with model results for a range of case studies in forest ecosystems world-wide. This model is being developed as part of an EU-funded INCO-DC project, in which an Internet-based user platform applies the model to selected case studies, especially in the tropics and sub-tropics (EU-CASFOR). The model, which is available on the project's Internet site, can be used to estimate the carbon sequestration potential of aforestation and reforestation projects, and can be used to quantify the effect of different types of forest management and forest use for the overall carbon budget. The model includes submodels for forest growth, forest management, utilisation of harvested products, and soil organic matter dynamics. It will be shown how the model complies with IPCC guidelines, and what the consequences are of the various definitions of aforestation, deforestation and reforestation as indicated in the Kyoto-protocol. Also, consequences of various types of forest management such as selective, low-impact logging and other sustainable forest management systems in tropical forests will be quantified with respect to their consequences for the overall carbon budgets will be outlined in a case study of Mexico and Costa Rica.

Interim Protocol for Sampling and Measuring Changes in Soil Organic Matter and Physical Properties Following Harvesting of Native Forests

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Forest roading, harvesting and regeneration operations can have a substantial impact on forest soils, including soil compaction, soil profile disturbance, soil erosion and changes in nutritional capacity. Soil compaction and soil profile disturbance change bulk density, porosity, soil strength, infiltration and saturated hydraulic conductivity. These effects in turn, can have a substantial impact on forest growth and floristic composition and in forest hydrology. For example, it may take more 25 years for soils to recover from compaction. Formal monitoring and evaluation of forest soil changes is expected in the near future as a basis for sustainability accreditation under Montreal process, ISO and/or consumer driven initiatives. Monitoring by planners, supervisors and contractors provides a basis for the continuous improvement in forest operations that will be required to attain sustainability accreditation. The purpose of this study was to provide forest practitioners with a simple system for monitoring and improvement of their on-ground roading, harvesting and regeneration operations. Sampling methods and systems for stratifying soil disturbance were critically reviewed and a draft protocol for assessing change in soil properties, particularly

Montreal process soil indicators was developed. Calculation and statistical methods are provided to make quantitative statements of the accuracy of the estimates of various soil disturbance classes and Montreal process soil indicators 4.1d and 4.1e. The protocol was tested on 30 harvesting coupes in southeastern Australia. The interpretation and evaluation of the indicators will differ for different soil and forest types. As an example, a method for evaluating soil indicators is presented for Victorian mountain ash (*Eucalyptus regnans*) forest.

Modeling Environmental Effects on Forest Growth

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Growth of the trees regulated by several internal (age; genetic bases; health conditions; etc.) and external (temperature; soil conditions; hydrological conditions; light, water and nutrients available; etc.) factors regularly as well as by disturbances (competitions, wild fire, grazing, frost, windstorm, epidemic events, environmental pollutants, etc.) sometimes. These factors and/or events are usually changing by space and time. Process models and empirical models were developed to describe growth of individual trees. Although these models are also very complex, modeling of growth relations for forest stand with distance dependent/independent single tree or stand models are much more sophisticated. Structures of process models would be appropriate to model environmental effects on growth of trees and stands. Unfortunately, stand models based on process modeling have not satisfactorily developed for practical use till now. Not only the models but also methodologies of modeling are essentially important for further developments.

The most important goals of the estimation would determine the structure of the model. Estimation of growth relations of a tree species for a certain site requires quite different empirical models than estimation of growth relations for the whole distribution area of the same species. Large area always contents more independent variables, which are changing by time, also. The site (characterised by similar soil, hydrological and climate conditions) is usually an adequate unit for structuring the model. Only a module system of sub-models is an appropriate tool for modeling growth of trees and/or stands under various conditions and different environmental effects. The model must content all the important factors as independent variables while the dependent variable is the biomass production of the single trees. Relations among independent variables practically are multiplication. Linear approaches are usually not applicable, because asymptotic limitations of the growth appear. That way asymptotic, "n" dimensional mathematical equations as "n" dimensional growing surface can describe the growth of the single trees under changing environmental conditions and effects. The structure of this growing surface in general:

$$B = A\ f1\ (x)\ f2\ (y)\ f3\ (z)\ \text{etc.}$$

where B is biomass production of single trees as dependent variable; A is an asymptotic value for growth of the species on the site; f1, f2, f3, etc. are non linear equations; x, y, z, etc. are independent variables.

Independent variables and equations are sub-models, and can be changed by different needs in the general model. Calibrations of the parameters require adequate databases.

4.01.00 / 4.02.00 / 1.07.00 Using growth models for better forest management in the tropics

Rapid Methods for Estimating the Age and Growth Rate of Rattan Stems in Lao PDR

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Measuring rattan growth rates is valuable because it allows one to estimate the potential sustainable yield from natural populations. However, estimating growth rates from permanent sample plots is labour intensive, takes several years to produce robust results and is always vulnerable to theft of the study plants or discontinuities in funding or personnel. It is not feasible to establish enough permanent plots to cover the wide range of species and habitat types for which data are required. This study examines two potential methods of aging stems directly to allow calculation of growth rates in the space of weeks rather than years. One involves analysis of the frequency and spacing of flowering events, which are believed to be annual and strongly seasonal in the strongly bi-seasonal Lao climate. The average spacing of such events probably indicates the average annual growth of reproductively mature stems. The second involves analysis of the variation in internode characteristics (especially length and diameter) in relation to the season in which they are produced. Some cyclical variation can be detected in these characteristics at the level of small populations - these cycles may relate to annual cycles of growth, and thus indicate annual growth rates. Data collection for this study is underway at several sites in Lao to calibrate these rapid methods against traditional long-term permanent plot methods. The dates of appearance of internodes and inflorescences will be recorded to confirm whether or not cycles really are annual.

La structure diamétrique de *Celtis zenkeri*: un indicateur du type de forêt dans laquelle l'espèce est rencontrée. Conséquence pour l'aménagement

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Cette étude est effectuée à partir des données de l'inventaire d'aménagement du projet Aménagement Pilote Intégré (API) de Dimako dans l'Est du Cameroun. Cet inventaire est de type systématique à 1% et couvre une superficie de 500 000 ha.

On décrit la structure diamétrique de *Celtis zenkeri* dans la zone inventoriée. Des variations importantes sont observées, la structure diamétrique de cette espèce pouvant passer progressivement d'une courbe en « J » inversé à une courbe en cloche en fonction de l'endroit où elle est observée.

Ces variations sont analysées en relation avec les types de forêts dans lesquelles *Celtis zenkeri* est rencontrée, son tempérament et l'histoire ancienne (passé paléoclimatique) et récente (action anthropique) de ces forêts.

Les conséquences de cette variabilité sont analysées dans l'optique de l'aménagement durable des massifs forestiers du sud-est du Cameroun.

Growth Rates and Dynamics of a Tropical Primary and Secondary Forest in the Amazonian Region, Brazil

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The variations of the species composition, horizontal structure and dynamics (recruitment, growth and mortality) of an unlogged (primary) forest and of one that had been clear felled (secondary forest) were studied over a period of 11 years, through continuous inventory. The area is located at the "Felipe" hill, and belongs to Jari Celulose S.A., in the State of Amapa.

A total of 169 species were found in the first inventory of the unlogged forest (1985) and 184 in the second one. Over the period of recording, the primary forest showed a 3% increase in absolute abundance and no significant variation regarding the species with the greatest abundances and frequencies. The forest showed a diameter distribution with J-reversed shape, for the whole forest as well as for the commercial groups of species. Between 1985 and 1996, the basal area of the forest almost did not vary, going from 35,61 to 35,54 m^2/ha. The volume revealed a 1,6% decrease between 1985 and 1996. The commercial and potentially commercial groups of species showed greater values of basal area and volume, when compared to the non-commercial ones. On the other hand, the non-commercial groups of species presented quite a greater value of abundance.

The secondary forest had 176 species in 1985 and 174 in 1995. During the observation period, the abundance of the forest increased in 217%. Over the period, the pioneer species of the *Cecropia* genus, dominated the area in abundance, frequency and dominance. At the end, a decrease in the number of plants of these species in the classes of seedlings and saplings was observed. As in the unlogged forest, the secondary one showed and J-reversed shaped diameter distribution, although with a less steep fall in the number of plants per DBH class. The forest presented a great variation in basal area and volume, the figures being, respectively, 760% and 710%. On the contrary of the primary forest, the non-commercial group of species dominated in basal area, volume and abundance in the secondary stands.

The periodic annual increment (PAI) of diameter, in the unlogged forest, was 0,14 cm/year and for the commercialization groups I, II, and III, the PAIs were 9,20; 0,14; and 0,12 cm/year, respectively. The greatest growth rates (PAI) were observed in the greater diameter classes. The growth rates in basal area and volume for the 1985-1996 period, considering all the species of the primary forest, were 0,086 m^2/ha/year and -0,39 m^3/ha/year, respectively. The secondary forest showed a diameter PAI of 0,60 cm/year, and for the commercialization groups I, II, and III the PAIs were 0,46; 0,44; and 0,63 cm/year, respectively. The growth rates in basal area and volume for the 1985-1996 period, considering all the species of the secondary forest, were 2,33 m^2/ha/year and 3,53 m^3/ha/year, respectively.

Considering the whole observation period (1985-1996), the primary forest presented a positive balance, the number of dead trees being approximately 16 ha/year and the number of recruited ones being 13 ha/year. The group of commercial species was the only one that showed negative balance (0,29%), but the groups of potentially and non-commercial ones revealed positive balance of 0,41 and 0,33%, respectively. Analyzing the entire period, the secondary forest showed a positive balance, with a mortality of 111 trees/ha/year and a recruitment of 264 trees/ha/year.

Selected Indigenous Tree Species and Design of Simulation Models for the Multi-Storied Forest Management Project in Peninsular Malaysia Naoto

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Keywords: Growth model; yield table; *Acacia mangium; Dipterocarpus*

Since 1992, a joint-project implemented by the Governments of Japan and Malaysia has been carried out in the State of Perak, Peninsular Malaysia. One of the objectives of this project was to examine the artificial conversion of a man-made forest and a selectively felled logged-over secondary forest to a multi-storied forest, considering the effect of industrial planting activities and environmental factors in the country.

As target forest types, hill forest, lowland secondary forest and lowland forest of *Acacia mangium* and rubber plantation were selected. For species selection, twenty-three species were recommended by the project based on the analysis of survival rate, diameter and height growth. For each forest type, following indigenous tree species were selected by multiple growth comparison;

1) Hill forest: *S. leprosula, S. macroptera, D. baudii, S. parvifolia*
2) Lowland secondary forest: *S. talura, S. ovalis, S. leprosula, S. glauca*
3) Lowland forest of *Acacia mangium* and rubber plantation, *S. leprosula, S. parvifolia, S. ovalis*

For planting direction, there were few differences in EW and SN on survival rate, height and diameter growth. About planting types, some significant differences were observed. The narrow planting type (A-type) was better than the wider ones (D-type, E-type) in survival rate. But the diameter growth was better in wider ones. By thinking of planting risks at initial stage and yield operation of crop trees, the C-type (4 rows of upper layer by 4 rows of under layer), D-type (8x8), or the medium type (6x8) were suitable and preferable.

Using simulation models for selected forest types and species, case studies were carried out under some managerial strategies and economic viewpoints of IRR (Internal Rate of Return). As a conclusion, if a high return of investment is only required, a short rotation period of mangium is recommended. However, the disadvantages of monoculture were evident in many cases in practice. By computer simulation, it was demonstrated that the reduction of the initial establishment costs and logging costs would be equivalent to twice the log price.

Growth Dynamic of *Anadenanthera colubrina* VAR. *cebil* and *Tabebuia impetiginosa*. From a Natural Forest of Pantanal Mato-Grossense, Brazil

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The information on the influence of environmental factors upon growth rate of trees is very important for the development of forestry management programs. The use of growth ring information is being enhanced and this is of great importance for tropical natural forests, where there is a great demand of wood, but usually no registered data are available to structure a management program. The Pantanal of Nhecolandia, sub-region of Pantanal Mato-grossense may be viewed as one of this regions, as its natural forests are being systematically used to extract wood, or deforested to introduce cultivated pastures, but the dynamic of the tree species are still unknown. Climatic and soil factors characteristics of Nhecolandia induce the formation of annual growth rings. The aim of this work was to determine the radial increments of *Anadenanthera colubrina* var. *cebil* and *Tabebuia impetiginosa* by growth ring analysis. The samples of disks of the stem of the trees were collected, in July 1996, in Nhumirim Farm, EMBRAPA Pantanal, located in Nhecolandia sub-region, Pantanal. Disks from eight trees of *Anadenanthera colubrina* var. *cebil* and six of *Tabebuia impetiginosa* were collected at 0.3, 1.3; 2.5; 5.0; and 7.5 m height. The trees were selected, by good canopy formation. The growth rings were counted and measured on eight radii of each disk. The trees of *Anadenanthera colubrina* var. *cebil* were 14-30 years old, with diameter increment at 1.3m height varying from 5.4-8.0mm/year and, *Tabebuia impetiginosa*, 15-30 years old, with diameter increment at 1.3m height varying from 4,8 a 11,6mm. The average time for *Anadenanthera colubrina* var. *cebil* and *Tabebuia impetiginosa* to reach 40cm of diameter was estimated in, at least, 55 years.

The Growth Performance of 15-Years Old Teak By Stump Planting

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Forest plantations are important in ensuring continuous supply of timber products. In view of this, several high quality timber species such as teak (*Tectona grandis*) are already being tried and planted in a large scale in Malaysia. Such plantation grown timber teak, with promising growth rates can be harvested within a short rotation of 15-20 years. One of the satisfactory planting method is using stumps because of promising growth rates, high survival and other suited economic factors required by the species. Hence, this paper discusses the growth performance of 15 years old teak planted using different stump sizes at Mata Ayer Forest Reserve, Perlis, Malaysia.

Net Primary Productivity of Tropical Tree Species on Semiarid Region

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The basic problem in forestry in India is the widening gap between supply and demand of wood on account of over population and lower productivity of the planting stock. Hence the goals of forestry involves taking short and long range practical steps which would be pro-nature, pro-poor, pro-women and pro-job generation decision. One type of forestry that emanates from such goals is restoration forestry. This brings about amelioration of degraded forest areas and enhance the productive capacity. The present study reports the net primary productivity of tropical tree species such as *Acacia auriculiformis*, *A. holocericea* , *Casurina equisetifolia*, *Eucalyptus tereticornis*, and *Leuceana leucocephola*, on semi arid region. The total biomass of *A. auriculiformis*, *A. holocericea*, *C. equisetifolia*, *E. tereticornis* and *L. leucocephola* were 16812, 19055,3711, 35460 and 21363. kg per ha. respectively. The ratio of aboveground biomass to belowground biomass was 4.3, 6.8 , .8, 4.5. and 2.6 for *A. auriculiformis*, *A. holocericea*, *C. equisetifolia*, *E. tereticornis* and *L. leucocephala* plantations respectively. The mean annual net productivity (MANP) of *A. auriculiformis*, *A. holocericea* , *C. equisetifolia*, *E. tereticornis* and *L. leucocephala* were 2.4, 3.2, 0.5, 5.1, and 3.1 t/ha/yr. respectively. Biomass accumulation ratio for *A. auriculiformis*, *A. holocericea* , *C. equisetifolia*, *E. tereticornis* and *L. leucocephala* were 2.98, 2.22, 0.88, 3.29, and 3.55, respectively. The total annual litterfall was 2.7, 4.5, 3.1, 5.1, and 2.6,t ha/yr. for *A. auriculiformis*, *A. holocericea* , *C. equisetifolia*, *E. tereticornis*, and *L. leucocephala* respectively. Turnover of litter in *A. auriculiformis*, *A. holocericea*, *C. equisetifolia*, *E.tereticornis* and *L. leucocephala* were 0.7 2, 0.43, 0.73, 0.73 and 0.82 respectively. The turnover time for five species were 1.38, 2.33, 1.40, 1.32 and 1.22 years. The superiority of *E.tereticornis* over others species in total biomass and MANP might be due to its capacity to resist drought, to thrice in low nutrient soils and to grow fast.

4.02.00 Forest resources inventory and monitoring

Shrubs an Alternate Source of Energy / Biomass for Himalayas - An Inventory

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Keywords: Energy; Sustainable development; Denudation; Genetic Resources, Floristic

Energy and environment are on the top most priorities for the sustainable development. As far as the rural scenario of Indian sub-continent is concerned, the two are immediately inter-linked, because of environmental degradation which is to a large extent the result of utilization of biomass for domestic energy consumption. In-fact over 50% of the fuel is consumed in India for cooking. Wood is the principal source of fuel accounting for 68.5% of the country requirement. The demand of wood for fuel and as a raw material in industry has been responsible for the large-scale deforestation that a country has witnessed.

The various factors contributing towards large-scale denudation of hills in the Himalayas are the over exploitation of fuel, fodder, and packing material from forest. Average per capita consumption of fuel wood in Himachal Himalayas is 0.6% per year, amounting to a total of 2.3 M tons per annum as against the prescribed yield of 0.7 M tons from the forests covered by working plan.

The Himalayas are endowed with rich diversity of genetic resources from subtropical to alpine vegetation comprising of mixed broad-leaved forests to coniferous stands and alpine scrubs to seasonal herbaceous flora. The floristic of the region embodies wide repository of economic plants irrespective of their habitat, weather herbs shrubs and trees, the harvesting of timber had been a major source of revenue from forests but the shrubs played an important role in rural economy by providing fodder, fuel, fiber and small timber, medicinal and aromatic sources, etc. Unfortunately, irrespective of their multiple uses, which are available with ease from the forest floor to hill people, these have not drawn the attention of foresters and scientists. This nature's reservoir, capable of self regenerating by coppicing have never been studied as systematic component of any ecosystem both from the ecological and economic stand point of view.

An attempt has been made to develop an inventory of the shrubby flora of Himalayas. In all 128 species have been described with respect to the habit, habitat and ecological niche and the indigenous uses, its potential for integration in the land use etc. Using the herbarium and the local interaction with the people did updating of this d-base. The shrubs due to their hardiness to frost and draught, resistant to pest and diseases are more adaptable to their habitat. There is a huge number of shrubs in sub-Himalayan tract which are not only helpful as soil binder but can provide a plentiful of fuel wood and fodder to the local people hence ameliorate the economic status. These shrubs are also valued for their medicinal properties, therefore it is a prerequisite to make these shrubs an integral part of the program of eco-development and management of watersheds. However the basic priorities in the planting of the shrubs should remain a step towards restoring green cover and subsequently to create favorable conditions for the growth of trees by improving the site. The useful shrubs also have an impact on agro-ecosystem, as these shrubs strengthen the field bunds, check runoff rate, maintains soil fertility, conserve soil, thereby augment economy.

4.02.01 Forestry products collection and sustainable forest management

An Overview of the National Forest Resources Study of Nigeria

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A study for the assessment of timber resources in Nigeria was commissioned by the Federal Government of Nigeria in 1996 through the Federal Department of Forestry. The overall objective of the study was to provide reliable data on the state of the resources with a view to enhancing industrial forest development and facilitating management of the remaining forest resources in an efficient and environmentally sound way. The study covered three major forest types, namely mangrove forest, freshwater swamp forest and lowland rainforest. The study area consists of 635 forest reserves, covering a total area of 4.8 million ha. The ratio of forest reserves area to total land area is 7.65%. For the field inventory, systematic cluster sampling technique was used for the high forests while stratified random sampling technique was used for the plantations. A sampling intensity of approximately 0.01% was used for both high forest and plantation areas. In the lowland rain forest area, timber-size trees (dbh>=60cm) account for 12.6%, 14.3% and 5.7% of the stem densities in undisturbed, disturbed and highly disturbed areas, respectively. In terms of volume production, these trees account for 62.8%, 61.2% and 41.9% of the volume per ha in the respective areas. Other forest types (freshwater swamp forest and mangrove forest) account for less volume per unit area. The gross volume within forest reserves is higher than that of the adjoining areas. The volume estimates of all tree species (minimum dbh = 20cm) are 140.6 million m^3 and 120.7 million m^3, respectively. Within forest reserves, existing forest plantations cover an area of 184,611 ha, representing only 3.8% of the total area of forest reserves. The three most prominent plantation species in the study area are *Gmelina arborea*, *Tectona grandis* and *Eucalyptus* species, occupying 59.3%, 25.1% and 2.8% of the total plantation area, respectively. In terms of gross volume production, the total yield of *Gmelina arborea* in the study area is about 57million m^3, representing 72.8% of the total volume production from plantations within the study area. When compared with previous studies and projections, results of this study indicate that the forest estate in Nigeria has suffered serious degradation in recent years. The major factors responsible for this trend were enumerated in the study.

Standardization of Propagation Technology of *Viola* Species Containing AIDS Curing Agent

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Keywords: Standardization, Propagation, *Viola* species, GA3, Flowering.

The use of forest plants as sources of medicines and human sustenance has been in vogue since antiquity. Plant based drugs have created a sweeping resurgence in the west in their favor and the demand for these has reached a scale never witnessed before. The excessive exploitation from the nature has resulted in shrinkage of these plant species while a few others are facing threat of extension and *Viola* species is one of them. The population of *Viola* species is threatened due to the indiscriminate plucking and uprooting of the plant material from natural habitat. The export quantity of this herb has declined considerably (from 2,800 to 710 quintals) during the past few years. Therefore, organized cultivation i.e., selection, propagation of the best strain of *Viola* sp. and scientific collection of its products is the need of the hour, which will help, in its sustainable production and conservation.

Viola species, a glabrous herb with deep violet, sweet scented flower and stout stolons, slender root stock which is likely to be threatened, is found in Himalayas upto an altitude of 1500m to 1800m. Flowers of this herb have been reported to be rich in active ingredients violin (0.003%), rutin (> 5%), rutoside (0.4%), total flavonoids (1.1%), tannin, anthocyanins (4.0%), mucilage (18.0%) and ash (8.5%). Rutin is an important pharmaceutical product. Recently, some preparations incorporating rutin have claimed improvement in-patients testing positive for HIV and showing the symptoms of AIDS and AIDS related syndromes. According to recent reports, *Viola* is also useful in curing eye inflammation and oesophagus cancer. Keeping these facts in view, the present study was undertaken.

The germplasm of *Viola* species was collected from different localities of Himachal Himalayas and selection of the best strain was done on the basis of their potential for the emergence of new plant-lets, which were than further used for cultivation studies *in vivo* and *in vitro*. The effect of various doses of FYM (30 t/ha, 60 t/ha & 120 t/ha) and planting densities (30x15 cm^2, 30x30 cm^2 and 30x45 cm^2) alone, was studied in field conditions. In order to enhance the flowering under the nursery, poly-house and mist conditions a growth hormone GA3 was also tested.

GA3 (1000 ppm) was found to be the most effective concentration for breaking the seed dormancy, when previously chilled seeds (40C) for one month, were treated with various concentrations of GA3 and kept in BOD at 300C in medium light intensity. On fresh weight basis of the flowers yield per 1000 plant, the spray of 100ppm of GA3 was found to be the most effective in poly-house condition i.e., 725g as compared to 410g in untreated population. Whereas, in the nursery condition the yield was 610g and 376g respectively. In field condition, FYM dose of 120 t/ha and planting density of 30x15 cm^2 gave the maximum flower yield of 154.2 kg/ha and 26.95 kg/ha on the fresh weight and dry weight basis respectively. In *in vitro* propagation, the best multiple shooting (80%) was observed when root cuttings were kept on Murashige & Skoog medium containing 6-benzylaminopurine (BAP) (2mg/l). This has helped in standardizing the protocol for mass multiplication of the strain for the future.

Rubber Forest Plantation For Wood Production

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Pilot Rubber (*Hevea spp*.) Forest Plantation Project was started in 1990 with the objectives to study and evaluate the planting of *Hevea spp*. for timber as the major product. To date about 1,667 ha of rubber forest plantation have been established by the Forestry Department of Peninsular Malaysia with technical assistance from the Malaysian Rubber Board in five states namely Negeri Sembilan, Selangor, Pahang, Terengganu and Kelantan. The clones identified suitable for hevea wood-latex plantation are from the RRIM 900 series, RRIM 2000 series and PB 200 and PB 300 series. They were selected on the basis of high log volume (clear bole height) and good characteristics such as vigour, good clear bole height, and wind tolerance and disease resistance. This paper will give some preliminary results on the initial growth performance of some potential rubber clones and highlighted experiences gained in the implementation of the project.

Wood Alternative Source in Sustained Forest Management Problem and Prospect

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Indonesian wood industries are now facing log shortage of approximately 25 million m^3 annually. The deficit is predicted to be more serious in the following years, hence, giving more pressure on natural tropical forests as well as forcing many people to search other woody source beyond the forest concession. The only realistic and instant measure to enlarge the use of woody wastes extracted is to intensify and enlarge the use of woody wasters extracted from replanting activities of the nature plantations.

This study investigated the current and future national plantation potential in wood production and problems associated with utilization of such materials. The most promising woody source plantations available in the country are rubber, coconut and palms oil, which respectively covered 3.6, 3.7 and 2.7 million ha. These plantations produce coconut and palm oil wood every year, which collectively exceeded the volume required to work out the national timber deficit. The figures may further increase in accord with the enlargement of the corresponding plantations, ensuring long-term sustainable supply. The most important factors limiting the use of plantation woody materials is inadequate infrastructure, technical processing expertise and plantation ownership.

A Study of Quality and Yield of Timber from *Pinus sylvestris* Harvested at Altitudes from 500 to 930 Meters Above Sea Level in Central Southern Norway

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12 pine trees from each of 8 different stands at altitudes from 500 to 930 meter (very close to upper growth limit of the species in the area) above sea level in a large area in Central Southern Norway were harvested in 1997. The stems were cut to saw log lengths and graded according to current practice by official log graders. Four quality classes as defined in the Norwegian log grading system were used - three of which are saw log grades and the fourth is a pulpwood grade. All logs of all four grades and of dimensions fit for sawing were then sawn into 25mm boards. Technical properties like density, annual ring increments, spiral grain, MOE, bending strength, heartwood percentage etc. were measured and described in relation to relevant stand factors like altitude and age. The timber was measured and graded according to the grading rules laid down in the Nordic Timber grading rules. The suitability of the boards as raw material for components for furniture and joinery products was also studied.

The log grading system used does not give a concise prediction of timber quality obtainable. Timber quality obtainable increased with log diameter. The timber quality graded according to the Nordic timber rules decreased with increasing altitudes. Density, MOE and bending strength decreased with increasing altitudes. The study of heartwood formation showed an increasing number of annual rings of sapwood with increasing tree age.

The correlations between growth factors (altitude etc.), log grades and product qualities are to be used as a basis for a possible revision of the log grading rules for pine logs.

Les perspectives de l'offre et de la demande de bois rond industriel en Tunisie - l'horizon 2015

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Afin de comparer l'offre et la demande de bois industriel à long terme, des modèles d'évolution de la récolte de bois bruts et des besoins en produits dérivés de bois sont élaborés pour la période 1995-2015. Les modèles d'offre tiennent compte du stock de bois, des accroissements et du taux de prélevement pour les differentes classes d'âge. Ces données figurent dans les résultats de l'Inventaire Forestier et Pastoral Tunisien (PAFT) récemment crée. Toutefois, la réalisation d'une seule série d'inventaire, le manque de précision proposée de l'âge des peuplements et l'absence de tables de production pour les différentes espèces forestières nous a amené à effectuer certaines hypothèses. Pour estimer la demande future de bois, des modèles d'évolution des besoins sont élaborés pour les produits dérivés tels que les sciages, les contreplaqués, les panneaux de particules, le papier journal, le papier d'impression et d'écriture et les papiers et cartons d'emballage. Il s'agit d'équations de régression de type linéaire ou logarithmique entre la consommation apparente par habitant de ces produits d'une part, et leurs prix, les prix des produits de substitution, le niveau de vie d'autre part. Les modèles obtenus révèlent une forte élasticité de la consommation des produits dérivés de bois au niveau de vie de la population. La comparaison entre l'offre et la demande montre une aggravation du déficit en bois d'oeuvre et en bois d'industrie au cours de la période 1995-2015. Ainsi, il convient d'améliorer le mode d'exploitation de bois et d'identifier les aménagements réalisables afin d'adapter l'offre aux besoins de bois industriel. Par ailleurs, l'engagement de la Tunisie dans la libéralisation du commerce extérieur nécessite la production de bois bruts, de sciages et de panneaux compétitifs pour confronter la concurrence internationale.

Quel rôle jouent les aspects scientiques et techniques dans la gestion durable des forêts tropicales?

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En termes scientifiques et techniques, la durabilité des actions forestières se heurte à plusieurs difficultés qui trouvent leur origine dans le comportement des acteurs: la dimension éthique dont dépend la définition de la durabilité, l'approche analytique réductrice propre au champ technique; et la prise en compte simultanément de différentes échelles de temps et d'éspace. Ceci entraîne concrètement de très grandes difficultés méthodologiques et métrologiques en particulier pour l'évaluation des pratiques sylvicoles. Il ne s'agit plus d'évaluer seulement, les effets mais aussi les conséquences qu'elles sont susceptibles d'entraîner à long terme sur d'autres objets ou systèmes (agronomiques, climatiques, hydriques...).

La gestion viable des forêts tropicales doit répondre aujourd'hui à plusieurs défis: garantir le fonctionnement des grands cycles écologiques, produire des ressources, fournir des emplois, et surtout participer au développement tant local que national ou régional. D'importants efforts techniques ont été réalisés au cours des dernières années. Pourtant, presque partout, la mise au point des plans d'aménagement n'a pas été suivie de mise en application. Les connaissances techniques disponibles sont importantes, même si elles sont encore à consolider. En effet, le bilan en matière de sylviculture est plutôt positif et de nombreuses études et projets ont permis de fournir la base nécessaire pour une sylviculture efficace dans les forêts naturelles tropicales. Il apparaît ainsi que trois impératifs techniques doivent être respectés: s'assurer que le taux de prélèvement de bois d'oeuvre coïncide avec le potentiel de production; faire en sorte que les modalités de prélèvement soient planifiées correctement et à temps; stimuler la croissance des essences de valeur tout en assurant la régénération naturelle et le maintien de la biodiversité.

Le concept d'aménagement forestier en Afrique et en Amérique tropicales est, certes, plus récent qu'en Asie mais aucun plan d'aménagement n'a encore atteint le stade de mise en oeuvre intégrale. En fait, ce n'est que récemment qu'a été ressentie la nécessité de gérer correctement la ressource par la forte pression exercée sur la forêt non seulement par le ranching ou par l'agriculture, mais aussi par la prise de conscience internationale.

Le dénominateur commun de la plupart des programmes d'aménagement interrompus dans ces régions, est qu'ils échouent rarement par infaisabilité technique! A titre d'exemple, l'expérience issue d'Asie montre que l'aménagement des forêts tropicales pour une production ligneuse durable, est techniquement possible, bien que les systèmes malais et indonésiens aient été plus ou moins respectés faute de réelle application et de contrôle. L'interruption des programmes initiés en Amérique latine est due à des problèmes socio-économiques ou politiques (maîtrise du foncier, commercialisation des produit ligneux...). En Afrique, ce seraient plutôt les déficiences dont souffrent les administrations forestières et les organismes en jeu qui font que la mise en application soit difficile.

La dégradation des ressources issues de l'écosystème forestier est directement liée à leur utilisation abusive ou excessive qui s'explique par une série de facteurs (ou écueils) souvent concomitants de nature: politique, économique, institutionnelle, réglementaire, démographique, conceptuelle et finalement technique; et ceci, du fait de l'ignorance de la nature précise des ressources et des modalités adaptées de récolte de celles-ci, aussi de l'inconstance et de l'impéritie pour leur maintien et leur reconstitution. L'ensemble peut être regroupé suivant deux facteurs: d'une part le facteur temps qui, faute d'être pris en compte, est à l'origine de nombreux échecs et d'autre part le facteur diversité des écosystèmes forestiers dont la complexité est source d'enjeux disparates et antagonistes, et alourdit les difficultés d'étude, d'approche et d'exécution.

Construction of Biomass Tables of *Quercus* in Zonguldak Forest Region Administration

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The general area of Turkey is 77 056 192 ha. The forest area that forms 26.6% of the soil in country is not completely productive forests and forested area that is high productive, covers approximately 39,4% of total forested areas. The rest of forested areas are low stocked or else composed of completely unproductive, spoiled marquis and bushes.

It is well known that there has been a shortage of forest wood production in Turkey. In the case of not finding efficient solutions, present state will continue increasingly. Oak plantations can create reliable resources to reduce this shortage. Oak forests have 380 118 ha areas as high quality forests and 4 220 875 ha areas as coppice forests and total 4 600 993 ha forest areas that forms 22,78% of Turkey's forest area.

The object of this study is to estimate the biomass per a single tree and ha for *Quercus spp*. (*Quercus robur* L., *Quercus hartwissiana* Stev., *Quercus petrea* Mattascka Lieb.) Fresh and dry weight tables are constructed by means of the material collected from 32 sample trees chosen in 32 trial areas in the Zonguldak Forest Region Administration.

The size of the established sample plots was 0,04ha (20 m x 20m) in stands of various maturity stages and density classes. In those fields all trees were measured for their height, dbh and average crown diameter. A tree with an average basal area has been selected as the sample tree in each trial plot. Again for each 32 sample tree, followings were measured: dbh, height, crown (height, diameter, volume), number of branches. Then all branches of trees were cut to be used in other measurements.

The main stems were cut from bottom to top for selections with 2,05m thickness. Sample disks with 5 cm thickness were taken from the middle of all stem section. Green mass of the branches: live and dead, were taken and recorded. Sample of stem disks, samples of live branches, samples of twigs and leaves were collected.

Following equations are used to estimate fresh and oven-dry weights of single tree components and perha . The equations of fresh weights of tree components are:

Stem Log FW= -0,692+2,369 Log (d1.3)$_I$ r= 0,96 s=0,09
Branch Log FW=0,622+0,059 Log (d1.3)$_I$ r=0,89 s=0,17
Leaves Log FW=0,269+0,034 Log (d1.3)$_I$ r=0,90 s=0,09
Crown Log FW=0,755+0,055 Log (d1.3)$_I$ r=0,90 s=0,16
Whole tree Log FW=-0,552+2,362 Log (d1.3)$_I$ r=0,97 s=0,07

The equations of fresh weights of tree components perha s are:

Stem Log FW = 30935 + 0,993 Log (d1.3)i r=0,56 s=0,19
Branch FW= 13469,8+3269,55 (d1.3)i r=0,67 s=20542,5
Leaves FW=28962,41-16202,8 Log (d1.3)i r=0,38 s=5087,5
Crown FW=-11130,9+3481,2 (d1.3)i r=0,66 s=22920,2
Whole tree LogFW=30959+1,071Log (d1.3)i r=0,63 s=0,17

The equations of dry weights of tree components are:

Stem DW= -207,805+19,033(d1.3)i r=0,95 s=36,9
Branch DW=-71,415+5,555(d1.3)i r=0,86 s=19,16
Leaves DW=-20,948+1,823(d1.3)i r=0,86 s=6,29
Crown DW=-94,388+7,532(d1.3)i r=0,88 s=23,09
Whole tree DW=-302,193+26,566(d1.3)i r=0,95 s=48,99

The equations of dry weights of tree components perha are:

Stem LogDW= 3,622+1,068 log(d1.3)i r=0,58 s=0,20
Branch DW=-12844,1+1795,9(d1.3)i r=0,71 s=10207,56
Leaves DW=1014,801+434,565(d1.3)i r=0,50 s=4319,37
Crown DW=-12990,7+2314,1(d1.3)i r=0,7 s=13601,87
Whole tree LogDW= 3,706+1,096Log(d1.3)i r=0,64 s=0,17

FW= fresh weight of tree components (kg), DW= oven-dry weight of tree components (kg), r= Coefficient of correlation (significant 0,01 level), s= Standard error

Production de gomme arabique par *Acacia senegal* dans les différentes situations pedoclimatiques de la zone soudanienne du Cameroun

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Acacia senegal est une espèce ligneuse très répandue dans les zones pastorales d'Afrique sahélienne. Sa diffusion en zone soudanienne agricole en tant que jachère productrice de gomme arabique et restauratrice d'un certain potentiel de fertilité du milieu dépendra de ses possibilités d'adaptation et de production de gomme.

La présente étude a été menée en zones soudanienne et soudano-sahélienne du Cameroun entre les isohyètes 650 mm et 1250mm. Les plantations ont été réalisées de 1985 à 1989 et les essais de saignée de 1993 à 1998. L'étude concerne la croissance de l'espèce, le type saignée pratiquée, le choix de la date de saignée et l'influence des facteurs climatique et édaphique sur la production de gomme. Une comparaison entre différentes provenances étrangères et locale est également présentée.

L'espèce se montre bien adaptée aux différentes situations pédoclimatiques de la zone étudiée. On observe une meilleure production lorsque la saignée est réalisée en début de saison sèche au moment du changement de climat caractérisé par une chute de l'hygrométrie et une hausse de l'évaporation. De plus, le stade phénologique correspondant à un degré de défoliation de 50% semble être le moment opportun pour réaliser la saignée. Selon l'isohyète (650 mm à 1250 mm), la date optimale de saignée s'étale du 15 octobre à la mi-décembre.

Entre 600mm et 900mm de pluviosité annuelle, les productions moyennes de gomme (100-500g par arbre saigné) sont en général supérieures à celles que l'on rencontre en zone sahélienne du Sénégal entre 250mm et 400mm de pluie (45-350g par arbre saigné). En revanche, au dessus de l'isohyète 900mm la production de gomme apparaît plus aléatoire.

Dans toutes les situations, lorsque des perforations dans le bois ont été causées par des insectes xylophages de la famille des Bostrichidés, la production a été de plus de 500 g par arbre attaqué.

A l'échelle pluriannuelle, on ne perçoit pas de différence entre les types de sol, néanmoins la production annuelle se montre relativement constante sur sol argileux et beaucoup plus variable sur sol ferrugineux en rapport avec les conditions climatiques de l'année. Du point de vue climatique, une saison des pluies qui se termine assez tôt et un début de saison sèche chaud semblent favoriser la production de gomme. La provenance locale se montre en général plus productive que toutes les provenances introduites d'origine sahélienne (Sénégal, Soudan).

Les caractéristiques des échantillons de gomme de la provenance locale (nodules issus de saignée et amas issus de piqûres d'insectes) sont tout à fait classiques et représentatives des exsudats d'*Acacia senegal* de la ceinture sahélienne.

Pour finir, la viabilité économique des plantations est discutée.

Determinación de Zonas de Protección y de Reforestación en Colombia

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La apremiante urgencia de implementar programas de recuperación de la cobertura boscosa de la zona montañosa de Colombia, ha creado la necesidad de establecer pautas y ayudas técnicas que apoyen de manera ágil y confiable la selección de áreas estratégicas para la conservación y la reforestación.

Para este propósito se inicia con la recopilación de la información general de la zona a estudiar, la cual una vez analizada inicialmente permite generar los vacíos de información; a partir de lo cuál se diseña un sistema de adquisición de la información faltante ó deficitaria, la cuál se obtiene mediante trabajo de campo directo, ya sea en campañas de medición, monitoreo ó reconocimiento en caso de aspectos biofísicos. Con la información de los diferentes aspectos, correspondientes a la cuenca hidrográfica, ó al territorio en estudio, se emplea un sistema de información geográfica como herramienta de comparación y evaluación.

En la determinación de los aspectos culturales, sociales y económicos, además de los informes oficiales é institucionales, se emplean censos, encuestas y foros con las comunidades. Los aspectos jurídicos son tomados de las normas vigentes y aplicadas al territorio respectivo. Se emplea información sobre los aspectos culturales, tales como la vocación y conocimiento forestal; los aspectos económicos relacionados con el tipo de actividades, seguridad, grado de pobreza, salubridad, infraestructura, composición, organización y características de las comunidades. Cada uno de estos aspectos permite zonificar el territorio estudiado.

Los aspectos relacionados con la cobertura de las tierras y su vocación, se comparan con las producciones hidrológicas, permitiendo así determinar áreas deficitarias en cuanto a cobertura boscosa. Esta información unida a las formaciones climáticas y características de los suelos ofrecen las condiciones para dar las recomendaciones de las especies recomendadas para las condiciones particulares. En este punto es conveniente tomar en cuenta las condiciones de mercado que tienen los productos y subproductos del bosque protegido ó la plantación establecida.

Después de haber evaluado y comparado las diferentes características sociales, económicas y biofísicas de la zona en estudio, se obtiene una primera aproximación en la determinación de áreas estratégicas para la conservación de los bosques ó para la reforestación, la cual se lleva a diferentes instancias para su ajuste, aprobación y puesta en marcha. Esta nueva etapa inicia con la consulta a funcionarios y técnicos de las instituciones del estado y de las empresas privadas, cuyas observaciones se toman en cuenta en la elaboración de nuevas versiones. Mediante talleres de participación de líderes representantes comunitarios, con representantes de las instituciones se presentan las observaciones y recomendaciones que alimentan el Plan de Manejo a ejecutar.

De acuerdo con la problemática de la zona en estudio, será necesario ó no, realizar un número variable de consultas, reuniones y foros entre comunidades, empresas é instituciones a fin de concertar un Plan de Manejo de las zonas de conservación y de vocación forestal é implementar su desarrollo; apoyo de programas é incentivos; de manera que se ajusten a los recursos del país y a las normas vigentes.

A pesar de las dificultades que implica el llevar a cabo el procedimiento de comunicación y concertación entre los actores de los territorios en Colombia, su culminación permite alcanzar un mayor compromiso de las instituciones y empresas; las comunidades desarrollan un mayor sentido de pertenencia con los proyectos y se presentan mejores condiciones para el éxito de los proyectos de conservación de los bosques ó de reforestación de áreas degradadas.

Ecological and Economic Evaluation in Monoculture Plantations in North - Western India

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Man-made plantations are being raised world over particularly in tropics to meet the growing demands of society. The sustainability of these plantations depends upon a balance between various ecological (vegetational and geo-chemical) and economic considerations (direct and indirect valuation of various forest products). However, sustainability needs to be measured and defined carefully depending upon the characteristics of a given ecosystem and the demands of the local people. A comparative study of 8 and 20 (2 year old plantations of *Eucalyptus tereticornis* and *Dalbergia sissoo* was made in terms of growth, vegetation analysis and evaluation of various wood and non wood products including medicinal value, fodder value, ash content and amount of oil in case of *Eucalyptus*. The presentation discusses in detail the significance of various ecological and economic parameters and their importance in determining the overall sustainability of these plantations. Various methods were used for determining productivity and their use values. The productivity was studied on the basis of the mean values of merchantable height and diameter at the breast height whereas use values of timber and fodder were based on the local market price and shadow price in case of ash content. The study reveals that overall plantations of *D. sissoo* provide more economic returns than *E. tereticornis* when both tangible and intangible parameters are considered unlike the conventional view. In case of the 8 year old plantations, the total economic return from *E. tereticornis* were more than that of *D. sissoo* mainly due to high timber value which is nil in *D. sissoo* at this stage. However, in 20 year old plantations, *D. sissoo* provided three times more economic returns than the *E. tereticornis* which includes timber productivity, fuel wood productivity, fodder value and ash quantity. Further, the *D. sissoo* plantations support more understorey vegetation compared to *E. tereticornis* which further adds to its value because many of the understorey plants have medicinal value and some are ecologically important. The rich diversity and heterogeneity of vegetation under *D. sissoo* plantations make their ecosystem more stable and balanced. Further the plantations of *D. sissoo* have some added advantages such as shading and sheltering which attract the wildlife as well as the local people who relax under them and get rid of monotonous city life. Though these benefits are not priced but in any way increase the value of these plantations compared to *E. tereticornis*. Based on the study, it is, therefore, concluded that indigenous plantations of *D. sissoo* should be maintained and preserved as they are more beneficial ecologically as well as economically compared to exotic plantations of *E. tereticornis*.

Forest-based Development in Finland and Chile- A Comparative Analysis

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The purpose of our paper is firstly to review the forest-based development conceptual framework. The term forest-based development used in our study refers primarily to forestry and forest industries and their linkages with other sectors in promoting economic growth. Secondly, we review input-output and other studies and statistics in order to reveal the direct and indirect empirical linkages of forest sector with the other sectors in Finland and Chile. Thirdly, the forest-based development concept is broadened from the pure economic one to the sustainable forest management term with economic, ecological and social aspects. The preconditions for historical sustainable forest development are inspected in a comparative analysis of Finland and Chile.

Finland

In the first half of the twentieth century, from 70 to 90% of the total exports in Finland were composed of forest products. Later on, the economy has been diversified and the respective share has decreased to 29%, which is still the highest among the industrialised countries. Another unique feature in Finland among the leading forest product exporters has been that originally farmers and later also other private individuals have jointly owned about 60% of the forest. This fact has ensured that competitiveness in the stumpage markets and real stumpage prices have increased since the end of the 19th century. This again has enlarged the value of the standing forest.

The forest industries have been continuously expanding in Finland since the 19th century. Until the middle of the 20th century the domestic use of roundwood for fuel, construction, fencing and exports exceeded the industrial use. Since then the industrial uses and imports of roundwood have increased. Finland has only 23 million ha of forest or 1% of the world total but her share of the total global exports of forest products is 8.5% and 27% in printing and writing papers.

Forest degradation and deforestation took place in Finland during the 19th and early 20th centuries. A series of land reforms and effective implementation of new forestry laws along with rising stumpage prices and increasing incomes as well as industrial transformation took place in the first part of the 20th century. Consequently, at the latter part of the 20th century the volume of the growing stock and annual volume increment increased by 24 and 40% respectively. A series of forestry master plans were also designed and implemented. They contributed partly into this success.

Chile

The forest based-development in Chile is more recent than in Finland, where forest-based development has progressed during more than a century. In Chile a swiftly growth has happened mainly since the early 1970`s. The Chilean forest sector has been frequently cited as an example that illustrates the way in which a developing country can use the comparative advantages of growing plantation forests for the forest-based industrialisation and expanding exports.

Chile is one of the rare cases among developing countries where forest sector plays an important role in her economic development. The exports of forest products account to 10% of the total exports. The major articles are composed of pulp, newsprint, wood chips and roundwood. Private companies and individuals own most commercial forests. Plantation forests cover 2.3 million ha and are highly concentrated in few hands. Fast growing monocultures of Radiata pine plantations provide more than 80% of the total consumption of industrial roundwood. Nearly eleven million ha of natural forests have survived. Forest industrialisation has been dominated by a wood production criterion and sustainable natural forest management has been widely neglected.

Finland and Chile

The two countries are relatively small by population but relatively large by land area. Both have succeeded to capture internationally high shares of exports in forest products. In this process Finland has increased her semi-natural forest resources while Chile has decreased them but increased her plantation forests. In both cases increasing carbon stocks are taking place but some degradation in sustainability of biodiversity and social aspects is occurring.

In Finland both ownership of forests and industries have remained in domestic hands but in Chile widely also in foreign hands. Small farmers were originally the principal forest owners in Finland while corporations and rich individuals became the owners of plantations in Chile. This has contributed to unequal income distribution. Clear and strong private tenure and cost-sharing systems have been effective in expanding forests in both cases. In Finland domestic R&D has played a key role in creating a number of linked industries to the forest sector - so called forest cluster - which also have been successful internationally.

We produced primary results in revealed comparative advantage of 12 export tigers. This indicator was defined as the value of exports minus the value of imports in forest products divided by GDP. From 1980 to 1996 this indicator was about 10 and 1% respectively in Finland and Chile. This level was highest in Finland and fifth highest in Chile. The trends were respectively +0.3 and +1.4%.

Fodder and Fuel Inventory of Temperate Himalayas: Biomass Productivity in *Robina pseudacacia*

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The temperate Himalayan forests face a heavy pressure from its inhabitants for meeting their timber and non timber needs, leading to severe ecological degradation. This in turn also affected the fodder and fuel availability for increased human and cattle population. These temperatures unlands are mainly comprised of coniferous forests while the broad leafed species, restricted to the moist southern slopes, contribute only 5% of the total vegetation. The plantation of fast growing multipurpose broad leafed species, yielding fodder and fuel, will not only fill this gap but also help to conserve and rehabilitate the ecosystem. With this objective in view a socio-economic analysis on demand and deficit of fodder and fuel requirements of the people was made for understanding the contribution of tree leaf fodder in meeting these exigencies. The share of leaf fodder came to 14% of the total fodder requirement while the demand deficit ranged from 32-40%. 77% of fuel wood is also met from the natural forests. The per capita consumption of fuel wood worked out to be 9.67 and 7.97 q/yr respectively in two mountain states of Indian Himalaya. The existing indigenous fast growing broad leafed trees such as maples, oaks, alder, poplar, elm, etc. are site specific, preferring moist ecological niches. In contrast to this introduction of *Robina*, an exotic from North America, naturalised in sub-tropical to temperate, dry temperate and cold desert conditions in the Himalayas, encompassing nitrogen fixing and sucking ability, is embodied with wide adaptability for pioneering all ecological niches. Its multipurpose uses, including fodder and fuel along with fast growth rate and deciduous nature makes and pasture/range lands. Locally it is also being employed as a substitute wood material for packaging of marketable fruit and vegetables. Short rotation age of *Robinia* can be used for innovative planning of farm lands and also for environmental and commercial forestry. Although, the cultural practices of the species have been worked but reliable data on the production of biomass and its distribution in different tree components, however, is not available. Forest inventory models, biomass production, wood characteristics and performance of *Robinia* plantation under four different ecological zones in four age groups and three DBH classes, were investigated. The biomass productivity was related with site specificity 10-year-old plantation from moist regime showed the maximum biomass in comparison to 22 year old plantation on the drier site. Rehabilitation of temperate forests with *Robinia* classified into ecological and economic models, as per the plantation objective is examined in detail. The significant correlation between DBH and biomass production indicated that the former can be employed as the lone indicator for estimating the biomass production under similar edaphic conditions. *Robinia* with multipurpose uses, wide adaptability and short rotation under favourable conditions, site rehabilitation characteristics offers an excellent broad-leafed substitute in the temperate Himalayas. The manuscript also includes the marketing channels for economic disposal of its timber and non-timber products.

A General Data Model in a Forest Resource Information System

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A general data model for forest inventory has been prepared. The data model is based on the entity-relationship model and it can be implemented by a relational database management system. The data model can be used as such, without any structural modifications, for inventories based on various kinds and levels of sampling designs. The structure of the data model is fixed, but its design is very flexible; and there is no need to change the database structure when entering new types of attributes into the database.

The data model and its implementing database support different forest resource management systems from forest stand to national level. An inventory and management system based on a 100% tree tally is supported, as well as a system gathering information using a sparse sample plot network.

In addition to the standard field data, the data model includes modules for forestry models, calculations and reporting. Regression models are stored in the database with their formulae and restrictions and are directly linked to forestry calculations and field observations. Calculations are organised in the data model from tree level to forest stand and area levels, which allows a multitude of detailed and general calculations from single tree to long-term projection of tree or stand parameters. The calculations utilise methods that are specific by sampling unit type, and regression models that describe forest characteristics. Reporting is connected to the field data and to the outputs of the calculations. It enables definition of report layouts and their automatic population with the data of the database.

The data model has been applied in constructing forest resource information systems which integrate a geographic information system, a database management system, and computation and interpretation of remote sensing data. Forest resource information systems have been designed and implemented in various computer hardware and software environments, and on several levels of forest inventory. The data model supports the data needs of complex forest surveys, but it can also be applied to other uses of natural resource data management.

Close-to-nature-forestry and its Origins - The Permanent Forest Movement in Germany Between 1880 and 1930.

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Between 1880 and 1930 the permanent forest ("Dauerwald") was a leading idea in German forestry and forestry science. In the corresponding literature only forest-specific and mostly natural explanations (above all calamities in even-aged forests) are discussed to account for the formation of this leading idea. In contrast, in the study the thesis is supported, that natural, silvicultural or forest-specific explanations alone are insufficient. To comprehensively understand the formation and the history of close-to-nature-forestry, in addition a socio-historical reflection is rather necessary.

The early phase of the permanent forest movement between 1880 and 1920 was mainly dominated by discussions concerning the introduction of uneven-aged forest systems ("Plenterwald"). The term permanent forest ("Dauerwald") was first used in 1920, but only very abstract characteristics of permanent forest such as 'mixed forests', 'uneven-aged forests', 'health' and 'equilibrium of state' were named. The lack of a clear definition resulted in broad interpretations of this term by other authors. From the mid-twenties the permanent forest movement rapidly was losing the eminent influence it had up till then in the forestry public. A second movement arose during the National Socialism and a third in post-war Germany.

To understand the formation of the permanent forest movement, the situation of educated classes in Germany at the turn of century is analyzed from a mentality-historical view. Extensive social and economic change caused the educated classes to retreat to their traditionally accepted knowledge and values. The critique of culture was a reaction by the educated classes to the cultural and intellectual crisis. This critique of culture found expression through the foundation of numerous movements, as the 'life-reform-movement', the 'home-conservation-movement' or the 'youth-movement'. Forestry officials and forestry professors, as the representatives of the permanent forest movement, were members of the educated classes in Germany. The following five leading ideas of the permanent forest movement were analyzed:

Leading idea, description and interpretation

1. Aesthetics and harmony romanticization of country life ("Back to nature"), hostility towards urbanization
2. Demand for steady state Reflection of a capitalistic orientated view of forestry, protection against materialistic and especially financial demands towards the forest
3. Concept of Organism Unity of soil and stands, element of a naturalistic and biologistic trend in the views of the educated classes, 'organism' and the antonym 'mechanism' as key words of the conservative milieu in the Wilhelminian period and in the Weimar Republic
4. Essentialism and the idea of intuition Method to grasp the nature of forests, concept of intuitively placing oneself within nature in order to gain a better understanding of forest, turning away from rationality in favour of a pronounced emotionality
5. Darwinism and social biologism Social biologistic ideas as the result of the transfer of darwinistic concepts on society (people as an organism), naturalistic terminology filled with political meaning and societal reality was naturalized.

Literature research and analysis shows, that the permanent forest movement was a result of anti-modernistic, anti-progressive and agro-romantical considerations: thus a more reactionary than avangardistic critique of culture, which could also be found at that time. Numerous parallels can be found to other movements supported by the educated classes. These considerations lead to the result, that the permanent forest movement could be unterstood as a part of the typical culture-critical reform movements of the educated classes at that time. Apart from forest-specific reasons, mentalities of that time form the conditions and the basis for the formation of the permanent forest movement in Germany.

4.02.03 / 4.02.06 Update calibration and enhancement of forest inventories through the inclusion of remotely sensed data

Drawing Stand Profiles by a Computer Programme

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A stand profile contains silvicultural and yield elements like stand density, crown closure, slope, exposure, relief, stand canopy projections, regeneration success, diameter, height and increment. Such as stated above, stand profiles that have wide contents, in practice, provide important clues at choosing and applying methods, and form an important ground to carry out more truth and productive studies, putting forward structural state of a stand with the stand profile previously, obtains advantages in cases of choosing a method and monitoring effects of the method on the stand structure and reduces faults.

Turkey's forest areas have very different stand structures depend on different ecological conditions. So forestry practices have important differences. The most suitable way to determine these differences before applying is putting forward stand profiles of the stands. For Turkeys forest managing, stand profiles have great importance because of significant differences among forested areas.

Nowadays, like every scientific fields, computer aided studies are increasing from day to day in forestry too. At forestry studies, one of the most suitable topics that can be realized on computer program is to draw stand profiles and to obtain three-dimensional appearance on the computer. Stand profiles prepared with the aid of computer provide many advantages to the forest managers such as learning of forest structure detailed and previously. These advantages become more important especially silvicultural practices. Thus, forest managers can watch effects if a chosen method on computer screen and can give up to apply the method because of its unsuitableness. Besides choosing of silvicultural regimes, allowable cuts can be determined with the stand profiles. Because a stand profile has a sample plot peculiarity.

Top and front view of stand profile can be monitoring with the aid of computer program. It can be changed tree data or removed on stand profile. Thus, last state of stand profile can be observed. Program is tested many experimental fields. It has been obtained successful results. Forestry will acquire time and new ideas will occur with the aid of computer program.

The Integration of Individual Tree Growth Model and GIS in Forest Ecosystem Management

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Growth model is very important to offer the reasonable projection and prediction of growing stock in the decision making of forest management. Individual growth model is used to simulate the tree crown, diameter of breast height and tree height of interested tree. The competition indicator (CI) of each individual tree were estimated under the concept of circular zone of influence with the size and distance of adjacent trees. The CI is used to judge the surviving growth and mortality risk of each individual tree. The growth pattern of individual trees in the stand reacted the complex growing history and the pattern of beginning stand. To study the description and analysis of spatial relationship are the most important direction in forest research. Geographic information system (GIS) is used to integrate tree location map and the attribute data of individual tree; the plot position map and stand attribute data; the landscape map and mosaic attribute data. The information of the status and change of spatial pattern in tree, stand and community, ecosystem and landscape levels could be analyzed and displayed in multi-scale maps. The spatial individual tree growth model and GIS database could be used to simulate the growing stock and stumpage price under different thinning criteria. The data of five different density plots of *Cryptomeria japonica* and *Cunninghamia lanceolata* were used to develop and simulate in different scenarios in the paper.

Keywords: Spatial analysis, Circular zone of influence, Individual tree location

Forest Plantation Assessment Using Remotely-sensed Data

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Effective plantation management requires frequent assessment of the divergence between expected and actual plantation development. A monitoring system based on satellite data collection can provide adequate information to address the above issue.

As the tree crowns expand it provides more light intercepting and reflectance surface. It is commonly observed that an inverse relationship exist between the overstory planted tree and their associated understory coverage (i.e. snow, shrub and herbs, etc.) in terms of their surface exposure. Given the fact that canopy reflectance of understory coverage dramatically affects the conifer-overstory reflectance, the objective of this study was to develop a monitoring system using the contrast between understory and overstory reflectance. This contrast, traditionally deemed "noise", changes over time in response to shifts of dominance of these two layers. This study has utilized this noise in such a way that canopy closure of plantations can be estimated, plantation disturbances and their locations can be displayed to plantation managers, and estimated, plantation disturbances and their locations can be displayed to plantation managers, and estimated canopy closure can be initialized in the tree allometric models to predict the dbh and height of plantation.

The proposed method was tested in a case study of planted black spruce (*Picea mariana* [Mill.] B.S.P.) on good and poor quality sites. Shrubs and herbs were the constant understory features against which the development of forest attributes was assessed. In this investigation, Thematic Mapper T digital numbers (DNs) were successfully correlated with canopy closure indices (i.e. canopy estimation model). TM bands 1, 2, and 3 were unsuitable for this purpose because of their small DNs range. TM band 4 had a very weak or nonexistent relationship at less than 0.6 canopy closure index, and an inverse relationship at greater than 0.6 canopy closure index. TM band 5 revealed a greater DN range and a stronger inverse correlation with canopy closure index than the five other TM bands. TM band 7 revealed a strong inverse relationship with canopy closure index. This band also revealed some potential for estimating canopy closure index. Both crown width and crown projection area revealed strong relationships with height and dbh.

The model's predictive capability was verified through a comparison on the estimated canopy closure index (initializing DNs of 1995 imagery into the 1994 model) with the 1995 measured canopy closure index. The estimated canopy closure index, for the stand developing normally, corresponded closely with the measured canopy closure index. However, the estimated canopy closure index, for the stands which had been disturbed, did not match with normality.

This study has demonstrated that the Landsat TM imagery is a valuable data source for monitoring forest plantations based on the contrast between understory and overstory reflectance.

4.02.05 Remote sensing and forest monitoring

Forest Types Delimitation on the Basis of Landsat TM Images

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Keywords: Remote sensing, forest types

Information of forest areas deriving from satellite images under Polish condition are useful not only for enriching knowledge of weakly recognised forests, but rather for generalisation of detailed information collected by forest services and for illustrating their spatial distribution. General information of forest types and its distribution in Poland would be very useful for forest management being under process of bringing back of ecological balance in the forest communities. In the poster three examples of forest types delimitation are presented. In the supervised classification process of Landsat TM images different types of forest were discriminated in the different forest regions of Poland. For supporting supervised classification process the forest inventory information were used as: tree species, forest stand sites, age of the forest stands, proportion of stand mixture. In the result of classification activities the forest types maps were printed. These maps illustrate spatial distribution of different forest types which are determined by forest stands site and dominated species of trees.

Watershed Prioritisation - A GIS Approach

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In India the population explosion, changing lifestyles and increasing pressures on land for urban and industrial development call for the optimum use of the available land based on its inherent potential and limitations vis-à-vis maintaining a quality of environment. The amount of arable land is continuously shrinking due to human activities resulting in land degradation by various causes. Watershed is natural hydrological entity which has a large number of variables and its management, in its broadest sense, implies prudent use of soil and water, hence programs are required to protect the environment to sustain the productivity levels of soil by reducing land degradation.

For the formulation of proper watershed management programs, the information on vegetation status and soil erosion are very helpful in identification of sedimentation sources and planning of erosion control measures. The regular monitoring of watershed characteristics, biotic interferences and soil conservation measures taken up is very essential. Satellite remote sensing provides reliable scientific input and also addresses some of the parameters of models related to quantitative spatial erosional soil loss and the priority classification of sub-watersheds for taking up erosion control measures.

The studies were carried out to prioritise and recommend erosion control measures for Kawal Khad watershed located in district Solan of Himachal Pradesh , India using GIS approach. The land cover of the study area consists of mostly chir pine (*Pinus roxburghii* Sargent) and mixed forests. The area has got undulating terrain with steep to excessively steep slopes. About 20% of the area is under the degraded forests and scrubs with medium category erosion status and needs improvement on priority to check the erosional losses and maintain the productivity of land. One sub-watershed covering about 7% of the watershed area fell under very high erosion status and qualified for top priority treatment. Various management practices recommended include gully plugging, construction of check dams and gradient control structures, afforestation with suitable site specific species.

Concept of the Forest Thematic Maps of Landscape Parks Based on Satellite Images

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Keywords: forest cartography, remote sensing.

The proper and effective forest management can be performed, among others, thanks to the inventory of natural resources and our knowledge about different changes that constantly take place in our environment.

Our temporary and long term aims for forest management are defined basing on the information that is obtained from the inventory following a 10-year cycle.

To use the above information in an effective and operational way we must base the inventory results on geographic information system which stores the information on both spatial and descriptive database. Such a system enables not only a dynamic display and printout of maps and reports that present selected stands parameters but is also used to conduct complex spatial analyses. Another advantage of forest GIS is the possibility to insert some additional information about the given forest area e.g. archival and current satellite images and aerial photographs. The spatial analyses of gathered data allow to present e.g. the conformity of species composition with habitat, determination of the state of health of forest stands basing on satellite images, determination of forest condition zones in connection with the parameters of the forest stand and habitat contained in the forest management database. The use of remote sensing data allow updating the information collected on the ground. Remote sensing may also serve as a source of information for cartographic purposes.

The maps and analyses were prepared taking into consideration the needs of landscape parks for which it is extremely essential to determine their natural virtues, in order to evaluate their biodiversity and conditions of their natural environment.

Monitoring of Forest Decline in the Sudety Mountains of Poland with the Use of Remote Sensing and GIS - 25 Years of Experience

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Since the middle of the seventies, decline processes have been observed in the spruce (*Picea abies*) forest of the Sudety Mountains in Poland. The main cause of these phenomena was the acid deposition transported by the wind from foreigner (Czech and German) and domestic factories, especially electric power plants based on sulphur contaminated lignite. Since the speed of decline processes was high and contaminated area was broad it was decided to use satellite remote sensing to evaluate health state of the Sudetian forests. First analyses were oriented to delineate the stands of different condition. Landsat MSS, TM, SPOT, Cosmos as well as ERS were used. Next step was to collect all existing data describing environment and its contamination, to analyse the forest state status versus different environmental aspects. So the use of forestry oriented GIS was necessary. The paper describes an evolution of the monitoring of area under study with the use of remote sensing and GIS. Experiences dated since 1976 have shown the changes in processing attempts and in defining forest classes derived from satellite images. Simple stratification of forest condition was replaced by deep analyses of multi-source and multi-temporal data stored in forest information system. Results of these analyses are presented in cartographic form as well as in statistics and are used not only by forest service for managing practices but also by environmentalists and spatial planners.

4.02.00 / 4.11.00 Design of small and large scale multipurpose forest inventories

Inventarios Forestales por Transectos Amostrales en Bosques de Galería

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Bosques de galería son formaciones vegetales que crecen contornando los cursos de agua en la región de las savanas llamadas en el Brasil de Cerrado. Cuatro características definen esas formaciones arbóreas: a) se forma una faja de vegetación con un ancho que varia de pocos a algunas centenas de metros, dependiendo del suelo, relievo y microclima; b) presenta una considerable biodiversidad natural con cerca de 1400 especies entre angiospermas e pterofitas; c) la vegetación presenta una variación temporal y espacial, paralela y perpendicular a la dirección del curso de agua; d) recibe fuerte influencia antrópica. En el aspecto económico silvicultural, estos bosques son importantes por el potencial de producir troncos de alto valor comercial con dimensiones para el proceso industrial. Varias especies tienen alto potencial de utilización doméstica. En el aspecto ecológico abrigan y alimentan varias especies animales, especialmente aves y pequeños mamíferos, protegen los márgenes de los ríos y son mantenedoras de la calidad y cantidad de agua, recurso que en el futuro próximo será el bien más precioso. La necesidad de conocer intrínsicamente estos bosques se hace imprescindible. Con esos fundamentos se desarrolló dentro del principio de los inventarios forestales continuos un modelo por transectos que contemplase una gran cantidad de variaveis y permitiese obtener el respectivo cálculo del error de muestreo, característica inédita en los levantamientos por transectos. Se definió el transecto, una faja de muestreo de 10 metros de ancho, que corta transversalmente la formación vegetal. Tres conjuntos de variaveis de medición fueron contempladas: 1) relativas al sitio (largo y azimut del transecto, altitud, nivel de influencia antrópica, declividad), 2) datos dendrométricos (número del árbol, coordenadas de localización, identificación de la especie, DAP, otros diametros, alturas total y comercial del troco, diametro y posição de la copa en la estructura vertical, estado fitosanitario y variables de tiempos de medición), 3) variables dasometricas (suelo, temperatura, luminosidad, humedad relativa). Para la obtención

de los datos de campo se utilizaron instrumentos forcípulas, clinometros Suunto y otros de última generación (medidores de distancia de ultra-som). Se formaron grupos de campo de tres personas. Para la interpretación de los datos de campo fueron elaborados archivos en Dbase y ejecutados en SAS (Statistical Analysis System).

Este trabajo pretende mostrar la metodologia de captación e interpretación de datos de campo del inventario forestal de un bosque de galeria localizado en el Parque Nacional de Brasilia. Fueron instalados y medidos 19 transectos de muestreo distribuidos sistematicamente a cada 1000 metros, produciendo una intensidad de muestreo de aproximadamente 1%. El tiempo médio de medición consumido por transecto de 300 metros fué de 5 horas por equipo de tres personas. Fueron colectados 56237 datos que fueron estructurados en archivos Dbase, formando asi el correspondiente banco de datos. El modelo del inventario forestal se reveló eficiente, lo que justificó continuar testandolo y aprimorandolo en otras áreas localizadas en el Parque Nacional Chapada dos Veadeiros y del Rio Jardím (Brasilia).

La precisión de los diversos cálculos se fundamentan en el analisis del cáculo de proporciomes y fracciones estadísticas. Los resultados permitieron mostrar coerentes parametros de la gradiente temporal y espacial de la vegetação arborea asi como la variación parametrica de las alturas de los árboles en función de la distancia del rio. La composición floristica presenta grande variedad de especies, diferentes entre si, confirmando la existência de una rica biodiversidad vegetal en esas formaciones. Además de los parametros clasicos de los inventarios forestales como resultados volumetricos, el modelo de muestreo permitió efectuar interpretaciones de la fitosociologia. Concluyese que el modelo fué eficiente, permitiendo obtener consistentes resultados en la precisión requerida.

PPS Stratified Two-stage Sampling Technique for Assessment of Village Forest Resources in Bangladesh

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PPS Cluster Sampling, PPS Two Stage Sampling and PPS Stratified Two Stage Sampling Techniques were examined with field data of village wood and bamboo resources in computer. A study population of 900 households was formed in the district of Chittagong in Bangladesh. The five parameters under five variables were computed through Complete Enumeration. The parameters were estimated through the examined sampling techniques considering 250 sample households in each case. The estimates were compared with the population values on the basis of percentage accuracy, percentage standard error and 95% confidence interval. The population values under Complete Enumeration and the estimated values of the parameters under the selected sampling techniques are given for total number of trees as 17333 & 16087, total volume of trees as 9480 & 8479 m^3, and total volume of compact trees as 8308 & 7345 m^3, total number of bamboos as 53229 & 38598 and total number of palm trees as 4748 & 4318 respectively. PPS Stratified Two Stage Sampling was found to be suitable technique for assessment of village forest resources (wood and bamboo) in Bangladesh. The technique will be helpful for assessment and monitoring which are essential for village forest conservation and planning.

Information for Forest Sector Policy

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If we examine the fields of forest inventory and the provision of data for forest policy making and public debate we witness, today, a number of contradictory developments and circumstances.

Both at national and international level there is a growing interest for broader, more accurate and more frequent information about forest and related resources. On the other hand the priority given to forest inventories is actually decreasing in many countries. Deforestation and forest degradation are major problems in many countries. Yet the forest inventories carried out in these countries are with few exceptions not designed to detect changes. The demand for new types of information (e.g. biological diversity, non-wood forest products, forest quality) has increased. On the other side concepts and methods to answer all the new questions are poorly developed. Studies about production and consumption of forest-related goods and services have become a priority in many countries and in international outlook studies. Yet statistics about forest resources and statistics about consumption and demand are often dealt with in different offices with little co-operation among them. Consequently it is rarely possible to express resources/production on one side and consumption/demand on the other side in comparable terms. In the same way there is much lip-service to the need of cross-sectorial approaches when dealing with matters such as forestry, agriculture, industrial development, environment, employment and rural development. However, the political environment does not favour the necessary cooperation across institutions, but rather competition and turf fights. There is almost complete agreement that democratic processes and participatory approaches should be prevailing in the development of policies and strategies in forestry and any other field. Yet systematic dissemination of full and correct information to the public are rather the exception than the rule. Recent decades have seen a rapid development of technical tools, e.g. remote sensing and Geographic Information Systems (GIS). Many forest inventories have been carried out using those new tools. Yet we observe that existing information is not used and that, at the same time, forest policy formulation is lacking relevant information.

The above circumstances and developments make it necessary to examine why information is needed at various levels, what information is needed and how information is used.

At national level the dominating use of forest and related information is the political process. A functioning political process is a condition for a country to develop a political will in the field of forestry. Steps in this process and the role of information in them are described. Examples are given of what information is required and how it enters the political process. It is argued that most countries need the following, in order to overcome the shortcomings mentioned:

- an Analysis Unit that analyses the forestry/land use situation and conflicts, identifies policy options and their implications and formulates scenarios
- a continuous National Forest Inventory (or some kind of inventory which is kept up to date)
- a Statistical Unit which collects information about consumption, production, social issues etc.
- a political process which formulates policies and decisions involving most stakeholders
- All four components must be in place. It is of little use e.g. to conduct a national forest inventory if some of the other components are missing. Therefore forest inventory specialists must be trained and encouraged to enter in a dialogue with users, to question the adequacy of standard methods and to help identifying gaps in useful information.

Forest Stand Growth, its Structure and Dynamics on Large-scale Forest Area. Method and Results

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Keywords: continuous forest inventory, stand growth balance, GIS

The estimation of total growth, its dynamics and use was based on application of sampling methods and the method of balance between the volume of increment of growing and ingrowing trees and volume of cut, dead or disturbed in any way trees.

Sampling scheme was based on choosing stands and trees representing large-scale forest areas. Sampling design contains three stage sampling units: sampling of plots in airphotographs, satellite images, ground survey sampling plots and sampling trees. The proposed system of allocation and measuring of trees per permanent plot guarantees an exact identification of all sampling units and measurement points on trees during regular remeasurement of invisible for the usual forest visitor plots.

Classification of the development of trees per plot from ingrowth, growing tree down to felled, dead and destructed decays was proposed and used in this work. System of volume and increment estimation of each tree per plot using regular remeasurements of diameter of each tree and other parameters (height, age of sampling trees and stands) was elaborated. Unified dendrometrical data processing system was based on general regularities and interrelations of the main parameters of trees and stands including regression functions.

The experiment was carried out in 1976-1996 in Dubrava forest, occupying an area of 5.7 thou. ha. Dubrava forest is representing Lithuanian forest, on the whole, by many stand and site parameters. The results of this study enable to predict the process of stand yield formation and to foresee measures for purposeful and multiple management of Lithuanian forests. In 1976 groups of permanent plots clustered by 4 into 250x250m size tracts were established. Tracts were distributed evenly in the forest by 1x1 km grid. A total of 188 invisible plots with 25-30 trees were identified at the time of each remeasurement. The plots after establishment were remeasured four times every 5 years. Total yield, net yield, ingrowth, the volume of dead and cut trees, as well as the volume of nonsalvable trees were estimated.

The established permanent sample plots on GIS base and collected data about the main characteristics of forest stands, their yield and dynamics during 1976-1996 serve as an excellent database for large scale forest resources dynamics modeling and further investigation of forest stand yield and its structure dynamics, combining field measurements and remote sensing methods.

Regular measurements by the proposed and approved sampling methods allowed to estimate Dubrava forest stand yield balance for two distinguished periods: 1976-1991 - normal growth and development of stands, as well as 1992-1996 - growth and development of stands under the influence of windstorm in 1992, drought in 1992-1995 and Ips typographus damages in 1993-1996.

Analysis of stand yield balance during the normal for stands growth and development period (1976-1991) allowed to estimate the real yield, intensity of tree mortality, reserve of sanitary cuttings, forest site productivity and its dynamics, to estimate the efficiency of intermediate cuttings in regulating species composition, stocking level and stability of stands, in increasing yield and changing stand structure.

Relationships of Stand Structural Diversity to Common Stand Measures

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The vertical and horizontal diversity (structural diversity) of stands affects the growth of trees and also the biodiversity of stands. The distribution of stems or basal area per unit area versus height, diameter, and species can be used as a measure of structural diversity. However, summary statistics which indicate the variability in these distributions (stand diversity indicators) may be more desirable. Two groups of summary statistics are suggested. The first utilizes an approach similar to that used to calculate a diversity index from frequencies by species. However, since both height and diameter are continuous variables, this approach requires grouping the height and diameter values into classes. Alternatively, the distribution can be modeled, and the parameters of the modeled distribution used as indicators of vertical and horizontal diversity of trees.

Several structural diversity indicators calculated from height/diameter/species distributions were examined for use in the University of British Columbia Malcolm Knapp Research Forest near Vancouver, B.C., Canada. Three of these indicators were then related to stand characteristics of average tree size and density, measured in ground plots, and also related to measures of species proportions, crown closure, and height classes measured on photographs. The suggested indicators are presented, along with the correlation results. Although the indicators relate to structural diversity, the addition of a measure of spatial distribution is desirable.

Image Analysis System for Crown Condition Assessment Using a Digital Camera, CROCO

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Crown transparency has been visually assessed in forest health monitoring programs of many countries, but the data reliability has been questioned. The objectives of this study are to develop a new semi-automatic image analysis system for assessing crown condition objectively and efficiently using a digital camera and to discuss the usefulness and limitations.

Three popular automatic thresholding algorithms were applied to blue-filtered gray level images. As a result, the between-class variance method was most appropriate to generate the silhouette, and it was reproducible in terms of weather conditions. Two fractal dimensions of crown images, Ds for the silhouette and Do for the outline, were examined in relation to crown transparency (CT) using the Swiss and British standard photographs. Ds tended to decrease linearly with increasing CT, but some species showed no clear tendencies. Do tend to increase rapidly with CT at lower levels of CT, but after that, different tendencies were found between species, i.e. increase, decrease, or constant. These results suggested that Ds or Do alone was a poor measure of CT. I proposed a new index DSO (=Ds-Do), decreasing curvilinearly with CT and closing to 0 at highest levels of CT. DSO was suggested to be a useful measure of CT.

Based on above results, image analysis system for crown condition assessment CROCO was developed. It is composed of a Macintosh computer, a digital camera, the public domain NIH Image program and commercially available and popular software Photoshop, including 4-step procedures 1) image acquisition, 2) preprocessing, 3) thresholding and 4) calculation of DSO. The main features are that a digital camera is used and most of processing are automated using the macro language of NIH Image and the batch function of Photoshop, which enable us to analyze large numbers of images cost-efficiently. The precision of the system was examined in terms of weather conditions, camera angle (CA) and overlap rate with other trees (OR). The results suggested that CROCO produced accurate results (DSO) when CA was less than 45 degree and OR was 50% or less than 50% of crown width, and weather conditions did not influence the accuracy.

Relationships between DSO, dry weight of foliage (FM) and stem volume increment (VI) were examined using 32 trees from two Japanese cypress (*Chamaecyparis obtusa* ENDL.) plantations. It was interestingly that DSO was proportional to foliage biomass density, expressed as FM divided by crown surface area (CSA). In addition, FM was strongly proportional to a measure, CSA multiplied by DSO, which was also proportional to VI for each stand. These results suggested that actual foliage biomass, stem growth and growth efficiency (VI/FM) can be estimated non-destructively from DSO and crown size measurements.

In conclusion, CROCO has potential to analyze large numbers of images efficiently, but the applicability is clearly limited by visibility from the ground. However, combining CROCO with visual assessments of CT would most useful so that bias that each country or observer has may be removed. It was recommended that crown size measurements should be added to field surveys, since combining DSO with crown size measurements would enables us to estimate actual foliage biomass and stem growth.

Analysis of the Mortality Model in PrognosisBC

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Growth model verification involves several interrelated steps and mensurational attributes. This is especially true for a mortality model. In this study, the predictive ability mortality model of PrognosisBC was verified for ten tree species.

Significant differences were found between the observed (PSP data records) and expected (PrognosisBC estimates) mortality rates by zones/subzones considered in PrognosisBC. However, there was no consistent over- or under-estimation of mortality within these zones and subzones. The highest difference was observed in IDFdm[2]. In the Nelson region, the differences between the observed and predicted mortality rates varied by species and diameter classes. There was consistent under-estimation of mortality for hybrid spruce (SE), white pine (PW), and subalpine fir (BL). On the other hand, there was consistent over-estimation of mortality for western red cedar (CW), Douglas-fir (FD), western larch (LW), and ponderosa pine (PY). No consistent estimation patterns were found for Western hemlock (Hw) and lodgepole pine (PL). In the Kamloops forest region, there was consistent over-estimation of mortality for the hardwood tree species (HM). No consistent under- or over-estimation of mortality was observed for the remaining tree species.

To alleviate this bias, average correction factors (CF-observed/predicted) were estimated by species and diameter classes. The predicted mortality for CF uses both the tree and stand based mortality functions of PrognosisBC. The CFs were, in turn, fitted as a function of the midpoints of the DBH classes.

Bivariate Distribution Functions in Assessing Leaf Area Distribution in Hybrid Spruce Crowns

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Bivariate distribution functions provide: (1) flexibility in assessing the clumpy nature of foliage spatial distributions in tree crowns; and (2) more information than univariate distribution functions when the spatial distribution of foliage within a tree crown varies in both vertical and horizontal directions. In tree crowns, leaf area and leaf weight show high variability at different heights, relative horizontal positions, and cardinal directions of the crown. These high within- and among-tree crown variation have contributed to the difficulty of tree crown sampling and single tree leaf area estimation. On the other hand, the use of tree leaf area (photosynthetic surface area) as a response variable in analyzing the impacts of silvicultural treatments (e.g., fertilization and thinning) is increasing.

The objectives of this poster presentation are to describe the distribution of leaf area in hybrid spruce (*Picea engelmannii*glauca*sitchensis*) crowns and to analyze variability of leaf area in tree crowns. This paper/poster demonstrate how bivariate distribution functions are employed in assessing the vertical and horizontal distributions of leaf area at specified points in tree crowns.

Data were collected and three-dimensional analyses and displays were made to observe the variability and/or the trend of leaf area spatial distribution in tree crowns and to select models for assessing leaf area distribution. The bivariate Weibull and beta probability distribution functions were selected for predicting leaf area per centimetre (APCM) using relative heights (vertical position) and relative branch lengths (horizontal position) and their model parameters were related to tree attributes.

Results of this paper/poster indicate that horizontal and vertical distribution of foliage is highly variable throughout the crown. Three-dimensional graphs of APCM illustrated that APCM increases towards the top of the tree and the tip of first-order branches. Trees between 50 to 60 years of age showed the highest APCM, whereas trees older than 120 years showed the least APCM. The average leaf area per twig for the sampled first-, second-, third- and fourth-order branches did not show any trend with increasing or decreasing age classes (i.e., <20yrs, 40-60 yrs, and >120 yrs). Trees between 40-60 yrs of age showed the highest APCM, whereas trees older than 120 yrs showed the least APCM. This variation will have a large influence on the amount of light intercepted, crown transparency, radiation transfer, photosynthesis, and respiration by the foliage. The relative horizontal and vertical positions where maximum APCM values were obtained indicate the zone of maximum photosynthetic capacity in the crown.

Model estimates of APCM were more precise when branch position from the tip of the tree was expressed relative to tree height (zi1) rather than relative to crown length (zi2). Thus, the reference of a branch using zi1 instead of zi2 is suggested for single tree growth and yield modeling. The bivariate Weibull and beta distribution functions are suggested for APCM prediction as these models resulted in more precise representations of APCM within tree crowns than the univariate Weibull and beta distribution functions.

Height and Diameter Growth of Rubber (*Hevea Brasiliensis -Muell*) Plantations at Rmu Rubber Estate of Bangladesh

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Bangladesh, a land of about 125 million people having an area of 14.4 million ha has only 10% forest. About 25,000 ha of rubber plantations have so far been raised in the country of which 20,000 ha are managed by the Government owned Rubber Estates while the rest are under the Private Estates, Tea Estates and Private Small-holders. The Government owned Estates are the 12 Rubber Estates under Bangladesh Forest Industries Development Corporation (BFIDC) and the six under Chittagong Hill Tracts Development Board. The major rubber growing areas are located in the North-East, the South-East and the West-Central regions of the country.

A few hundred ha of these plantations had been raised in the early sixties most of which have gone out of latex production by the time. Considering the multipurpose uses and the recent trend about rubberwood, estimation of timber as well as prediction of growth and yield of these plantations have become an important researchable problem. A study was, therefore, conducted on the height and diameter growth of the rubber plantations at Ramu Rubber Estate during 1996. It is one of the 12 Rubber Estates managed by BFIDC located in the South-East region of the country. There is a total of 1027 ha of land under 20 different years of plantations in the Estate established from 1961 to 1995. The seedlings and clones used in these plantations are TJIR, GG-seedling and RRIM-600. Generally, an 8m-by-8m spacing was maintained in most of the plantations. The evaluation made from these plantations will provide an average picture of height and diameter growth performance in Bangladesh. Data on total height, merchantable log height and over-bark diameter (dbh) were collected from three sample plots of (36 plants each) from every year of plantations. As many of the rubber trees in the Estate were broken at the top by the cyclone of 1991 it was very difficult to get the total and log heights of each tree. Considering this fact, total heights and log heights of three dominant or co-dominant trees were measured from each sample plot while over-bark diameter at breast height (dbh) were recorded from all the trees. The total heights and the log heights of the rest trees of the sample plots as well as the subsequent mean growth performance of each plantation were then estimated from the regression equations developed from the height-dia relationships.

The regression equations developed from the sample trees are: (i) Total height (T/Ht) = 4.2027 + 0.4091*D/ob (r=0.99), (ii) Merchantable log height (L/Ht) = 0.6576 + 0.3468*D/ob (r=0.99) and (iii) Over-bark diameter (D/ob) = 6.5386 + 1.1463*Age (r=0.97). The estimated mean annual growth performance of 20 different plantations has been presented in a table. Among the plantations raised between 1961 to 1995, the youngest merchantable trees were found in the 7-year old plantations of 1989. While the mean total heights of the 1, 2 and 3-year old plantations raised in 1995, 1994 and 1993 showed an average of 3.4, 5.7 and 6.4 meters, the merchantable height of the 7-year old plantation was 10.3 meters. On the other hand, the oldest 35-year old plantation raised in 1961 had an average total height of 20.6m while the merchantable log height was found to be 14.5 meter. The over-bark diameters of the 1, 2 and 3-year old plantations were found to be 2.1, 3.8 and 5.4 cms while the youngest merchantable trees had an average of 15.0cm and the oldest showed an average of 40cm dia. The Two-way Frequency Distribution Tables prepared for different heights and diameter-classes for each age will reflect the timber volume in each year of plantation. The age-height, age-dia and also the height-dia relationships have been shown by line diagrams.

4.04.00 Advances in combining productivity and sustainability in forest management

Timber Production Possibilities and Capital Yields from the Norwegian Forest Area - Basic Information for Policy Formulation

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How intensive should a forest be grown? This is a fundamental question in the process of formulating policy guidelines for the management of a forest area, both at the individual property level as well as at the national level. The question is related to a number of factors; the objective(s) of the forest owner, the productivity of the forest land, the accessibility within the forest, assumptions regarding future prices and costs and the real rate of discount. This paper presents an applied analysis with the objective of mapping the possible future timber harvest and state on the productive forest area in Norway, given different levels of the required real rate of return on investments in timber production. The analysis is deterministic. The regeneration strategy is a key factor for the long run development of a forest and thus given particular attention. The analysis is restricted to deal with timber production only and maximisation of the net present value of the forest area is used as the objective function. The real rate of discount is varied and used as the driving force to find the best (optimal) level of intensity in silvicultural management.

Analyses are done with GAYA-JLP, a model based on simulation of treatment schedules for individual management units and linear programming for solving the management problem at forest level.

The analyses cover the productive forest area in Norway. This forest area is divided into 10 regions. Sample plots from the National Forest Inventory were aggregated into 1000 treatment units for each region, i.e. the entire forest area is described by 10000 units. Thus, a large amount of the variation regarding the current state of the forest area is represented. The forest management problems are solved at county level, while the country level results were obtained by summing over the individual regions. The following issues were emphasized in the analyses:

- provide a realistic description of the timber production possibilities of the productive forest area in Norway
- aim at consistency in forest treatments with respect to the real rate of discount
- maximisation of the net present value with, and without, a non-declining felling path constraint

The results include estimates on the possible development for a period of 100 years with respect to the volume of harvests and growing stock, according to different real rates of discount. Sensitivity analyses to estimate economically non-accessible areas and changes in the intensity in silvicultural investments due to different timber price levels are also provided. The total timber production for the period of 100 years increased with 15-20% when the real rate of discount was decreased from 3.5-1.5%p.a. The assumptions about regeneration are crucial for the results, and it is emphasised that the different options for natural regeneration is poorly supported by empirical knowledge. From a capital management point of view, the results are used to estimate potential losses in capital yield of adapting forest management strategies to a different real rate of discount than elsewhere in the economy.

The results from the project were provided to the Ministry of Agriculture during the work with the Report to the Parliament on the national forest policy, which was submitted to the parliament in December 1998. Despite the fact that the questions raised in this work is fundamental for an evaluation of the economic performance and profitability of timber production, these issues are not discussed explicitly in the Report to the Parliament.

Control of Sustained Yield and Productivity of Forest Designed Stochastically.

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Forests are during their growth influenced by adverse natural factors the most important of which being damage caused by wind, fire, insects, snow, man, especially at last half century by industry, wars etc. These processes have a stochastical character and represent the main risk of forest management. The summing up of this risk into economical considerations and calculations is therefore of great importance for the improvement of control of forest sustainability and production. The long-term character of forest production requires a suitable organization of the forests as to their surface distribution according to age in order to attain steady and sustained forest production which should represent at same time a long-term maximum. Consequently, the age structure of the forest must be suitably arranged on the basis of optimum rotation period.

The author studied a lot of time the use of theory of random processes, especially of Markov chains (in close connection with theory of renewal and systems of differential equations), in solving these problems. Author's results (see literature) are referred in common with works of Suzuki in a number of European scientific articles and monographs.

On this base, a new theory of sustainable forest (normal forest) is offered, based on the consideration of salvage cutting, with help of the theory of random processes, in dynamic point of view.

A main part, the theory and estimation of forest calamities are dealt with. Here, the basic functions of the theory of reliability are used, expressed on the basis of Weibull's distribution - the basic types of damage of forests that cannot be more precisely defined.

Modeling the development and scenarios of sick forests by means of random processes is the next part of applications of this principle. A general model of the development of sick forests has the importance where nonhomogenous Markov chains are used.

A special part of this work is the theory of optimal steering of the process of adjustment to normal forest (sustained yield), defined stochastically. The process of adjustment is optimized by continuous linear programming where the criterial function maximizes the final felling by the time of adjustment period. There is possible a lot of other constrains taking into account (market and nonmarket conditions, standard economical constrains etc.).

Introducing an Approach for the Computation of Forest Allowable Cut

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Traditionally, allowable cut (AC) in Iran is computed on the basis of average tree increment in a unit area of forest (Asli & Etter 1969). Then the average increment is simply multiplied by the area of forest district, which would result, the AC of the forest district. In this approach, the whole forest area is considered homogenous, when the AC is supplied for tree making in the later cutting operations. Such procedure has resulted in over cut in some areas, which are not ecologically capable areas it has caused undercut. A new approach is introduced to overcome these over and undercut in forest district of Iran. First, forest district is divided into homogenous areas of arbitrary ecosystems (Makhdoum 1992). Second, in every arbitrary ecosystem, forest ecological capacity would be evaluated, classified, and mapped. Then, for every capability classes of forest district the AC would be computed. By this approach tree marketing would be based on the actual forest ecological capabilities, which is shown on the capability map, rather than on an average figure for the whole district.

The Implementation of an Integrated Land Management Information System to support the Plan Sectorial Forestal del Entorno del Parque de Sierra Espuña, Murcia, Spain.

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Sierra Espuña Natural Park is located in the province of Murcia on the Southeast area of Spain. As a consequence of a new natural resources management regime established in the region, an Integrated Land Management Information System (ILMS) was proposed in order to ensure that sustainable forest/environment management is achieved within the target area. The objective of the project is to formulate an integrated forest management plan over the total project area, which includes almost 15,000 ha of forested areas on which long, medium and short term forest management plans will be developed and analyzed. At the same time, the management of other lands with different uses and structures will be included in the planning process so that a global and integrated plan for forest, agriculture and other lands can be developed.

In order to achieve this, an Integrated Land Management Information System (ILMS) was proposed to support the implementation of the Plan Sectorial Forestal del Entorno del Parque de Sierra Espuña. The goal of the project is to improve the integrated management of forestry and other social-economical objectives of Sierra Espuña and surrounding areas. The territory to be managed is close to 30,000 ha within 3 different management zones as defined by the Sierra Espuña Natural Resources Management Plan (a legal document).

The ILMS is envisaged as an integrated system that will be used to support the planning, implementation and monitoring of multi-objective forest management activities for the Sección de Espacios Naturales, Unidad Técnica of Consejería de Medio Ambiente, Agricultura y Agua of Murcia Region, Spain. The ILMS will be used by managers for strategic, tactical, and operational planning and implementation, and operational control in the Unidad Técnica. Besides the databases and models required to support decision-making in the management process, ILMS will also include the ability to maintain data on current forest inventories and generate maps of spatially-oriented data. The two main components of the ILMS, which will be necessarily be linked, are an Integrated Forest Management System (IFMS©) of FORCE/Robak Associates, Ltd. and a geographic information system (CARIS©) of Universal Systems Ltd.

Contribution to a more Rational Management of Heterogeneous uneven-aged Forests in Rio Grande do Sul (Brazil)

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The management of heterogeneous, uneven-aged forests is a major challenge of forestry in the outgoing 20th century. Estimates show that Brazil has about 546 x 106 ha of native forests. 68 x 106 ha of them seem to be currently available for wood supply (FAO, 1998). Many of the remaining native forests are in danger of disappearing due to timber exploitation and the advancing agricultural frontier. The new forest legislation, however, requires a management plan for native forests in order to attain sustained yields. Management of native forests is seen as capable of meeting the demands of society towards the maintenance of the principal forest functions. Furthermore, the discussion about certification of timber products increases the pressure for a management of native forests on a sustained basis. The management systems of heterogeneous forests are commonly classified in monocycle and policycle systems. In the former, the total amount of wood is removed in one operation; in the latter only proportions of the wood are cut in several and shorter cycles. Quite many policycle systems are used in practice, among them the Tropical Shelterwood System, the Malaysian Selective Management System or the Celos System of Suriname. Principal methods of regulation in heterogeneous and uneven-aged forests are:

- Transition matrix
- Diameter-limit-method
- Basal-area-maximum-diameter-q-approach.

Based on de Liocourt's observation of a reversed J-shaped stem distribution curve in Central European selection forests, the concept of the balanced forest was developed by introducing the regulation factor q. There, the ratio of the tree number in subsequent diameter classes remains constant. By setting a diameter goal and a remaining basal area of the stand, a balanced distribution of trees in a heterogeneous forest can be attained. This approach frequently has been denominated the "Basal-area-maximum-diameter-q-approach".

The intensity of intervention has to be determined on the basis of increment evaluation. The percentual volume increment, calculated on a species, or ecological group basis, seems to be a promising approach in order to determine the periodic allowable cut. With methods like the so-called "Mexican Method" (periodic increment is calculated with the aid of a compound interest formula), it is possible to determine the wood to be removed, so that the existing growing stock will not be affected during a planning period. This amount of wood has to be removed according to the desired stem distribution curve. Recommendations concerning silvicultural treatments are inevitable to promote growth and regeneration of desired (valuable) tree species.

A Review of Forest Management in Venezuela and Perspectives on Sustainable Development

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Venezuela is considered a pioneer country in neotropics forest management. In 1970 the government awarded the first long term concession, 20 years after the first forest reserves have been created. At the same time, a Research Program with Management Purposes started in the Caparo Forest Reserve. During the first decade of this program the technical basis for the management of lowland forests in the north of the country were established. This knowledge was also used to initiate forest management in the south of the country, which possesses the highest proportion of the forest in Venezuela. After almost thirty years, however, forest management is the subject of severe criticism. In this paper we examine its strengths and weaknesses and propose solutions towards the building of sustainable development. Among the achievements during this period we mention the awarding of more than three millions ha of forest in long term concession with management purposes, the design and application of a forest stratification system of great utility for management planning, the development of economically successful forest regeneration methods and the carrying out of one of the most complete forest species trials in South America. Furthermore, the long term concessions in the lowland forests assured, or a time, their permanency. However, at present these forests have almost disappeared, due to strong human pressure and the scanty results of forest management. It was assumed that the benefits of forest management would be extended to the human population; unfortunately this expectation was not fulfilled. In reality, the social component received the least attention during the mentioned period. Furthermore, the forest sector's contribution to the country's Gross National Product did not increase, remaining as low as 1%. Similarly, the majority of the adopted forest regeneration methods were based on either the simplification or transformation of the forest, ignoring natural forest dynamics. This approach has generated strong criticism regarding biological diversity conservation. Likewise, the indiscriminate use of minimum felling diameter, inappropriate felling cycles and the application of selective logging methods characterized by deficient planning and high impact have led to forest deterioration, thus casting doubts on the ecological and economical sustainability of the system. Forest management flaws has been attributed to deficiencies in public and private forestry organizations and the existence of a political system that has allowed, or even stimulated, widespread corruption. Due to the seriousness of the situation, we propose a complete revision of forest management in Venezuela that should lead, among other goals, to the strengthening of the forest sector, the development of new policies on forest concessions, a more effective incorporation of local communities, a higher benefit for the country, and lower impact on the forest.

4.04.04 Economic planning systems for forest management

Does Standard Discounting Incorrectly Show an Advantage of Leveraging Forestry Investments with Debt?

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Typically one uses a risk-adjusted discount rate (RADR) larger than the risk-free rate to calculate the net present value of a project with risky cash flows. In those cases, one can show a present value advantage of borrowing funds at a loan interest rate lower than the RADR. This results because, under the above conditions, the negative present value of loan payments will be less than the positive loan value. Using a zero inflation example for simplicity, at a 5% loan interest rate, annual payments on a \$100,000, 10 year loan will be \$12,950. Incorporating this loan into a discounted cash flow analysis using a 7% real risk-adjusted discount rate, the negative present value of loan payments is $90,955, or $9,045 less than the loan amount, thereby boosting the project's present value. However, the borrower should view loan payments as risk free cash flows based on a legally binding contract, in which case payments should be discounted with a risk-free rate, say 3%, which is lower than the risk-adjusted rate and lower than the loan interest rate. In that case, the negative present value of loan payments will exceed the loan value because the loan interest rate will be above the risk-free discount rate. For the above example, the negative present value of loan payments would be $110,466 at 3% interest, which is $10,466 more than the loan amount. Thus, the previously-calculated present value advantage of borrowing is really a disadvantage. Analyses show how results will vary depending on levels of relevant interest rates, inflation, income tax interactions, loan duration, project life, and the degree to which borrowing increases the overall risk of a project. Forest policy implications are that typical discounted cash flow analyses of leveraged forestry investments could make borrowing appear deceptively attractive. The result could be overpayment for leveraged investments in forested properties or forest management. The analysis raises interesting questions about economic efficiency. Do incorrect analyses of leveraged investments cause a sub-optimal distortion toward higher borrowing levels? Could the result be higher-than-optimal levels of leveraged forestry investment, strictly from a financial efficiency viewpoint? Further research is needed to determine the degree to which such inefficiency is manifested in actual practice in forestry and other investment areas.

4.12.00 Integration of GIS and Remote Sensing for Assessment of Forests and Landscapes

Assessing Biodiversity - SPOT Satellite Image Analysis for Tree Species Diversity in Uganda

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One of the challenges of forest management is to satisfy both the need for forest products and to conserve biodiversity. A common approach is to spatially separate the forest into different management units, according to the assigned production or conservation function. This assignment should be based on information about the production and biodiversity status and potential of the forest. This study investigated the existence of possible relationships between the digital numbers (DN) and NDVI values of a SPOT XS satellite image and field-measured biodiversity indices. For this, the Shannon index, based on tree species? 10cm dbh in sample plots, was used. Moreover, an assessment was made of the GPS accuracy in field plot location. No good relationships could be established, leading to a further investigation in the biodiversity index itself that was used. Although no further improvement in the sought relationship could be established, a systematic analysis of the index behavior under a variety of species combinations showed that the Shannon index is not robust, and may have to be modified in order to represent the local tree species diversity.

Development of National Forestry Information System (A Case Study In Kelantan)

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With a combination of techniques such as Remote Sensing (RS) and Geographical Information System (GIS), the development of forest information system becomes very useful in ensuring sustainable management of forest resources. In general, Forest Information System (FIS) should contain important information such as the extent and distribution of the forest resources, the various information on silvicultural and management practices as well as other forms of databases related to the production and economic aspects of the resources. The system should be comprehensive and can be used in assisting decision making process by the policy makers. This paper highlights a comprehensive Forest Information System based on a case study done in the state of Kelantan, Malaysia. The system is based on geo-referenced sampling and the combined use of multi-source data, e.g. remote sensing and Geographical Information System (GIS) in a PC environment. It is customized for forest resource inventories, management planning and monitoring of changes and dynamics of forest ecosystems. It can be flexibly applied to both strategic and operational planning. Advantages of Forest Information System (FIS) covers aspects as effectiveness, efficiency, and supplement of basic applications for forest benefits. On one hand, the Forest Information System (FIS) will facilitate integrated and flexible management of forest

resources both for strategic and operational planning at reasonable costs. On the other hand, the system can be modified for the purposes such as monitoring of forest dynamics and environmental changes.

Utilization Prospects of Digital Aerial Orthomosaics in GIS and FRIS

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The poster presents the latest developments of an airborne digital image acquisition, image mosaic creation and mosaic utilization. The developed methods are reviewed for their utilization potential in GIS (Geographical Information System) and FRIS (Forest Resource Information System) particularly in regions where the use of traditional optical remote sensing data is difficult, for instance in the tropics.

The poster would focus in the following issues: A) The small format digital aerial imagery itself, B) the creation of digital geocoded orthomosaics, C) the interpretation of mosaics and D) the utilization of mosaics in GIS and FRIS.

The system is in operational use and more than one million ha on four continents have been imaged and processed for forestry mapping, land use planning and monitoring of natural resources. Further developments are on way for A) conversion of the mosaicking software to be used for any aerial imagery data, B) digital false-colour imagery (RG+CIR) and C) image processing system based on parallel computers.

Satellite Remote Sensing Technology for Forest Type Classification and Inventory with Special Emphasis in Malaysia

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In accordance with the national objective and priorities and in compliance to international agreements, the forests in Malaysia will continue to be managed not only to ensure the sustained supply of timber and non-timber products, but also to maintain environmental stability, provide sanctuary for wildlife, as well as to conserve biological diversity. In this endeavor, Malaysia faces serious challenges ahead which calls for further dedication, prudent planning and wise management. Issues ranging from the timely and cost-effective acquisition of inventory data, organization and proper management of the information, the development of sound plan and effective implementation on the ground, need to be adequately addressed. The advance in satellite remote sensing technology has provided one way to make monitoring forest activity easier. The objective of this paper is to highlight the application of remote sensing in forest type classification and inventory. The paper presented previous studies of using remote sensing data in forest type classification and forest inventory to estimate forest stand and timber volume. It can be concluded that satellite remote sensing has the most potential in forest type classification and inventory to be operationalized for macro-forest planning in Malaysia. However, high resolution remote sensing data such as THEMAP airborne data taken from aircraft need to be further investigated for the micro-planning of forest management due to its high resolution capability for tree counting and mapping.

Study of the Seasonal Changes of Spectral Reflectance of Forest Vegetation

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Keywords: forest vegetation, remote sensing, spectral reflectance characteristics, seasonal change, and purified reflectance analysis.

This paper uses Landsat TM data to study differences of spectral reflectance and the spectral heterogeneity of different vegetation types caused by seasonal changes. It aims to find the best imaging season and sound data processing logic for monitoring forest vegetation. Results revealed that there is a significant influence of vegetative reflectance produced by seasonal change, yet the quantity changing in each TM band is not consistent. In spite of this fact, the basic reflection properties of visible and near infrared wavelength light are almost identical and distinguishable in a year's duration for both vegetation and bare land if viewed from the pattern of spectral reflectance curves. This implies that it is possible to detect illegal development in a forest with remotely sensed data. Photosynthesis can directly and indirectly affect the visible and near infrared reflectance of trees, such as conifers, broadleaf trees, and bamboo; while background materials can also enhance the spectral reflectance of grass as a result of the photosynthesis process. In spring, the beginning of the plant growth season, physiological processes rarely change the total leaf area and canopy structure; furthermore the solar elevation is high enough to decrease the shadow area in the spring image. These conditions indicate that the spectral characteristics of plants are most stable in springtime. Further considering the best classes divergence and classification accuracy of the spring image revealed in this study, one can conclude that spring is the most suitable season for detecting forest vegetation with TM data. In the presence of the relief effect in an image, the spectral reflectance deviation of an object always expands. The light reflectance purification method separates the reflectance of an object into 5 classes, and hence can minimize the data deviation of each class. Results also revealed that the purification method is better than the relative proportion transformation method in reducing terrain effects in this study; and hence one can use this logic to process multispectral scanner data to upgrade the accuracy of classification in forest vegetation monitoring.

An Investigation into the Potential of High Resolution Stereo Satellite Imagery (IRS-1C) for Forest Inventory

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The deficiencies in detail and information content have so far imposed substantial constraints on the exploitation of satellite imagery as a mapping and measuring tool. In contrast, the new high resolution satellite imagery in marriage with a softcopy environment provides potential benefits such as improvements in accuracy, flexibility, efficient processing and reduction in cost.

The aim of the investigation has been twofold: firstly to scrutinise the performance of the DTM tools as provided by the Leica/Helava system centred on the extraction of terrain data from stereo satellite imagery (IRS-1C), and subsequently to perform a feasibility study on the application and/or development of a practically viable forest inventory design.

My approach used a softcopy photogrammetric workstation, IRS-1C panchromatic satellite imagery, and digital aerial imagery. The aerial images were obtained by scanning panchromatic aerial photographs at a nominal resolution of 15 micrometers. All the tests were carried out on a Leica/Helava DPW 770 softcopy workstation. The study was conducted over various sites in the Sabie area (Mpumalanga) in South Africa, where extensive man made forests (predominantly pine and eucalyptus) are to be found. An IRS-1C subscene representing an area of 70x70 km was chosen, for which a network of highly accurate ground control points were used as reference. The extraction of stand parameters such as tree/stand height was performed manually as well as automatically. The Digital Surface Models (DSMs), as representing the canopy structure of the stands, extracted from the IRS-1C imagery were validated through a comparison of the resulting contours with the corresponding contours generated by aerial photogrammetric methods.

The manual determination of tree/stand heights on the IRS-1C imagery yielded accuracies of up to 95% compared to the terrestrially obtained measurements. However, the results of the automatic extraction of height parameters in the plantations did not turn out to be very useful.

The prevailing situation in the forestry sector is characterised by the dependence on labour-, and cost-intensive inventory methods. The results are of considerable relevance to those concerned with the inventory of vast, inaccessible forest areas and for those searching for highly efficient, cost-effective schemes.

Monitoring Mangrove Deforestation Using Satellite Optical and Radar Data: A Case Study from East Kalimantan, Indonesia

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Mangrove forests are one of the primary features of coastal ecosystems throughout the tropical and subtropical region of the world. Mangroves are rich in biological diversity including many varieties of flora and fauna. Various kinds of fauna including shrimp, fishes, crabs, molluscs, mammals, reptiles, birds, insects and micro-organisms are also found in mangroves ecosystem. Mangrove forests have been utilized for food resources, firewood, charcoal, timber and other minor products. The mangrove forests are complex ecosystem because they represent an interface between two clearly contrast ecosystem. Firstly, terrestrial ecosystem represent by inland forest, and secondly marine ecosystem represent by community coral reefs and community sea grass meadows. Mangroves are very sensitive and fragile resources. If damaged, it will take a lot of efforts and time to bring back to a close to the original condition.

The pressures of increasing population, food production, industrial and urban development have caused a significant proportion of the world's mangrove resource to be destroyed. As population rose, the shortage of productive land in underdeveloped countries resulted in mangrove swamps being converted to agricultural purposes and the provision of fish and shrimp ponds for commercial production. Much of the reclaimed land proved unsuitable and today it lies derelict. To control or monitor or manage the mangrove forest, an up dated spatial information is essential. Remote sensing is an important source of spatial data. Two major remote sensing sensor systems exist: active sensors (using their own energy), and passive sensors (using natural solar energy). Radar is an active sensor, which transmits and receives a microwave signal. Some advantages of the use of radar in remote sensing are that it can be used during both day and night, has all weather capability (cloud cover, rain, fog, atmospheric dust, etc.), and its energy has the ability to penetrate through some surficial features.

The objective of this research was to monitor the mangrove deforestation using optical and radar satellite images. In this study, GIS approach was applied to investigate the mangroves deforestation in Delta Mahakam River, East Kalimantan, Indonesia. The main aims of this overlaying are to know how big the mangrove areas in Delta Mahakam River were deforested and to show where are the locations of the deforestation during period of 1982 to 1996. The result of overlaying showed that the total area of mangroves in Delta Mahakam River are increasingly depleted during 1982 to 1996. In 1982 the total area of mangroves area 96,228 ha and becoming 91,827 ha on 1994 and 78,799 ha on 1996. The results showed that deforestation in the Delta of Mahakam River altered the mangroves to: oil extraction areas, agriculture or orchard establishment and shrimp ponds establishment.

4.04.02 / 4.13.00 Sustainable forest management under conditions of growing global pressures

The Profit from Trust Thinning with GIS at the Forest Owners' Cooperative in Japan

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Keywords : Trust thinning; Thinning profit; The forest owners’ cooperative; Geographic Information System (G.I.S); Personal computer

The profits that the forest owners’ cooperative makes from thinning with Geographic Information System(GIS), are considered. The forest owners’ cooperative in Japan, is founded on the Forest Cooperative Law. The forest owners’ cooperative is entrusted by the forest owners to execute forest operations, and make the forest operation plans. The amount of business at the forest owners’ cooperative is growing every year, so the cooperative is becoming the core of the forest enterprises in various regions in Japan. In the case of thinning by the Kuma-mura forest owners' cooperative in Kumamoto prefecture in Japan, thinning profit is found by deducting expenses from proceeds. The thinning evaluation record, made from the tally of these sales and expenses, becomes an estimate of thinning.

However, the calculation method becomes more and more complicated these days. One reason is the diversification of forestry machine to lighten the labor strength. For example, in extraction work on thinning, the group of laborers attached to the forest owners' cooperative can use the yarder(winch), crane truck or mini-forwarder to reduce man-hours. Similarly, in the work process, there are some methods which the group can select. The person in charge at the cooperative must consider which work methods will increase profit the most.

In making this calculation, the computer is useful. So, for utilizing a personal computer, an estimate making system has been developed. This system can freely change the variable of expense, average price of wood market necessary for sales calculation, etc. Therefore this system can simulate profits attainable by using various work methods or processes of thinning, simply and cheaply. And using the forest information system which applies the technology of GIS, the stands to be thinned, can be selected. In this study, with this information about these thinning stands and the estimate making system, the profits from thinning are evaluated.

In conclusion, thinning was carried out within a 100-meter range on either side of the spur road in process with GIS. By the simulation with GIS, a higher profit was obtained by group thinning than by individual thinning. The profit was higher with the mobile yarder than with the standard yarder. It was also noted that the spur road establishment enterprise costs were higher than the profit on thinning. Therefore, some financial support is necessary for the spur road establishment.

Economic Valuation of Carbon Sequestration by a Forest Stand: Precondition to the Political Use of Forestry against Greenhouse Effect

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Forestry is more and more considered as a useful and efficient tool that could help to stabilise atmospheric concentrations of carbon dioxide. More precisely, forest plantations could be marginally substituted to emission reductions. This possibility could be implemented by the way of either a taxation system or a real carbon market. It raises several questions of economic nature: governments have to determine the general frame in which this substitution would be authorised (possible locations, species and harvest schedules, surface area for hundred carbon tons emitted, harvest schedule, penalties following a contract breach); inside this frame, a firm would have to find the best choice; moreover, be it owner or manager, a forest operator could negotiate with an enterprise or a government the environmental advantage to sequestrate carbon dioxide.

A quantitative and integrated economic and biological forest model allows to answer such questions. It manages biological processes including stem, branch and root growth, leaf development and fall, mortality, humus mechanisms, wood decay and incineration. It takes into account not only forest stands but also economic activities that process, use, recycle wood and give to it a lifetime at the end of which carbon is sent back to the atmosphere. It is based on management costs, wood prices and carbon price or cost. It allows to analyse the cash flows generated by a stand during its rotation as such as the main physical and monetary carbon flows during the rotation and beyond. The present values of these flows can be simply calculated or optimised and provide the economic benefits of wood production, of carbon sequestration and of both phenomena.

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5.00.00 Division 5 Meetings

Small sized broadleaves – added valued chains for a growing resource

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Small sized broadleaves represent a substantial part of the forest resource world-wide. This is also true in Europe, where new silvicultural strategies promote broadleaves for ecological reasons. Therefore within the next decades, growing quantities of small sized broadleaved timber from thinning, plantations and copice forests, will come to the wood markets. In contrast to small conifer logs, small broadleaves still represent resource of a low value, substantial proportions are still used for firewood only. Today it is difficult to achieve a higher added value due to log and fibre characteristics: Small broadleaves usually show a bad quality in terms of straightness of the bowl, taper, branchiness and a very variable internal structure of the wood (fibre deviation, tension wood, short fibres) and bruncheness. There exists a conversion technique (sawmilling, pealing, slicing) especially adopted to small conifers logs, a comparable specialised technique for small broadleafs is still missing. In Germany in central Europe, beech (fagus sevatica) presents a remarkable part of small broadleafs. An integrated research concept had been developed an executed, which aims to overcome these ”natural” disadvantages of small broadleafs by the following steps: Analysing the future resource and the existing markets, testing developed cross cutting and sawing techniques for badly formed small broadleaf logs, analysing wood structural and fibre characteristics typical for small beech logs. Conclusions are drawn and strategies are developed to improve the added value of small sized beech logs at the different steps of the forest-wood-industry chain. Key-words: small sized timber, wood-quality, processing, added value, fagus silvatica.

Wood Identification for Utilization of Timber in Nepal

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Nepal is rich in forest products. Different species of timber plants are extensively used, 85 species of timber trees are recorded. Among them more than 40 species are used for different purposes e.g. furniture, beam, poles etc. However due to technological limitation, there is under utilization of forest resources. The paper examines the problems and issues of timber identification in Nepal and works on the strategy for better utilization of timber products through technical capacity building and developing identification method.

Timber identification as a key role to effective utilization has not been given the much needed impetus. Many wood users are facing the problem of wood identification. The main problem of misidentification and underutilization and undergrading of timber species are the lack of timber identification manual, trained manpower, research and training facilities and modern equipment.

Treatability and CCA Preservative Macrodistribution in Rubberwood (*Hevea brasiliensis* Muell. Arg.)

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Today, rubberwood is mainly used for furniture manufacture. However for rubberwood to be use exteriorly, preservative treatment is necessary. This study evaluates the treatability and macrodistribution of CCA component in rubberwood. Rubberwood samples were quarter-sawn cut into blocks of 35mm x 35mm x 125mm. Blocks surface were sealed to permit chemical penetration in only one or two direction at a time. A set of blocks were pre-steamed prior to sealing process. Treatability was measured by chemical penetration and retention of CCA type C after pressure treatment. Preservative distribution was evaluated through microscopic observations of CCA distribution in various tissues such as vessels, fibers, and rays. The penetration and retention in the radial direction was about 3 times higher in the

tangential direction. Longer pressuretime favors the penetration and retention of chemical in rubberwood. Complete penetration was achieved after 4 hours of pressure treatment. The CCA preservative components distribution patterns in different types of tissues will be observed. Complete data will be presented in the conference.

Current Status on the Subsistence Use and Trade in Mangroves along the Kenya Coastline

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Mangrove exploitation has been going on for many years with exportation to the middle East in the first half or so of this century being most common. Mangrove forest are highly valued for their richness in biodiversity i.e. many species of fauna and flora. In the recent past there has been allot of debate on the exploitation and trade in mangrove products in the country. Many local people depend on this vital resource for their livelihood i.e. income and subsistence. In terms of the contribution to the household economy, the contribution of mangroves can be ranked second to fishing. Export trade in mangrove products played a significant role in the socio-economic status of the local people in this country until a ban was imposed in 1982.

A socio-economic survey was designed and carried out with the aim of developing an understanding of the current exploitation and trade dynamics of mangrove forests along the Kenya coastline which covers a distance of 874 Kilometres. This study, therefore, presents the state of information on the current mangrove cover, species, levels of exploitation in three districts and socio–economic implication of lifting the export ban. The study was carried out at three levels where the focus was on the mangrove managers, licensees/merchants, and the local communities. Personal observations and information on secondary data have been incorporated.

The results revealed that mangrove resources are not being utilised on sustainable basis as a result of the increasing population and the expanding tourism industry. There are nine different species of mangroves in Kenya with *Rhizophora nucronata* and *Ceriops tegal* being the most abundant and highly exploited. The annual off-take in terms of poles and posts was estimated at 6,610 scores , 8,704 scores and 23,428 scores as reported by the Forest Department, mangrove dealers and the local communities respectively. The three major products in order of importance from mangroves are: poles and posts, firewood and wood for dhow ribs. Poles and posts are classified into seven different classes based on their diameters. A large consignment of mangrove poles and post were being smuggled into the market without the knowledge of the Forest Department as revealed from the study. Apart from incidences of over exploitation, the other threats include: encroachment from private developers, salt farming and development of fish/prawns farms. These threats have hence attracted a lot of interest from a number of institutions though with very little taking place on the ground. Attempts have been made in the area of rehabilitation though much still needs to be done. The study does conclude by recommending that the lifting of the ban on the export of mangrove products should be based on concrete scientific information like on the silviculture and ecological parameters, consultation with stakeholders, reforming current regulations and policies and the local demand.

Potential Equipment For The Cutting Of Oil Palm Fibres For The Wood Composite Industry

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In Malaysia, the oil palm plantation covering an area of approximately 2.5 million ha will generate large quantity of residues in the form of trunks, fronds and empty fruit bunches (EFB), which can be considered as an alternative raw material for the wood composite industry, particularly particleboard and medium density fibreboard (MDF). For the period of 2001-2005, approximately 10.7 million tonnes of trunks, 262 million tonnes of fronds and 18.7 million tonnes of EFB will be made available in Peninsular Malaysia. Currently, there are 8 particleboard mills and 9 MDF mills, with a total capacity of 600,000 m^3 and 1 million m^3 per annum respectively. Over reliance on rubberwood as the raw material would cause these industries less competitive in future. This would possibly due to among others, scarcity of the rubberwood supply, increase in manufacturing cost as well as market demand for diversified products. Therefore, it is timely for industries to consider using oil palm fibres as another source of raw material. Recently, more concerted efforts to improve the existing technology of processing oil palm fibres have been shown by R&D institutions and private sectors. In view of the high silica and moisture content of the material, emphasis has been on reducing wear and tear of the cutting tools and producing fibres of desired sizes. Thus, this paper will highlight FRIM's experience in assessing the prototype of fibre cutting technology which is commercially viable for the wood composite industry. In addition, this paper will also discuss the reliability, flexibility and conformity of the prototype in processing oil palm fibres to be used in the particleboard and MDF industries.

Keywords: oil palm fibres - particleboard - medium density fibreboard (MDF) - processing technology - cutting technology - prototype

Pulping of Jute Plant by Neutral Sulphite Anthraquinone Process

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Today, by far the largest amount of pulp is produced from wood, but interest is growing in the utilization of non-wood fibres. In many countries, the wood supplies will not continue for long to meet the rising demand for pulp and paper. In many countries wood is not readily available for pulp making. In such a situation non-wood fibre like jute plant may be a valuable source of pulp raw material.

Several studies were previously conducted on pulping of jute plant by the alkaline processes. But the response of the plant to alkaline pulping is poor. Neutral sulphite anthraquinone (NS-AQ) process has proved more advantageous over the alkaline processes with retted jute bast fibre. Hence, the response of jute plant to this process needs to be investigated.

It has been observed in this study that NS-AQ process responds well in pulping of jute plant. The process is capable of producing a significantly higher yield compared to the alkaline processes. The physical strength properties of NS-AQ jute plant pulp stand in between hardwood and softwood kraft pulps.

Success of commercial utilization of jute plant in pulp making largely depends on effecient means of collection, transportation and storage of the plant. Hence due attention to these problems must be given.

How Wood and Paper Products are Meeting a New Societal Need by Sequestering Carbon

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The 1997 Kyoto Conference of the Parties to the United Nations Framework Convention allows the possibility that countries may be able to offset emissions of carbon to the atmosphere with sequestration in forest or other sinks in order to meet objectives to reduce net carbon emissions to the atmosphere. A number of studies worldwide have suggested that accumulation of carbon in wood and paper products may be a significant and growing sink of carbon. This paper reviews research that has evaluated how carbon is accumulating in products in the United States and projects future accumulation using Forest Sector models that project forest products production and use.

The paper provides historical estimates and projections of U.S. carbon sequestered in wood and paper products, and compares them to amounts sequestered in U.S. forests. There are large pools of carbon in forests, in wood and paper products in use, and in dumps and landfills. The size of these carbon pools is increasing. Since 1910, an estimated 2.1 Pg (billion metric tonnes) of carbon have accumulated and currently reside in wood and paper products in use and in dumps and landfills, including net imports. This is notable compared with the current inventory of carbon in forest trees (13.8 Pg) and forest understory, floor, and soils (24.3 Pg) (Birdsey and Heath 1995). On a yearly basis, net sequestration of carbon in U.S. wood and paper products (additions including net imports, minus emissions from decay and burning each year) is projected to increase from 61 Tg/year in 1990 to 74 Tg/year by 2040, while net additions (sequestration) in forests is projected to decrease from 274 to 161 Tg/year. One Tg is one million metric tonnes. Net sequestration is increasing in products and landfills because of an increase in wood consumption and a decrease in decay in landfills compared with phased-out dumps. Annual additions to forest, products, and landfill carbon stocks are slightly greater than annual drain of carbon from the atmosphere. Forest, and product and landfill stocks increased 333 Tg/yr in 1990, while net drain to forests, products and landfills was 331 Tg/yr in 1990. This difference is because net additions to stocks includenet imports while annual drain from the atmosphere does not. We can increase additions to the stock of carbon in products, landfills and forests while satisfying the same projected needs for wood and paper products (with same net imports) by 1) shifting product mix to a greater proportion of lignin-containing solid wood, paper, and paperboard products, which decay less in landfills, 2) increasing product recycling, and 3) increasing product use life. Carbon dioxide equivalent emissions would also be reduced by the actions noted above which increase stocks. Emissions would also be reduced by increasing landfill CH}{\fs22\sub 4}{\fs22 burning in place of fossil fuels.

Heartwood Proportion Models for Pine

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Keywords: Cambium age, Heartwood, Radial growth rate

The durability of Scots pine (*Pinus sylvestris*) heartwood far exceeds that of other Finnish commercial timbers. Obviously, there would be general interest among lumber buyers, window and outdoor woodwork manufacturers in buying pine heartwood as a separate item if it were available. The biggest obstacle to better utilization of such lumber is the difficulty of separating heartwood in the sawing process. In this poster a set of models is presented that allows us to predict heartwood taper for Scots pine (*Pinus sylvestris*) while handling the tree at harvest if the age of the tree is known. The study material comprises 59 sample trees from five Scots pine *(Pinus sylvestris)* stands in southern Finland.

In accordance with many previous investigations the number of rings in heartwood of any tree height is under a control of time and is thus best predicted by cambium age. The results suggest that the heartwood start to form at the age of 20-21 and increases by circa two-thirds year rings annually after it has been initiated. In order to apply this model in practise we need accurate estimates for the cambium age and the radial growth rate.

If tree age at the stump height can be given from other sources (e.g. historical records), cambium age for any height of the tree can be predicted by tree age and stem taper values (i.e. height and corresponding diameter) provided by the harvester head. In order to predict the heartwood taper, we not only need to know the number of rings in the heartwood but also how fast the diameter of the tree has been grown up to this stage of life. The cumulative radial growth rate for certain height and distance from the pith can be derived from cambium age and corresponding stem taper values.

The residual analysis suggests that the set of models created slightly overestimates heartwood radius with small diameter values and correspondingly underestimates heartwood radius with big diameter values. On the other hand, the set of models gives slightly biased results (+1,5 mm). The root mean square error (RMSE) for heartwood radius with the current data is 10.7 mm which means roughly 2 cm in diameter.

Demand Analysis and Policy Discussion of Pulp and Paper in China

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Along with the rapid advancement of the national economy and the sharp increase in demand for paper products, China's pulp and paper industry has scored remarkable development since the mid-1980s. In 1994 the production of paper products reached 21.38 million tons nearly tripling the production in 1981.

Despite of the rapid development in China's pulp and paper industry in recent years, the domestic market demand can not yet be met not only in quantity, but more importantly, in quality and variety the end users require. Due to the fact that 60% of the raw material for pulp making in China is crop straws, wood pulp (including imported wood pulp) only makes up about 14% and waste paper 25%, sufficient quantity and high quality paper and various special paper products can not be produced in China at present. Each year China spends more than US$ 3 billion on the import of wood pulp, paper and paper products totaling almost 4 million tons. However, the excessive import not only intensifies the burden of the country's foreign exchange, but also restrains the development of pulp and paper industry in China to some extent.

As a country with big population and limited forest resources, China must further develop its pulp and paper industry under the principle of sustainable development. According to the national plan, it is expected that the consumption for paper and paperboard will be increased from 29.789 million tons in 1994 to 71.728 million tons by 2010, and the production capacity of paper and paperboard by year 2010 is expected to reach 40 million tons, of which 22% should be from wood pulp. The major challenge is how to find a proper way to increase the supply of pulp and paper products so as to satisfy the growing demand by the rapid growth of the national economy and the improving of living standard of the people under the condition of limited timber resources.

This paper analyzes the present status and the trends of production, consumption and trade of pulp and paper products in the world and in China, and put forward resources, industry and trade policy recommendations including the development of pulpwood plantations, restructure of pulp and paper industry and trade, etc.

Forest Products Research in IUFRO: History and Future in Meeting Society's Needs

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When silviculture researchers in central Europe were gathering together to form IUFRO in 1892, forest products researchers were occupied with making useful forest products and conserving the forest resource through wise use. Forest products researchers did not become an active part of IUFRO until 50 years later. Research in forest products was stimulated by World War I and II-wood was essential for airplanes, ships, packaging, construction, and derived products. As World War II drew to a close, the newly established United Nations provided a forum for bringing together efforts that would encourage world stability and peaceful development. Utilization of forest resources was an important element in this effort, and those involved in this area found common ground. Initial efforts were focused on mechanical conversion of wood, but wood quality, wood chemistry, and wood protection soon captured the attention of researchers.

Meanwhile, IUFRO had been growing in both size and scope. The organization recognized the need to include the effective utilization of forest products, together with other aspects of forestry, as a key element in ensuring that forests could meet the increasing demands of society. Thus, forest products research was incorporated as Section 41 of IUFRO at the XI Congress in Rome in 1953. This program was greatly expanded at the XIII IUFRO Congress in Vienna in 1961.

The rapid growth in size and scope of IUFRO during the next decade led to a complete reorganization, which was formalized at the XV Congress in Gainesville, Florida in 1971. From this arose Division 5, which included subject groups on wood quality, wood engineering, wood protection, and wood processing, each with several specialized working parties, and a project group on properties and utilization of tropical woods. All of these reflected the increasing scientific and technical needs for wise use of the forest resource in both domestic and international industry and the increasing trade in forest products from the tropics as well the industrialized world.

Since that time, the program of Division 5 has broadened to recognize new needs for research on forest products as scientists in various parts of the world have sought a forum for sharing ideas, notes, and accomplishments. The results have been many: (1) new knowledge of wood quality factors, (2) new approaches to the efficient use of wood as an engineering material, (3) effective processing methods to deal with the growing diversity of resources, processing conditions, and product needs, (4) effective, environmentally friendly methods of wood protection, (5) new concepts related to composites of wood and other materials, (6) methods for dealing with the growing trade in tropical woods, (7) more efficient use of wood for energy, (8) better understanding of non-wood products, their sources, and their derivatives, (9) improved use of bamboo and rattan, (10) new advances in growth ring analysis, and (11) broader understanding of marketing techniques to effectively match products to consumer needs.

We face new challenges as we consider the future of forest products research in IUFRO. No major problems are purely technical and disciplinary-they are social, economic, psychological, and traditional. Here are some points we should consider as we plan for what will be reported at the XXII Congress and beyond:

- Develop depth and disciplinary strength within our groups and working parties, but join with others in this and other Divisions to focus on solutions to problems.
- Plan joint efforts to identify and solve forest-related problems, rather than limit efforts to meetings for sharing information.
- Develop planning and management techniques that are uniquely adapted to voluntary organizations.

- Strengthen channels for communication and for transmitting and discussing information.

CIRAD Creates A Molecular Data Bank Of Wood Decaying Fungi

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Keywords: wood protection, molecular data bank, wood decaying fungi

The early detection of wood decaying fungi is a major challenge for wood preservation for the future. Molecular studies of nuclear rDNA can be used as a tool to get an accurate characterization of wood decaying fungi using only 10 to 100 mg of fresh vegetative mycelium. Thus, using PCR, it is now possible to characterize fungal rDNA directly on contaminated woods.

The necessity to have a molecular data bank of these fungi in order (i) to assess the name of a species and/or (ii) to know whether it is a virulent species or not, is clearly demonstrated. One hundred and three species of wood decaying fungi responsible of cubic and white rots from the CIRAD wood preservation laboratory collection have been characterized.

First data of this molecular data bank concern restriction profiles of the internal transcribed spacer (ITS) of rDNA. The amplified region include intergenic spacers ITS1 and ITS2, the 5.8S ribosomal small sub-units and parts of 25S and 18S ribosomal. This region has been digested using restriction enzymes TaqI, Sau96A and AluI. That way, more than 250 different profiles have been identified. In the next future, ITS sequences, other rDNA sequences (e.g.: 18S and/or IGS) and partial sequences of ligninase and cellulase genes will be introduced into this molecular data bank.

This data bank will allow to control fungal strains used during normalised tests in laboratory (natural durability and tests of effectiveness of products). Furthermore, this work might conduce to the elaboration of a method of early detection and accurate identification of fungi decaying wood before fungi have reached an advanced stage of development.

5.01.00 Wood quality

The Effects of Beating Load Programs on Bleached Kraft Pulp Physical Properties

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Keywords: Pulp and Paper; Physical Properties; Beating

Gradual beating effects on fiber length distribution, breaking length and folding endurance of bleached Kraft pulp at different freeness levels were compared with the same physical properties at the laboratory standard beaten bleached Kraft pulp.

Analyses of variance showed that long and short fiber percentages were significantly affected by beating load program. In addition to fines percentages, they were significantly affected by freeness, too.

Gradual beating give the highest mean of long fiber percentage (75.5%) and the lowest mean of short fiber percentage as well (6.9%). The highest percentage of long fiber (77.1%) was at 53 SR (Schopper-Reigler) freeness of gradually beaten pulp.

Breaking length and folding endurance of hand sheet papers were significantly affected by beating program and freeness level. Gradual beating gave the best mean of breaking length (8680m) and folding endurance (654 double fold). The highest value of breaking length (9087m) was obtained from pulp gradually beaten to 63 SR freeness, and the highest value of folding endurance (711 double fold) was obtained from pulp gradually beaten to 53 SR freeness. Breaking length and folding endurance of standard beaten pulps were decreased when the freeness increased more than 43 SR.

Mathematical models were obtained for the relationships between studied pulp strength properties on one hand and fiber length distribution and freeness level on the other. The interrelationship equation between breaking length and folding endurance was obtained for both standard and gradually beaten pulp.

The study showed that pulp physical properties were highly related to controlled beating which maintains the highest possible ratio of long fiber and lowest ratio of short fiber at high level of freeness, increasing of fines ratio didn't show the drawbacks of short fibers ratio increasing.

Wood Quality of Black Locust (*Robinia pseudoacacia* L.) from European Clones and Natural Populations

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Within the framework of the European INCO-Copernicus research program on Black locust (*Robinia pseudoacacia* L.) resources for degraded area rehabilitation, basic and applied technological wood properties of *Robinia* are studied by a pool of Italian and Greek laboratories. The program in progress foresees to assess the wood quality on standing trees and on small specimens of selected clones and European natural populations by the means of both non-destructive (ND) field tests and laboratory tests. Four main topics are scheduled within the research programme: 1) basic technological properties on cores and on small specimens, 2) non-destructive tests on standing trees, 3) early evaluation to estimate the minimal age suitable for wood testing and finally 4) industry-oriented tests. The ongoing standard tests are providing data about basic properties of the material, such as shrinkage and density characteristics of juvenile wood, anatomical properties, sapwood/heartwood proportion. The early evaluation tests are scheduled to estimate the minimal age suitable for investigation on technological properties carried out on young clones coming from genetic selection. These tests will be performed on disks from Hungarian clones 10 and 15 years old. Juvenile wood will be studied by measuring the length of fibres and the anatomical features. Density, shrinkage and sapwood/heartwood proportion will be evaluated and/or measured in order to check the lower age of *Robinia* stem for carrying out technological tests. Moreover, the wood quality will be performed during field tests by means of some non-destructive testing methods on standing trees selected for cut. The methodologies that will be used are: Resistograph (drilling device), Ultrasonic apparatus for standing trees testing, instrumented hammer for sonic analysis on standing trees, and the Fractometer (mechanical tests on cores). The data collected from the above listed instruments will be correlated to the data collected from the wood characterisation tests. The aim of industry-oriented tests is to carry out some tests to improve the industrial uses for Black locust timber. Some properties, such as gluing and drying processes are critical in this species forward the industrial uses. Therefore gluing and diffusivity tests are scheduled. According to potential final uses, standard gluing tests will be performed on two groups. In the first group ordinary specimens will be tested. In the second group the specimens will be soxhlet treated to decrease the wood extractives content before gluing tests. Diffusivity tests will be performed on small size specimens. These tests will provide indications about the drying aptitude of Black locust timber. Drying process will be then performed.

Gains potentiels par la réduction des coûts de la non-qualité dans l'industrie du panneau de fibres

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Mots clefs: Coûts de la non-qualité - Industrie du panneau de fibres - Qualité.

L’analyse économique des coûts permet d’aider la prise de décisions, de fixer les prix et de déterminer les choix entre les solutions alternatives pour la production ou pour de nouvelles implantations (Gormand, 1986). Les systèmes actuels d’information comptable d’une entreprise ont une lacune importante pour le bon développement de la gestion de la qualité d’une entreprise: les coûts de la non-qualité n’apparaissent pas de forme explicite dans les rapports comptables. L’évaluation de ces coûts est nécessaire parce que, même s’ils n’existent pas dans les systèmes comptables, ils font partie des charges de l’entreprise. Un coût de non-qualité est le résultat provenant d’une organisation qui ne produit pas correctement du premier coup (Juran, 1979). L’évaluation des coûts, visant son contrôle, est facteur de survie de l’entreprise. En effet, on peut affirmer que la non-qualité diminue la performance économique potentielle de l’entreprise.

L’objectif de ce travail est de quantifier les gains potentiels qui peuvent être obtenus quand, après la détection des coûts de la non-qualité, les causes analysées permettent l’adoption des mesures correctives qui engendrent la suppression qui génère ces coûts.

Le travail fût réalisé dans une usine de panneaux de fibres durs dans laquelle était implantée un système de détection des coûts de la non-qualité (CNQ) sur l'ensemble des étapes du processus de fabrication: transformation du bois en fibres, formation du mat, pressage, séchage, découpe et conditionnement.

Pour chacune des étapes, la quantification et l'analyse des causes les plus importantes engendrant la déclassification des panneaux au triage et au conditionnement ont été effectué au moyen des outils de la qualité tels que le brainstorming, les graphiques de Pareto et d'Ishikawa. Avec les données obtenues (coûts de production, volume mensuel des déclassés au triage et au conditionnement), nous avons pu calculer les gains en terme de réduction des coûts qui pourrait être obtenue par l'élimination des causes et nous les avons comparés aux coûts de détection des non-conformités du processus.

Parmi ces anomalies, 33% étaient dus à la déclassification de panneaux tachés. Par ailleurs, le coût de la déclassification représentait 0,074 US$/ton en sortie de séchage, alors qu'il représentait 0,53 US$/ton au conditionnement.

Les gains obtenus à ces étapes ont été, respectivement, de 200 kUS$/mois et de 11 kUS$/mois. L'utilisation du calcul des gains potentiels et de la marge de bénéfice de l'entreprise ont démontré que, si la production était effectuée « correctement du premier coup », il serait possible d'obtenir une marge théorique bénéficiaire de 7%.

Les économies provoquées avec la suppression des causes de la non-qualité peuvent facilement compenser le coût de la détection des anomalies du processus, réduisant ainsi les coûts de production proprement dits et disposer d'un produit plus compétitif.

Research on the Properties and Utilization of *Paulownia* Wood in China towards the 21st Century

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Paulownia is one of the most important fast-growing trees in the world. IT is naturally distributed in China, Japan and Korea and have been introduced to Southeast Asia, Australia, New Zealand and Europe. *Paulownia* is abundant in China and farmers like to plant. Research on wood science of *Paulownia* play an important role in the efficient utilization and development of the new wood products. The research results also benefited to the other countries with introduced *Paulownia*. Chinese scientists first described the wood anatomical features in 1936 and in 1944 the physico-mechanical properties of *Paulownia* was first studied. Until the end of 1970's, research had made great progress. Recent work mainly focus on wood variation, secondary processing, and the mechanism of the discoloration of *Paulownia* and its control. The main research results obtained since 1970's consist the following: (1)Determined the main wood properties including anatomical features, physical-, mechanical-, chemical- and machining properties of 9 species of *Paulownia* grown in China; (2)Progress on the theory of wood discoloration and its control in *Paulownia* because the discoloration problem has influenced the end use in producing wood products and wood processing such as wood drying and plywood making;(3)Obtained the wood variations relationship for several species and selected the best hybrid clones from the new breeding clones from the view of wood quality;(4)Developed processing technologies for wood drying, plywood, MDF and particleboard and furniture and chemical utilizations.

Considering the development trend of research in wood science and the problems that affect woodworking , utilization and silvicultural management of *Paulownia* trees, the important research in the future should strength focus on: to study the *Paulownia* discoloration control technology of *Paulownia* wood, to improve the wood quality through genetic and silvcultural improvements, to carry on research on modification of *Paulownia* wood.

Keywords: *Paulownia*; Wood Science; China

Within Species Variations of Standing Tree and Wood Quality in a Tropical Rainforest (French Guyana)

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A better knowledge of wood biodiversity and the increasing of the number of species used are needed for a sustainable harvesting of tropical rain forests. Therefore, research activities on forest products from natural tropical rain forests has focused on the species level: botanical identification, mean wood properties of species, promotion and marketing of secondary species.

However, a sustainable harvesting of natural forests involves an increasing of wood value (standing tree prices) and a decreasing of logging and processing wastes. Thus, forest managers and timber harvesters are more and more interested in wood variations appraisal within trees for the most important (i.e. of higher value and not too rare) species, especially in French Guyana where forests are managed and production costs high.

Different works are in progress and concern:

General diagnosis of main defects for each species. Studies are done in timber yards and sawmills, and also experimental forests.

The main defects are identified: decayed hearts in most of the species, buttresses or grooved trunks (Wacapou: *Vouacapoua americana*) insect decays (Louro Vermelho: *Ocotea rubra*, Mandioqueira*: Qualea spp, Ruitzerania spp*) compression failures silica content, and thick sapwood in basralocus (*Dicorynia guianensis*), ring shakes of Bacuri (*Platonia insignis*) felling shakes in Walaba (*Eperua sp*.), *Wacapou (Vouacapoua americana*). Most of these defects vary a lot within sites and trees.

Description of wood variations and relationships with environmental and growth conditions. In order to explain the spatial variations of these defects, trees are sampled in order to analyze the influence of diameter, soil (or ecological coherent unit including soil, topography), architectural development, growth rate. As the number of sources of variations can be great, preliminary tests are done, using the knowledge acquired in the previous diagnosis and sampling the extreme conditions. Growth rates and tree ages are estimated through tree ring analysis.

Development of methods of quality appraisal in standing trees

As the results of previous studies are not always clear, simple and easy to apply for a reliable appraisal and cartography of wood quality. Direct methods, applicable in inventories, tree by tree, are tested. Visual observations are decomposed and classified in order to allow reliable appraisal. However, some hidden defects cannot be assessed in this way. Felling shakes can be predicted by growth strains measurement. As the estimation of heart decays is of great importance, some temperate technologies are tested: ultrasonic waves are not simple to use as they require a calibration of the propagation time versus the decay amplitude on a great number of trees and give a poor information on the form of the cavity. Special penetrometers must be built, as commercial apparatus are not adapted to tropical conditions up to now. Sapwood thickness can often be measured by increment cores.

Improved Utilisation of Non-Conventional Timbers in India

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Shortage of wood in general and of conventional timber species in particular is being experienced in India. To narrow the gap between supply and demand, plantations of fast growing species are being raised in a big way. Timber from industrial plantations is, often, deprived of quality due to saw milling practices which compromise strength properties in favour of timber recovery, variability in strength properties as compared to naturally grown timber. Predominance of juvenile wood poses problem in sawing and subsequent drying, and also variability in gluing behaviour. Research is being pursued to evolve technologies for processing of such species so as to improve their suitability for various end uses. *Eucalyptus* hybrid (eucalypts), *Populus deltoides* (poplar), *Hevea brazilensis* (rubberwood) etc., are some of the species which have been upgraded and find use in building construction, furniture and joinery, value added packaging like pallets, cable drums and other items. Special sawing techniques have been developed to reduce warp in converted material from eucalyptus, poplar etc., which have high growth stresses. Treatment methods to treat refractory species like eucalyptus have also been developed which have been adopted by the industry to affect economy in use. Rubber wood has also emerged as an acceptable alternative to conventional forest species. It has also been attempted to up-bring colour, texture and decorative features in plain looking plantation timber through ammonia fumigation alone and after bark extract swabbing to match conventional timbers like teak, rosewood, etc. Efforts have been made to develop composite wood products to supplement solid wood as they have the option of using inferior woods, small wood, lops and tops, wood waste and also agricultural residues. As composites have a large potential to reduce the wood content in engineered wood products, it is essential that the cost of manufacture is kept low. A major component in costs of such composites is the government levies on raw material as well as the manufactured products. A variety of reconstituted wood products like plywood and allied products, fibreboard, particleboard, laminated veneer lumber (LVL) from plantation species, structural wood from lops and tops from poplar and eucalyptus, etc., have been developed. Properties of such products can be monitored to make their best use even for structural purposes. For economic production of reconstituted wood products, it is essential that cost component of adhesive is reasonable. Efforts have, therefore, also been made to substitute phenol in phenolic resins with naturally occurring phenolic substances. Cashew nut shell liquid (CNSL) based adhesives; both cold and thermosetting have been developed by condensation with aldehyde using variety of catalysts. Tannin based adhesives using bark extract from *Acacia mollissma*, *Shorea robusta*, wattle (*Acacia mearnsii*), and myrobalon nuts (*Terminalia chebula*) and thiolignin isolated from *Pinus roxburghii*, lignin from spent black liquor of *Eucalyptus* hybrid, *Dendrocalamus strictus* etc., have been tried to substitute phenol in phenolic resin with promising results. Multivalent phenol or tar acids, a coal tar distillation product, has also been studied for substituting phenol in PF resin with encouraging results. The industry has adopted use of lignin, tar acids and other natural phenolic constituents from CNSL in making board products.

Maximization of Lumber Yield (Case Study of a Tropical Ghanaian Sawmill)

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Lumber is an important wood product accounting for over half the total earnings of the forest products export from Ghana. Lumber yield study was conducted in a sawmill in Kumasi, Ghana to assess the existing mill performance in the conversion of tropical hardwood logs. Twenty seven logs comprising ten logs of Obeche (*Triplochiton scleroxylon*), ten logs of Iroko (*Milicia excelsa*) and seven logs of Mahogany (*Khaya ivorensis*) were selected for the study. A mean lumber yield of 39.39% (standard deviation, 4.69%) was determined for the hardwood species. This value appeared to have been influenced by the availability and quality of logs, condition of sawmill machines, processing efficiency, mill operatives and contract specifications. Regression analysis indicated significant (5% level) effect of log diameter on lumber yield. Good correlations were observed between log diameter and lumber yield with R square values of 0.51, 0.81and 0.77 recorded for Obeche, Iroko and Mahogany respectively. Procedures anticipated to maximize yield of lumber were recommended.

Biological and Chemical Investigations of the Composition and Distribution of Accessory Compounds in Discoloured Beechwood (*Fagus sylvatica* L.) after Felling

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The discolouration of raw timber of beechwood (*Fagus sylvatica* L.) after felling and, in sawn logs or boards, after steaming and drying is of considerable economic importance due to the increased demand of lightly and uniformly coloured wood in Europe.

In order to provide practical procedures and techniques for its prevention, individual studies have to be carried out on the biological and chemical characteristics associated with the different types of discolouration. For this reason, it is necessary to identify these discolourations as either physiological processes already initiated in the living tree or as biochemical and chemical reactions during storage or steaming and drying. As soon as the specific reaction mechanisms and accessory compounds responsible for discolouration are identified, methods for its prevention can be developed.

In order to characterize the different reaction mechanisms and accessory compounds, sections from stored, steamed, and kiln-dried beechwood logs were selected. For the study of the distribution of accessory compounds on a cellular level, sections were prepared from cambium to pith. This study on the cellular level was extended to a subcellular level by using UV-microspectrophotometry with a special scanning technique which allows scanning of transverse sections with a characteristic wavelength. The accessory compounds of the acetone and methanol extracts were separated by high performance liquid chromatography and qualified with a diode array detector. The element content of inorganic compounds in discoloured beechwood, which might be involved in discolouration, was analyzed using optical emission-spectroscopy with an inductively coupled plasma flame (ICP-OES).

The light microscopical investigations revealed that the accessory compounds responsible for the discolouration of beechwood were mainly restricted to the axial and ray parenchyma cells. The intensity of discolouration is correlated with the concentration of the deposited accessory compounds. The enrichment of the accessory compounds in the parenchyma cells indicates that the discolouration was initiated by physiological reactions depending on the oxygen potential in the vessels. By using UV-microspectrophotometry, the content of the accessory compounds was determined separately in parenchyma cells and the lumen of vessels. The interpretation of the UV-absorption spectra reveals that the isolated extractives in the parenchyma cells and in the lumen of vessels can be detected as phenolic compounds. Additionally, differences in the intensity of UV-absorption of the accessory compounds in the parenchyma cells and the deposited extractives in the lumen of the vessels can be proved.

The separation of the acetone extractives of discoloured beechwood shows different low molecular phenols such as catechin, 2,6-dimethoxy-p-benzochinon, syringic acid, taxifolin, taxifolin glycoside, conidendrin, and eugenol. Some of the isolated compounds represent dimeric structures, which are similar to parts of the lignin molecule. Furthermore, the element analyses of the inorganic components indicate an increasing mineral content especially in the transition zone of discoloured tissue.

From the present study, there is a hint to the possibility that the different kinds of discolouration in stored, steamed, and kiln-dried beechwood are caused by the synthesis of phenolic and flavonoid accessory compounds in parenchyma cells, due to different processes.

Variación de las propiedades físicas y químicas de la madera de *Pinus elliottii* Engelm. y *Pinus taeda* L.

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Palabras claves: *Pinus elliottii*, *Pinus taeda*, densidad, contracción, contenido de humedad, analisis qúimicas, madera juvenil y adulta.

El presente trabajo tuvo por objetivo el estudio de las propiedades fisicas y quimicas de las maderas de *Pinus elliottii* Engelm y *Pinus taeda* L. procedentes del Bosque Nacional de Irati, Paraná, Brasil. Fue estudiada la variación de las propiedades en la dirección radial (madera juvenil y adulta) y en diferentes alturas del fuste (5%. 25%, 50%, 75% de la altura comercial).

Las propiedades físicas estudiadas fueron: densidad básica, contenido de humedad y contracción radial, tangencial, longitudinal, volumetrica y coeficiente de anisotropia. Las determinaciones quimicas realizadas fueron solubilidad de extractivos en agua caliente, de acuerdo con las normas ABTCP-M4/68 y solubilidad en alcohol-benzeno ABCP M 6/68. Fueron analizados modelos de regresión para las diferentes y posiciobes del árbol y las relaciones entre ellas.

La variación del contenido de humedad en las especies estudiadas es considerable, tanto en el sentido radial como en altura. La variación mas significatiba fue encontrada en la faja de transición de la albura (120%) para el duramen (30-60%), aumentando también en relación con la altura. La densidad básica decresce con la altura del fuste. La disminución entre la altura relativa 5% (1,30m) y la altura comercial (diámetro en la Hc = 5cm) fue aproximadamente de 18%. Tambien los valores de la densidad há variado considerablemente en el sentido horizontal del tronco, donde existe un aumento en el sentido medula corteza. En la parte externa (madera adulta) de las dos especies fue aproximadamente de 22-23% mayor do que la madera juvenil.

Las contracciones volumetricas máxima, radial y tangencial determinadas para la madera juvenil y adulta confirman las diferencias existentes entre las mismas, aumentando en el sentido médula – corteza, disminuyendo con la altura; la contracción longitudinal y la anisotropia de contracción presentarón un correlación inversa con la densidad.

La tendencia general observada es de un aumento en el contendio de extractivos a medida que aproxima a la médula., siendo que los mayores aumentos se producen en la madera juvenil, debido a la formación de duamen, donde se acumula mayor cantidad de extractivos y resina. Existe una tendencia bien definida en cuanto a la altura en el árbol, verificandose que el contendio medio de los extractivos disminuyen con el aumento de la altura.

El análisis de los modelos de regresión, para estima las caracteristicas en relación el sentido radial, edad y altura del fuste, en las dos especies, mostraron coeficientes de determinacion satisfactorios.

The Relationship Between Strength and Some Anatomical and Physical Properties of Typical Tall Coconut (*Cocos nucifera* L.) Varieties in the Philippines

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The natural variations of strength and related properties of about 80-year old trees from three (3) varieties of tall coconut stems were investigated. The properties were determined from test on small clear specimens in the green condition. The mechanical properties studied include stress at elastic limit, modulus of rupture, and modulus of elasticity in static bending; shear parallel to grain; maximum crushing strength, fiber stress at proportional limit, and modulus of elasticity in compression parallel to grain; and compression perpendicular to grain. The related properties closely examined include anatomical (fibrovascular bundle frequency and fiber dimensions) and physical (specific gravity, shrinkage and fiber saturation point) properties.

The San Ramon variety significantly showed higher average values in all the mechanical properties investigated than the Baybay and Laguna varieties, the former having longer and thicker fibers and higher specific gravity but had lower fiber saturation point than the other two varieties. However, the anatomical, physical and mechanical property values of the Baybay variety appeared not to be significantly different from the values of the Laguna variety.

Regardless of varieties, the coconut trees with brown nut color showed markly higher values of mechanical properties than those with green nut color, the former exhibited longer and thicker fibers but indicated lower fiber saturation point than the latter.

For all the varieties, both brown and green nut colors the values of strength properties markedly increased radial from the core of the dermal portion of the stem and tended to increase with increasing height level.

Variance component analysis revealed that the main factor that affects the anatomical, physical and mechanical properties is the radial segment. Although the affects are significant for variety and nut color, the variance contributions were found to be relatively small.

Coconut lumber taken from the dermal portion of the first and second logs of the stem (i.e. 6 to 8 meters from the butt can be safely used for structural purposes particularly in low-cost house construction while the dermal section can be utilized for non-load bearing structures.

Key Properties and Quality of Larch (*Larix* spec.) Concerning End-User Requirements

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Wood of Larch species is becoming of a strongly increasing importance in the field of wood building technology in middle, eastern and northern Europe. Main reasons are the high natural durability of the heartwood which allows to avoid the application of chemicals for wood-protection and the excellent performance regarding density, MOR and MOE as well. However a big uncertainty can be stated for the larch wood processing industry because of less detailed information about big range of roundwood and sawn wood properties which have to be regarded while processing larch wood. There is a demand to describe the quality of the resource "Larch" systematically and sufficiently in terms of custody requirements. There are less studies done, which are describing roundwood and timber properties detailed with the intention to gain predicting simulation models for wood quality of certain Ressource locations.

The objective of the presented study is to provide information on the properties of Larch timber out of the South West Region of Germany which is relevant for ensuring the quality required by different construction techniques. Roundwood was taken from stands with a typical range of site qualities and space regimes. Stem dimensions were selected according to mostly common roundwood-sizes covering a BHD range of 20-60 cm. Stem characteristics like crown dimension and shape, stem dimension and taper, knottiness, eccentricity and defects were measured. A survey on experiences and key-problems of larch processing enterprises in Germany, Austria, Denmark and Switzerland provide important aspects for a purposeful analysis of properties. According to the chosen "End-user-groups" the trees were cut into beams and boards of different dimension. The products were taken from different tree heights and radial positions. In addition clear specimen were formed from the boards and beams. At both industrial dimensions and clear specimen as well the following properties were analysed: Density, static and dynamic modulus of elasticity (MOE), modulus of rupture (MOR), tension strength, shrinkage and warp. Visual and automatical (Machine-Stress-Rating) grading procedures were done according to bending strength, dynamic MOE, static MOE, density and different visual aspects. The mechanical properties were found to be on a very high level, strongly influenced by compression and juvenile wood. The performance of mechanical behaviour marks a distinct transition zone between juvenile and adult wood at a cambial age of 15 years. Warp is the main reason for grading into lower classes.

Further steps are done to describe the influence of sites and space regimes detailed and to complete and improve methods to locate juvenile and compression wood. Consequences for wood processing are analysed and recommendations are given.

Pulp and Paper Properties of *Acacia mangium's* Forest Plantation Thinning Residual

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Acacia mangium forest plantation at Kamasul's Compensatory Forest Plantation is thinned four times during a rotation. The thinning residual is low in strength and small diameter and is not suitable either for saw or veneer logs, therefore one of the potential utilization is for the production of pulp and paper. The objectives of this study are to determine the variation in pulp yield and quality caused by alkaline pulpings and the effect of beating on pulps' properties. In this study, thinning residual of 9 years old forest plantation was pulped by soda, soda-AQ and kraft pulping. The pulps were evaluated using the method of a standard beater evaluation (Lampen mill). The kraft pulp was also evaluated by using different beater apparatus (PFI mill, valley beater and disc refiner) and the properties of laboratory-made paper were compared to machine-made paper. The pulp screened yields are ranging from 44.98% to 51.46% and kappa number from 23.1 to 55.7. As the beating period increased, the handsheets' properties changed, and the rate of changing depends on the pulping method. At the freeness of 350 CSF, the tear indexes are ranging from 5.8 to 10.1 mNm^2/g, the tensile indexes from 75 to 115 Nm/g, the burst indexes from 3.5 to 7.4 kPam^2/g, and folding endurance from 40 to 1093. Different beating apparatus gave different strength value development. These are due to different degree of fibre shortening, external/internal splitting and fines production. There were differences in properties between machine-made and laboratory-made paper. The machine-made paper was found to have a lower bonding index than the laboratory-made paper eventhough they were made from the same stock.

5.01.01 Formation of wood

Wood Anatomy of Malaysia *Grewia* and *Microcos* (Tiliaceae)

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The generic delimitation between *Grewia* L. and *Microcos* L., established by Linnaeus in 1753, has been the subject of controversy and confusion in past few decades. Many botanists either sunk *Microcos* into *Grewia* or segregated *Microcos* from *Grewia*. Recent studies on wood anatomy showed that the Malaysian species of *Microcos* can be consistently distinguished from those of *Grewia* species by the distribution and size of vessels, presence or absence of vascular/vesicentric tracheids, and some other anatomical features.

5.01.02 Natural variations in wood quality

Within and between Trees Variability of Mechanical Properties, Colour and Natural Durability in Coppice Trees of Chestnut

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Chestnut in mediterranean regions is almost always cultivated in coppices giving only small diameter logs appropriate to fence, posts and pols. Today most industrial products of this kind for exterior use are made from conifers after pressure treatment with CCA preservatives. For environmental reasons these treated woods should be as limited as possible to uses where a strong controls possible both at manufacture and recycling state. Both high natural durability and low sapwood thickness are interesting factors for chestnut coppices for exterior round wood uses. Experiments on selected representative plots and trees shows that chestnut is very often in the higher class of natural durability

and have good longitudinal mechanical properties. Although it has low mechanical strength in perpendicular to grain direction. Variations of properties are rather small within the tree, but significative differences can be found between trees for most of the properties, so that it can be useful to select the best ones for the highest risk situations.

Surface Analysis Of Oil Palm Fibre Using X-Ray Photoelectron Spectroscopy (XPS)

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The surface analysis using X-Ray Photoelectron Spectroscopy (XPS) technique were used to determine the binding type of carbon and oxygen in samples extracted oil palm fibre empty fruit bunch (EFB). The method were used to find information of chemical composition C18 and O19 photoelectron peaks deconvolution technique gives several new peaks. Both C18 peak and C18 showed 3 types of carbon binding. Each binding energy of new peaks are compared to reference showed EFB sample composed of C18 of C-OH, -C-O-, -COO and -Ca and oxygen (O18) of -O, H2O, -O-H, -O=C and C-O-C type.

Relations de la couleur du bois avec quelques parametres anatomiques pour quatre essencis de bois tropicaux

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Le travail de recherche, développé au laboratoire de Qualité des Bois – INRA à Champenoux (France), porte sur quatre essences de la forêt amazonienne: Fava Amargosa (*Vataireopsis speciosa* Ducke); Jequitiba Rosa (*Cariniana micrantha* Ducke); Peroba d'Agua (*Rauwolfia paraensis* Ducke) e Peroba Mico (*Aspidosperma macrocarpum* Mart). Les paramètres mesurés de la couleur sont: la clarté (L), la coordonnée a* (coordonnée rouge-vert), la coordonnée b* (coordonnée bleu-jaune), la saturation (C) et l'angle de teinte (H). Le calcul des paramètres a été réalisé selon le système CIELAB, 1976. Il montre les corrélations existantes entre les variables de la couleur et quelques éléments anatomiques pour les quatre essences en fonction des directions radiale et tangentielle.

Pour l'espèce *Fava Amargosa*, présente en direction radiale, la clarté (L) augmente avec la hauteur et la largeur des rayons ligneux et diminue avec la longueur des fibres et la hauteur du parenchyme axial. On peut donc supposer que cette coloration brun jaunâtre est une conséquence des corrélations suivantes: - corrélation négative entre a* et la largeur des rayons, ainsi que entre a* et la hauteur de la série du parenchyme axial; - corrélation positive entre b* et la largeur des rayons ligneux. Dans la direction tangentielle, l'espèce *Fava Amargosa* présente une clarté qui est corrélée négativement avec la longueur des fibres et la hauteur de la série du parenchyme axial. La coordonnée b* est corrélée positivement avec l'épaisseur de la parois des fibres. Ces corrélations aident à caractériser la coloration brun-jaunâtre claire dans cette direction.

L'espèce *Jequitiba Rosa*, présente en direction radiale, la clarté (L) est corrélée négativement avec la hauteur et la largeur des rayons. Cette corrélation négative peut être expliquée par la coloration rouge plus foncée des rayons ligneux par rapport au reste de la masse du bois de l'espèce. La corrélation entre la coordonnée a* et la largeur du rayon confirme ceci. Etant plus foncée, les rayons se présentent en petite proportion par rapport aux autres éléments anatomiques du bois, ce qui explique la dominance de la coloration rouge claire. Dans la direction tangentielle, la clarté est corrélée négativement avec la longueur des fibres et la hauteur de la série du parenchyme axial. Les coordonnées a* et b* sont corrélées avec l'épaisseur des parois des fibres de façon opposée, c'est-à-dire au fur et à mesure que l'épaisseur des parois des fibres augmente, la couleur rouge augmente aussi, alors que la couleur jaune diminue. Ceci peut aider à comprendre la coloration rougeâtre plus claire de cette direction par rapport aux deux autres. L'épaisseur des fibres sert souvent de "guide d'ondes" pour absorber les rayons lumineux, donc diminuer la clarté (L).

Pour l'espèce *Peroba Mico*, en direction radiale, la clarté est corrélée négativement avec la longueur des fibres et positivement avec la hauteur du rayon. La couleur jaunâtre dans cette direction augmente avec la hauteur des rayons ligneux. Dans la direction tangentielle, l'espèce *Peroba Mico*, montre une corrélation positive entre la clarté, la largeur et hauteur des rayons. Les coordonnées a* et b* sont corrélées positivement avec l'épaisseur de la paroi des fibres. Ces corrélations contribuent à l'explication de la coloration jaunâtre plus claire dans cette direction.

Pour l'espèce *Peroba d'Agua*, direction radiale, la largeur des rayons est corrélée positivement avec L, b* et H et négativement avec a*. C'est-à-dire que la coloration typiquement jaune de cette direction est expliquée surtout par l'épaisseur de la parois des fibres et par la largeur des rayons ligneux. Dans la direction tangentielle, la clarté est corrélée négativement avec la largeur des rayons et la hauteur du parenchyme axial. Celle-ci est aussi corrélée positivement avec les paramètres a*, b* et C. La hauteur du rayon ligneux montre des corrélations positives avec a* et C. Ces corrélations sont les principaux responsables de la coloration jaune dans cette direction.

En conclusion, les éléments anatomiques montrent des corrélations intéressantes avec les paramètres de la couleur. Ces corrélations aident à expliquer la variation de la couleur dans chaque direction pour l'espèce en question. Ces corrélations sont variables d'une espèce à l'autre et d'une direction à l'autre.

Dans la direction radiale, la largeur et la hauteur des rayons ligneux ont un rôle très important pour aider à expliquer les paramètres, clarté et les coordonnées a* et b*. Pour la direction tangentielle, les corrélations des paramètres de la couleur avec les éléments anatomiques sont très variables, il faut considérer chaque cas à part.

Mots-clés: Bois Tropicaux, Couleur, Anatomie, Correlations

Juvenility in Rubberwood (*Hevea Brasiliensis*) and its Relation with the Physical and Mechanical Properties

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Knowledge on anatomical, physical and mechanical properties of wood is necessary in assessing the potential utilisation of wood. The main objectives of this study are to determine the cellular composition and anatomical properties variations of juvenile rubberwood (*Hevea Brasiliensis*) in the selected clones and age groups. Another objective is to determine the structure of juvenile wood in relation to physical and mechanical properties. Three different clones, PB 359, PB 366 and RRIM 600 from two age groups, namely 10 and 22 years old were selected from Golden Hope Plantation Bhd. Three trees were felled for each clone and age group. Each tree was divided into three portions along the height namely, stump (S1), trunk (S3) and branch (S5). Outer and inner samples along the radial position were chosen for comparative studies on the anatomical, physical and mechanical properties. All samples for each test were prepared in accordance with the British Standard (BS 373: 1957) specifications.

Juvenile wood from the 10-year old, *Hevea* trees of the clone PB 359 exhibited the highest values for fibre length (1152.16µm) and initial moisture content (60.36%). Clone PB 366 showed the highest values in fibre proportion (53.83%), MOR (112.49N/mm^2), MOE (9149.90N/mm^2), and compression parallel to grain (50.64N/mm^2) whereas RRIM 600 possessed the highest value in fibre diameter (25.27µm), lumen diameter (12.28µm), shear parallel to grain (17.87N/mm^2), tangential shrinkage (2.13%) and radial shrinkage (0.99%).

For mature wood of 22-year old, clone PB 359 showed the highest values in fibre length (1248.69µm), initial moisture content (65.96%), radial (0.69%) and longitudinal shrinkage (0.34%). Clone PB 366 possessed the highest value in fibre proportion (47.32%) and MOR (137.60N/mm^2), whereas clone RRIM 600 showed the highest value in fibre diameter (24.61µm), specific gravity (0.61g/cm^3), tangential shrinkage (1.49%), MOE (10422.48N/mm^2), compression parallel to grain (64.05N/mm^2) and shear parallel to grain (20.57N/mm^2).

All clones from the 22-year old age groups showed higher values for the fibre length, proportion of rays, moisture content, specific gravity, MOR, MOE, compression and shear parallel to grain when compared to similar clones from the 10-year old age group. For both age groups, the values for fibre length, fibre diameter, lumen diameter, cell wall thickness, vessel diameter, proportion of rays, specific gravity, MOR, MOE, compression and shear parallel to grain at the trunk (S3) section were higher compared to the stump (S1) and branch (S5) sections.

The mechanical strength of the wood was found to be affected by fibre length, fibre diameter, cell wall thickness, proportion of fibres and specific gravity. Based on mechanical strength, 10-year old juvenile rubberwood is suitable for the manufacturing of pulp and paper, solid wood products and medium-density fibreboard. Clone PB 366 is suitable for sawn timber due to the superior mechanical strength. Clone PB 359 can be processed to pulp

and paper due to its lower lignin content and higher alpha-cellulose and hemicellulose contents. Branch wood (S5) possess similar anatomical, physical and mechanical properties to the trunk (S3), and is also considered suitable for industrial utilisation. The stump (S1), however possess lower mechanical strength properties and is not recommended for industrial utilisation.

Quality Parameters of the Wood of Oak (*Quercus petreae* Liebl. and *Quercus robur*) in Variation of the Ring Width and Plantation Patterns

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Due to a changing economical environment the European forest owners start to think about rotation cycles as an economical variable. This is true even for oaks which are traditionally managed in very long rotation periods of 240 years and more with the objective to produce big high quality logs. Today more advanced growth concepts with a shorter rotation time of about 180 years and various plantation patterns are under discussion but still with the unchanged goal to produce big timber with a diameter of 60cm and above. The consequence is a much wider width of the annual rings. The effect of these wider rings on wood and veneer quality is not known so far.

Material

Altogether 60 trees from four stands with a well known history (190 years old) were selected, covering the dbh range from 40-70 cm. The ring width ranged between 1mm for the lower end and 2mm for the upper end, thus representing the natural differentiation which is representing the different growth concepts. After felling external log quality was assessed. Two logs from different heights in the were cut and sawn into boards or sliced into veneer. Two discs each from the top and bottom of every log were cut to evaluate selected wood properties on a laboratory scale.

Results

Sawn timber quality

The quality of the boards from trees with wide rings (lower and upper sections) was significantly better than for the narrow ring trees. The knot free volume of the boards was significantly higher, and they showed less rottened knots. Out of the upper sections of the narrow ring trees few boards could be sorted into the highest quality class.

Veneer quality: The surface quality (roughness) of industrial sliced veneer showed no significant difference between wide ring trees and narrow ring trees. This was also true for upper and lower sections. But within each section an influence of the radial position was found. In contrary to veneer surface roughness microtome cut reference cubes showed a roughness which is caused by wood anatomical properties. This is the roughness that can be reached with an optimised cutting process. The comparison of the roughness of wide ring trees and narrow ring trees rings showed a difference: The wide ring trees rings were significant less rough than the narrow rings. An additional analysis of individual ring width showed that the roughness decreased with increasing ring width.

Conclusions

Oaks which were grown with a relatively wide spacing had a significantly higher volume of logs, boards and veneer. The comparison of quality parameters of industrial sliced veneer produced from upper and lower sections of trees width wide and narrow ring width showed that there are only slight differences. For practical purposes it can be said that there is no difference between the two analysed ring width groups. Although the evaluation of the laboratory sample cubes show that the roughness is clearly linked to ring width: Wide year rings result in a significantly lower roughness than narrow year rings. The roughness caused by an industrial cutting process is overlaying the roughness caused by wood anatomical structures. Alltogether, an increasing ring width within the investigated group as a result of a higher speed of growth does not have negative consequences for the wood and product quality of oak.

Red Heartwood in Trees of Beech (*Fagus sylvatica* L.)- Occurrence, Biological Causes and Consequences for Utilisation

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Beech (*Fagus sylvatica* L.) is the most important broadleaf species in Germany and the area of beech stands shall even increase - following advanced silvicultural programs. The wood of beech is highly appreciated in the furniture industry and just now a very modern light wood species. The most important so called wood defect is the red heartwood that often occurs in older beech trees (more than 80 years). Red heartwood leads to a severe devaluation of the stems. In this context interdisciplinary investigations about the occurrence, the biological causes and the consequences for utilisation are just going on and the results shall be presented in this paper. The open questions are: when does red heartwood occurs, how is the coloured heartwood developing in the standing trees, and is there any possibility to use this timber for high-quality products?

In the past the formation of red heartwood was often correlated with the age as well as with the dimension. But for the modern silvicultural strategies that deal with uneven-aged mixed stands the correlation between tree architecture and the formation of red heartwood is the most interesting aspect. The possibilities to influence or even to avoid red heartwood by special silvicultural strategies are actually evaluated. Most important in this context is the aspect how the stands of beech shall be treated when the first time during a thinning the harvested trees show the red heartwood. The transfer of the empirical results will be reached by modeling. Besides marketing aspects for red heartwood of beech are evaluated. The formation of red heartwood doesn't influence wood strength or elasticity but for special processing (drying, impregnation) the great number of thyllosis' are quite negative. But most important for the furniture industry is that the red colour is not stable under UV-light. So the end-user prefers today light wood of beech trees. Only a very small percentage of beech trees with red heartwood are actually used for the production of very individual, handmade furniture. The surface is often treated by oil or wax, but the problem how to protect the strong red colour over years is not yet solved.

Tree Stands on Peatland, Quality of Wood Raw Material and Suitability for Different Use Objects

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Keywords: drained peatland; Norway spruce; Scots pine; sawn timber; quality; wood property

According to the National Forest Inventories forest drainage seems to be a major factor for the increased volume growth observed in the Finnish forests. The real contribution of the increased growth is, however, heavily depending on timber assortment distribution as well as the quality and usability of the wood raw material. This knowledge has to be considered insufficient. Most of the tree stands on drained peatland are reaching the logging maturity thus their importance for mechanical wood industry is growing.

The aim of this study is to clarify the most important external and internal quality properties of Norway spruce (*Picea abies* (L.) Karst.) and of Scots pine (*Pinus sylvestris* L.) timber trees growing on drained peatlands. The suitability of wood raw material for sawn timber and its further processed products are examined as well as the differences in quality properties between tree stands on peatland and mineral soil.

Study material was collected from two different kinds of sites of Norway spruce and two sites of Scots pine. Five sample plots were chosen to represent each site. Part of trees was measured and graded and a part was felled for study trees on each sample plot. Data of the study trees were registered and the stems were cut into butt, middle and top logs. Furthermore logs were sorted according to size, top diameter, length and external quality properties. To study the wood properties sample discs were taken from butt end of each log and from top end of top log. The diameters with and without bark, the eccentricity of pith, the amount of heartwood and compression wood, defects in discs, density, growth ring width and the amount of latewood were measured in the laboratory. Logs were sawn using normal blade settings.

Sawn timber was graded before and after drying according to grading rules of Nordic Timber. Centre yield was also graded according to Nordic stress grading rules. Special attention was paid to the properties affecting the quality. Sawn timber was kiln dried to 20% final moisture content. The changes in timber quality during drying and factors affecting them were studied.

According to preliminary results, the wood properties are in accordance with those referred in literature. Basic density of spruce is nearly constant in the longitudinal direction of stem, whereas basic density of pine decreases from butt to top. In the radial direction the basic density increases slightly from pith to bark in both tree species. Exceptional phenomenon can be found at stump height, where the basic density first decreases strongly and then increases towards bark. The variation in single density samples was quite extensive. The highest heartwood percentage of cross-section area was found at about 10% height in spruce stems and at about 20% height in pine stems. It has to be noted that both basic density and amount of heartwood depend e.g. on the geographic location, age and growth rate. The amount of compression wood was surprisingly small.

Study on Pulpwood and Mechanical Properties of Three Tropical Acacias

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Wood density, fiber and mechanical properties of *Acacia mangium*, *A.auriculiformis* and *A. crassicarpa* from two sites, tropical area and subtropical area, were determined and analysed. The results showed that there were remarkable difference in wood density, fiber length, fiber width, MOE, MOR and crushing strength among species, provenances individuals and sites. Three species with 0.38-0.56g/cm^3 wood density, 1.0-1.3mm length and 16.5-20.0 µm width of fiber, are all suitable for pulpwood, but *A. craasicarpa* is the best one, *A. auriculiformis* is followed and *A. mangium* is the worst. The mechanical properties of *A. auriculiformis* and *A. craasicarpa* are quite similar, they are all better than *A. mangium*. The correlations between growth and wood properties for different provenances within same species were not significant. The selection of species, provenance and individual for wood improvement are all effective.

5.01.04 Biological improvement of wood properties

Exogenous Influences on the Cambial Growth Dynamics of Plantation-grown *Swietenia macrophylla* King., *Carapa guianensis* Aubl., and *Cedrela odorata* L. (Meliaceae)

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The present study on exogenous influences on the cambial growth dynamics of plantation-grown *Swietenia* macrophylla King., *Carapa guianensis* Aubl., and *Cedrela odorata* L. was initiated by the urgent demand for reforestation of degraded areas of the Central Amazon. The investigations were carried out from 1995 until 1999 at the experimental site of the EMBRAPA Ocidental located 25 km north of Manaus, Brazil (3ø08'S, 59ø52'W). At a plantation of *Swietenia*, *Carapa*, and *Cedrela* established in 1992, the significance of mineral elements, water and light for the cambial growth dynamics of these species was studied. During the experimental period of four years, the mineral element supply of the soil and the element content of different plant fractions were investigated in monthly intervals. The distribution of mineral elements in the cambial region was investigated also on a subcellular level by Energy-Dispersive-X-Ray analysis (TEM-EDXS). The water supply of the trees was studied in terms of tensiometer measurements and xylem sap-flow-measurements (Granier sensors). The study of the leaf water potential was carried out by means of a Scholander pressure chamber. The significance of light intensity for the wood formation of the trees was studied with PAR-sensors. The cambial growth dynamics of the trees was identified by means of dendrometer measurements, the pinning method and the repeated collection of cambium and xylem samples obtained by a microborer (diameter of the samples 1.4mm). The lignification of the cells was studied on a subcellular level by UV-spectrophotometry.

Mineral element analyses indicated a high K, Mg, and P demand of *Swietenia* and *Cedrela*, compared to *Carapa*. During the dry period from July until November, a strong reduction of periclinal cell divisions and even an extended cambial dormancy of *Swietenia* and *Cedrela* were observed on poor soils, compared to *Swietenia* and *Cedrela* grown on more fertile soils.

A reduction of the soil water content during the drier season from July until November (montly precipitation less than 150mm) led to a strong reduction in water uptake and to an increase in the leaf water potential (dry period > 30 bar, wet period 2-12 bar) of *Swietenia* and *Cedrela*. Even in short time periods with a reduced soil water supply, formation of parenchyma bands and a dormancy were induced at the cambium of *Swietenia* indicating high sensitivity of the wood formation of this species towards drought.

Light intensity measurements and the analysis of reserve carbohydrates indicated a strong light demand of *Swietenia* for photosynthesis and carbohydrate production. Consequently, in plantation systems with strong shadow, the cambial growth of *Swietenia* was strongly reduced compared to *Swietenia* grown under full light conditions. In contrast to that, the intra annual growth dynamics of *Carapa* trees were only slightly influenced by a 50% reduction of the light intensity.

5.01.05 Wood properties desired by end-users

Quality and Properties of Wood Species from Natural Forest: Evolution of the Test Methods - Relation between Quality and Uses Application to Brazilian Timber Species

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Technological characteristics of timber species from natural forest are commonly considered as weakly variable at the level of the botanical species. These properties change little with time, and data and information given ten or fiveteen years ago into technical documents are quite similar to those which are given nowadays. However, some changes have been occuring during these last years, in relationship with the evolution of the test methods and procedures, but also with the own quality and origin of the woods which are presently marketed.

Recently, some physical and mechanical properties were still measured in a routine way, and the laboratory tests results (splitting test, resistance to perpendicular traction determined according to standard procedures) were distributed and mentioned in technical documents intended for wood industry. These information must help to select the most suitable uses of woods, and to assess woods behaviour during processing according to their characteristics.

Nevertheless, it frequently appeared that a part of these data were not really relevant and consequently of relative interest for wood processing industry and final users. On the other hand, complementary properties and parameters as fissility, sensitivity to air humidity give more indications about the ability of any wood to process well or to pose any problem.

In the field of processing, especially for sawing, drying, machining, finishing, gluing, wood industry particularly needs and asks information and technical help about the parameters to apply to optimize these operations. The compatibility between woods and finishing products, the life span of these products after applying (in particular for exterior uses), the possibility to glue some species considered to be unsuitable (Ipe, Cumaru, Jatoba) must be more widely studied to enlarge the range of possible or potential uses.

Other topics as the measurement and quantization of wood color linked to its changes with time for exterior uses are being investigated in order to help architects and construction companies to do the best choice when selecting timber species for wood building.

Quality Assessment Of Planted Coconut Wood (*Cocos Nucifera*) Linn.

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The studies are essential as to determine the prospect of utilising *Cocos nucifera* Linn. wood as supplement timber to our hardwood due to the diminishing supply of the conventional wood. An assessment on anatomical, physical and mechanical properties of coconut palm (*Cocos nucifera* L.) was carried out on a 30-year old and a 50-year old stem. Variation of both coconuts palms in fibre dimension; metaxylem, vascular was the important physical properties measured was specific gravity by the water displacement method. The mechanical properties assessed were static bending, compression parallel to grain and shear parallel to grain.

Three discs each measuring 5 cm were taken from three different height level: bottom, mid level and top portion. Sample blocks measuring 5x5x10mm were taken from both outer and inner regions of each disc. Macerated fibres were used for fibre dimension measurements and analysed using image analyser. The specimens were obtained from billets sawn at the butt, middle and top of the trunk with two billets from each position. The wood from the outer and inner were taken as testing samples. Mechanical testings were conducted in accordance to the British Standard (BS 373.1957) for testing Small Clear Specimens of Timber by using the Zwick 1974 Universal Testing Machine (UTM).

The results showed that high concentration of vascular bundles occurred at the outer part of the stem and the amount increased with stem height. The mean number of vascular bundles for 30-year old and 50-year old stems was $93/cm^2$ and $84/cm^2$ respectively. The fibre length for both trees showed an increase value towards outer region and decrease over stem height. It ranged from 1.97mm to 2.14mm in 30-year old stem and 1.78mm to 1.90mm in 50-year old stem. Fibre diameter and fibre-wall thickness showed an increasing trend from the top portion towards the bottom while it decreased towards the core. The mean lumen diameter increased over stem height as well as from the inner to outer region for both trees. However, there was no significant difference in all properties measured between the 30-year and 50-year stem. The mean diameter of metaxylem decreased over stem height for the 30-year old stem but it showed an inconsistent trend for the 50-year old stem. However, The mean diameter of metaxylem showed an increase value towards core for both trees.

It was found that specific gravity of the outer wood range between 1019.70 kg/m^3 to 614.286 kg/m^3 and 1017.16 kg/m^3 to 826.317 kg/m^3 for wood aged 30 and 50 years old respectively whereas the inner wood were mostly less than 500 kg/m^3 for age group. Mechanical strength increased from core towards outer wood but decrease as the height increase. The butt billets of both trees exhibit the most superior strength value with MOR range as height increased, decreasing from 121.20 MPa to 61.71MPa and 142.20 MPa to 71.46 MPa for outer wood of stem aged 30 and 50 years old respectively.

Most strength values obtained for the outer wood were about twice as compared to the inner wood. The analysis of variance at $P<0.05$ indicated significant differences between all properties of outer and inner wood. There was also significant differences when comparison in properties was made between the different aged *Cocos nucifera* Linn. wood. The analysis between properties and stem height showed significant differences at $P<0.05$. Strong correlation was also found between the density and bending strength as well as the density and modulus of elasticity (MOE). When compared to the properties of Heveawood of aged 25, all properties except the MOE of *C. nucifera* wood is superior than Heveawood. The study indicated that attempts to utilise *Cocos nucifera* Linn. wood as conventional wood exhibit great prospect due to a number of its features that makes it a unique source of wood materials.

Physical and Mechanical Wood Properties of *Melia Azedarach* L. Planted in Areas in the North of Vietnam

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Forest products and wood-based industry are of great importance for Vietnam. They considerably contribute to the economic development and meet the needs of the growing population regarding merchantable wood, fuelwood and wood-based panels. *Melia azedarach* is mostly planted along the rivers, as solitaire or in rows at a wide spacing along the roads and tracks or in gardens. Regarding the possibilities of its utilization *Melia azedarach* so far belongs to the lesser known species.

The goal of the extensive investigation in the main wood technological properties of *Melia azedarach* was to infer better yield and possible uses of the timber. Substantial investigation in physical wood properties (wood density, swelling and shrinkage) as well as in mechanical wood properties (tensile, compressive, bending and shear strength) were carried out on twenty sample trees from two different sites (Dong-ngac and Tay-tien) in the delta region of the river Song-Hong. The results of the investigation revealed that the wood of *Melie azedarach* possesses good dimensional stability and mechanical strength properties (medium till high strength class) and therefore is suited for many-sided use in interior wood work and for light and medium timber construction. *Melia azedarach* as a timber tree is a possible substitute for many endangered species in the Vietnamese natural forests.

The results of the investigation constitute an important basis for estimating the possible uses of *Melia azedarach* timber based on scientifically ascertained data. A high timber quality orientated silvicultural treatment of this species contribute to the improvement of the converted timber and fuelwood supply of the rural regions in Vietnam. By the development of adequate forest management conceptions *Melia azedarach* as light demander could be cultivated in plantations with increasing yield in view of high timber quality.

Technological Characterization and Development of the Uses of South American Tropical Timber Species

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The technological properties of more than 200 timber species from natural forest of Central and South America have been studied in the laboratories of CIRAD-Forêt. Around two-thirds of them come from Brazil. The disciplines concerned are wood anatomy, sawing, drying, machining, physics and mechanics, preservation and natural durability.

These studies aim to identify the best suited utilizations of woods according to their qualities, to supply relevant data and usable information on wood properties and utilizations to the wood sector operators, and to contribute to enhance the acceptance of lesser known species by final users.

They have been carried out in close cooperation with partners from different origins, among others, INPA, EMBRAPA, Eldorado Firm, Instituto Brasileiro de Desenvolvimento Florestal in Brazil, the Guyana Forestry Commission, the Escuela Nacional de Ciencias Forestales in Honduras, the French Guiana Region, the Tropenbos Foundation in the Netherlands, the International Tropical Timber Organization.

Various kinds of outputs have been produced:

- Guide on Major Timber Trees of Guyana - Timber Characteristics and Utilization
- Technical sheets "New marketable Timber Species from South-America"
- Tropical Timber Atlas of Latin America
- Identification Atlas for Woods from Amazonia and Neighbouring Regions
- Diagrams of Technological Characteristics of Tropical Timbers: Volume VI - Brasilian Timbers
- Data Base on Technological Properties of 200 Tropical Timber Species

These documentary outputs are widely utilized by wood industry in the producing countries (Brazil, Guyana, French Guiana) and in the importing countries. Moreover, they constitute basic technicals tools for CIRAD-Forêt in the framework of the technical assistance operations carried out at the demand of wood firms.

Considering the evolution of the international timber trade and taking into account the institutional and industrial demand, the CIRAD-Forêt has begun to enhance its actions on South American tropical timber species to improve their utilizations. Based on all the data ever obtained, they will be carried out in the framework of a R&D project entitled Development of the technological knowledge on timbers species from natural forest and rational uses of their variety.

This project is organized according to three main stages:

- Technological study of commercially less accepted species from Tropical America.
- Analyze of processing and marketing sectors in order to optimize the utization of these species.
- Technical assistance to the primary processing industry so that to improve the quality of the products.

Basic Density and Strength Properties of *Grevillea robusta* Cunn. Grown in Agroforestsry in Moshi District, Tanzania

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Basic density and some strength properties *Grevillea robusta* Cunn. grown in agroforestry in Moshi district, Kilimanjaro region, Tanzania were studied. The relationships between these properties were also determinded. The study area was divided into low and high altitudinal zones. Ten sample trees aged 26 years, five from each zone, representing the entire diameter range were selected. Three disks measuring 5 cm in thickness were cut from each sample tree at 1.3m, 45% and 755 of total tree height for basic density. A two metre long central board which included the pith was cut at 1.3m up-wards for strength properties. Standard methods were used in the determination of these properties. The basic density was found to be 500 and 460 kg/m^3 for low altitude and high altitude trees respectively with average basic density of 490 kg/m^3. The difference in density between the zones was statistically significant ($p<0.05$). Within tree basic density variation i.e radial and axial, was also significant at $p<0.01$. With exception of cleavage, other studied strength properties (Modulus of Elasticity, Modulus of Rulpture, Work to maximum load, Total work, Compression and shear strength) decreased uniformly from the pith outwards. Cleavage increased from the pith to about 20%, then decreased slowly to 40% followed by sharp decrease towards the bark. Positive regression coefficients were found between basic density and all strength properties studied. Recommendations on the efficient utilization of timber of *G. robusta* have been included in this paper.

Effect Of Thinning on The Anatomical Characteristics and Properties Of Beech Wood (*Fagus Orientalis* L.)

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When thinning is a forest stand, growth condition is going to better for root and crown of remaining trees. Therefore thinning causes spreading of crown size, increasing of leaves number and also branches diameter, so far by reason of this environmental factor effects on cambium activity is considered that the production of wood increases to comparison of before the thinning. With precise comparison of beech wood anatomical characteristics and properties (*Fagus orientalis* L.) between 10 trees in thinned and 10 trees in dense stand of natural forest from P.F.P. (Pajim Forest Project) in BEHSHAHR region in the north of IRAN was studied the following factors like as: Growth diameter of trees, Fiber length, Number of vessel and fiber permm^2, Fiber and vessel diameter, Number of cell in uniserate ray, Fiber coarseness ¸, Number of fiber per gram of wood (Ng), Fiber thickness index (T), Findings show growth diameter of trees in thinned forest is more than the dense one. Tree shape in thinned forest is more conical,meanwhile in dense stand goes toward cylidrical form.

Fiber length in trees of thinned stand is longer than dense but in spite of this difference there is no significant difference between them. Number of fiber per mm^2, average fiber and vessel diameter and average ray height in thinned stand show increas but in contrast high decrease of vessel number obtained per mm^2, so according to T test trial and analysis of variance was found significant difference between thinned and dense forest, and for the rest of factors which were pointed (e.g. Number of ray per mm length, Average ray width, Number of call in uniserate ray), there were no significant difference. In the other hand the results shows increasing in fiber thickness index (T) and fiber coarseness¸ and decreasing in number of fiber per gram of wood (Ng) in thinned forest which are the most important factors relating to pulp and paper making process and the signifying of difference shows that the thinning has positive effects on the properties of wood.

The Effect of Growth Site and Felling Time and Timber Drying on the Wood Properties of Norway Spruce and Scots Pine

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The aim of this study is to find out variation in wood properties between different growth sites and the effect of felling and storage times on discolouration during drying. The effect on the quality and end-use value of wood raw material is discussed in another presentation (Sipi and Hemmilä). Knowing the effect of these variables on the quality and properties of sawn timber and end-use products the trees can be felled timely and the wood raw material can be delivered directly to its most suitable end-use target. The use of wood material can be optimized and the benefit of wood material can be maximized. This is important especially for high quality joinery timber.

The study material is collected from two sites of Norway spruce (*Picea abies* [L.] Karst.) and two sites of Scots pine (*Pinus sylvestris* L.). Sites with a high site index and with a low site index were included. We had three felling times: winter, spring and autumn. Part of the logs felled in spring were stored under sprinklers (wet storage) for 6 weeks.

Data for the study trees is registered at the felling site either from trees, logs or discs. The discs of 2-5 cm thickness are taken from the butt end of each log and from the top end of each top log. Age, stem height, crown ratio, diameter, amount of compression wood and sapwood/heartwood are measured. Disks are transported to the laboratory for measurement of growth ring width, basic density and wood moisture content from pith towards bark.

In each stand two dominant trees were selected as sample trees in each cutting seasons. The cutting seasons were winter, spring and autumn. Part of the spring felled trees were stored under sprinklers. The wet storage lasted six weeks. The sample trees were felled and sample disks were taken from log ends for the detailed laboratory studies of wood properties. The logs were cant-sawn with a circular saw in the field. The dimension of the side yield was 25 x 100mm^2 for both tree species. The dimension of centre yield was 38 x 100mm^2.

The temperatures used for kiln drying were: 50, 70, 90 and 110°C. Winter and spring felled specimens (one group of each) were also air seasoned. One group from autumn felling was also vacuum dried at 70°C. The drying schedules in kiln dryings were common schedules used in industry for 38mm thick boards. The surface colour of every board was measured both before and after drying with a Minolta spectrophotometer CM-525i at 6 points in each board.

Drying temperature is most significant factor causing discolouration of boards. Discolouration in sapwood increased remarkable at temperatures above 70°C. At elevated and high temperature drying the lightness of boards significantly decreased. The winter felling showed increased disclouration of boards sawn from both Scots pine and Norway spruce. There were no significant differences between sites of different site index. The relationship between wood properties and discolouration will be discussed.

The Effect of Growth Site and Felling Time on the Quality and End-use Value of Sawn Timber of Norway Spruce and Scots Pine

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Keywords: Norway spruce; Scots pine; growth site; felling time; sawn timber; quality; small log

The aim of this study is to find out how different growth sites and felling times effect on wood quality and end-use value. The quality and usability of thinning trees are at the moment quite unknown and very controversial question in Finland. Thus one purpose of the study is to clarify the properties, quality and suitability of thinning trees for mechanical processing.

The study material was collected from southern Finland from four different thinning stands of Norway spruce (*Picea abies* (L.) Karst.) and of Scots pine (*Pinus sylvestris* L.) at four felling times: winter, spring, summer and autumn. The purpose was to have two comparable pairs of growth sites for each species. From each stand 8-10 sample trees were felled at four felling times during 1999. Data of the sample trees were registered at the felling site: age, stem height, crown ratio and diameter at breast height (1.3m). Stems were cut into normal butt, middle and top logs and also into so-called small logs. Growth ring width, basic density and moisture content from pith to bark and amount of compression wood and heartwood are further analysed in the laboratory from sample discs taken from the end of each log. Logs were sorted according to size, top diameter, length and external quality properties using criteria common in Finnish sawmills. Logs were sawn using normal blade settings and sawn timber was kiln dried mainly to 16-18% final moisture content. Sawn timber was sorted before and after drying according to grading rules of Nordic Timber. The changes in timber quality during drying, factors affecting them and their correlation with wood properties are clarified. Especially deformations of planks and boards during drying are studied closely as well as the effect of felling time on deformations and other quality properties of timber.

The following preliminary results are based on sawn timber quality of 150 Norway spruce small logs, top diameter 145-163mm over bark and length 3.1-5.8m. Each log was sawn to two 44*100mm planks. Wane and other defects caused by sawing technique were ignored in grading.

The quality of sawn timber is clearly better in the less fertile first thinning stand than in the more fertile one. The best timber quality comes from the trees the size of which is a little smaller than the average size in the stand. Timber quality is poorest in the small logs of the biggest trees. Dry and sound knots are the worst defects in sawn timber. However the medium-size trees of the less fertile stand give the best quality. The high density of stand and incomplete crown cover explain partly the poor sawn timber quality of more fertile stand. Generally in a dense stand shading dries efficiently the lower branches of a tree but the dead branches do not fall away why dry knots are not covered.

The differences in sawn timber quality between the two later thinning stands are rather small. The amount of the best timber quality is quite big and nearly the same in both stands. In the less fertile stand the biggest trees and in the more fertile stand the smallest trees give the highest share of the best timber grade. Sound knot is usually worst defect in sawn timber. Dry knot is most harmful in the smallest trees of the less fertile stand. Exceptionally the number of sound knots and not the size is worst defect in sawn timber from the biggest trees of the less fertile stand.

Sorting of Spruce Wood Raw Material for Pulp and Paper Products

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Properties of paper products are highly dependent on the properties of fibers used in manufacturing, and on the properties of the network formed by the fibers. The requirements for functional behaviour of paper vary between paper grades, and thus, also the critical properties of raw material. It is commonly known that the wood properties vary between tree species. Besides, within each tree species the fiber properties do vary within and between individual trees, even between trees of similar genotype. The knowledge of the variation in fiber properties is essential when sorting the wood raw material for optimal paper products. By selecting an appropriate raw material source, or by mixing two or more raw material sources using optimal proportions, may lead in savings in material and processing costs, in a better control of pulping and papermaking processes, and in a higher quality of the end-product.

The objectives of this study were to find out, (1) what is the amount of variation in fiber dimensions, (2) how does this variation relate to growth mechanisms of trees, (3) which are the sorting criteria for varying fiber dimensions, and (3) how affects the sorting of wood raw material on the variation. The study concentrates on Norway spruce (*Picea abies* (L.) Karst), because of its wide use in pulp and paper products in Finland. Two independent sample series were collected at varying vertical and horizontal locations from several Norway spruce trees. The amount of variation in fiber length, perimeter, and cross-sectional cell-wall area was of same magnitude within and between the samples, each consisting of five growth rings. The amount of variation in cell-wall thickness and cross-sectional compactness ($4\pi A/P2$), indicating fiber flexibility and collabsibility, was clearly higher within the samples than between them.

Four hypotheses were formulated concerning the control of the variation between the samples. On the basis of the experimental materials it was concluded that (1) the maturation processes contributing to fiber dimensions are localized in the growth meristems rather than throughout the entire tree, (2) the amount of production, i.e. the size, is at least an as good indicator of the maturity as the age, and (3) the fiber dimensions are highly related to the cambium maturity, but also the growth rate has an influence on them. In the case of cell-wall thickness and cross-sectional compactness the influence of the growth rate was greater than the effect of maturity.

Based on the results obtained, an application for sorting Norway spruce raw material was developed. In this application the average fiber properties of individual trees and logs, as well as the distributions of fiber properties, are predicted using rather easily measurable tree or log parameters, namely the diameter and the age of a tree or a log.

The consistent results obtained from the two independent sample series indicate, that the studied phenomena are characteristic for Norway spruce. This supports the feasibility of utilized methods and the use of this application in practice.

The results indicate that for chemical pulps of high fracture energy requirements trees or logs of large diameter and high age, consisting of long fibers, should be used. Young and fast-grown trees or logs, consisting of low compactness fibers, are suitable for chemical pulps of high tensile strength requirements. Old and slow-grown trees or logs are also suitable for newspaper, because their thick-walled fibers fibrillate effectively, and thus form strong pulp, during mechanical pulping. On the other hand, young and fast-grown trees or logs are suitable for optically effective mechanical pulps for SC- and LWC-papers.

Still a lot of research remains to be done within the field of wood raw material classification for papermaking purposes. The other tree species may respond differently to the growth mechanisms, the co-operation of sorted raw material groups and the pulping processes need to be studied, and, finally, the optimal fiber and fiber-network properties for different paper grades need to be clarified.

Anatomical Physical Properties of Wild Pear, *Pyrus communis* L.

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The pear wood is valuable especially in joinery work and was used in historical buildings and door restoration made by Kündekâri technique originating from Anatolian Seljuks and Ottomans.

Pyrus communis L. wood has a homogeneous and diffuse porous structure. Vessels are individually arranged and there is no group formation. Earlywood vessels arranged tangentially in annual ring border. In early wood radial vessel diameter was found to be 46.55±6.17µm, tangential 35.06±3.50µm. Likewise, in latewood radial and tangential vessel diameters were 32.03±3.84µm and 26.11±3.48µm, respectively. Procumbent (horizontally elongate) parenchyma form homocellular rays. Most of the rays were biseriate, but multiseriate rays were also observed. Maximum height of the ray parenchyma cells was 35. There were 15 rays in 1mm and 68 in 1mm^2. The results were compared with those of other hardwoods. Generally the tips of fibrils are sharp. Ratio of fibril/vessel is 1.93. The length of fibril was found to be 1.001mm, the width 20.78µm, the lumen diameter 6.84µm and the wall thickness 6.97µm. The results indicated that the width of annual ring was 1.81mm and the latewood 0.873mm.

Oven-dry specific gravity of *Pyrus communis L.* wood was determined to be 0.655 g/cm^3 and the air-dried specific gravity 0.676 g/cm^3. Average volumetric shrinkage value was 13.848% and the volumetric swelling 16.640%. The volume-weight value was determined to be 0.547 g/cm^3.

Key Words: Pear, *Pyrus communis L.*, Kündekâri, Vessel, Ray, Specific gravity.

Models of Knot Properties as a Basis for Optimising the Utilisation of Scots Pine Timber

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The quality requirements of blanks for window production are rigorous. The most important wood properties are knots, checks and heartwood. Since the variability in these properties normally is large and unknown, the yield is rather low. This affects the economy of the production, and in turn the prices of the raw materials and of the products. This study was a part of a project with aim to increase the yield in production of blanks for windows. The specific aims of this part was to analyse the difference between forest types, and to propose a method for optimising the cross cutting of trees into logs with respect to the knot structure. 30 experimental trees were sampled from three sites in eastern Norway. The site indexes, defined as dominant height at 40 years age, were F11 (Sites 1 and 2) and F17 (site 3). At site 1 the soil was deep but poor while at site 2 the soil was shallow and open bedrock was frequent. The knot structure was described as the radial extension of knots at various vertical positions. In the lower 5 m of the tree, a whorl was sampled from each 0.5 m, and from the rest of the tree for each 1.5 m. In the sample whorl knot length was measured as radial distance from pith to where the knot was enclosed by the wood. The stem radius was measured just above each measured knot and the mean knot proportion (KNPROP) was calculated for each whorl. The vertical trend of this quantity was described mathematical at each single tree: where z is distance from stump height. From this model the vertical position where KNPROP reached fixed levels was calculated. This model was used to propose log lengths for each individual trees, by setting KNPROP= 0.7 which is the position of the sawn surface closest to the pith. The average log lengths were 3.89 m at site 1, 1.16 m at site 2 and 6.05 m at site 3. It proved that site 2 did not have trees suitable for this product. The surface of the cylinder from this point and down to the stump was simulated for each tree and in average 5% of the knots were visible on the surface. Finally, the point was related to crown characteristics and a method for cross-cutting the stems into logs was proposed.

Fiber Morphology in Relation to the Handsheet Properties of Thirty-seven Sumatran Hardwoods

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A total of 37 hardwoods, belonging to 20 families, including 9 species of Dipterocarpaceae grown in the native forests of Sumatra, Indonesia were sampled, each species with 2 to 5 stem bolts. Fiber morphology of each species were analyzed in detail. After kraft pulping, standard handsheets were prepared from each species, and the results evaluated in light of their fiber morphological characteristics. The species have an average fiber length of 1.33mm, width of 25.3µm, cell wall double thickness of 10.82µm. Secondary fiber parameters such as slenderness ratio, Runkel ratio, flexibility index and coarseness were also derived, when physical properties of the handsheets were regressed with the fiber morphological parameters, except for tearing strengths, most didn't show discernible correlations with them, suggesting that interfiber interactions are more important in handsheet strength development than individual fiber characteristics. Fiber morphological

properties thus would be a poor predictor for papermaking potential of the hardwood pulps studied.

Mechanical Properties of Naturally Curved Growth Chestnut (*Castanea Sativa* Mill.) Trees Used for Wooden Ship Building

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In our country, especially in the Black Sea Region, Chestnut tree is the species used commonly for wooden ship manufacturing because of strong and high quality of the wood material. In this study, patterns were prepared test specimen from Chestnut tree with unstraight bale tensile wood and normal wood that occurred at he opposite direction to tensile wood. On the specimens, tensile strength parallel to grain, bending strength, compression perpendicular to grain and Brinell-Hardness values have been determined and compared with each others. Results indicated that there were considerable differences between tensile wood and normal wood in mechanical properties. Compared with normal wood, percentages of sorption in tensile wood were low in parallel to grain, radial and tangent directions, whereas Brinell-Hardness value was found higher. From mechanical properties tensile strength, shearing strength and bending strength are higher in normal wood than tension wood.

5.02.00 Timber engineering

Guianese timber in construction: an example of an individual dwelling

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Keywords: Tropical woods, building construction, structural timber, wooden house, French Guiana

The state of affairs established by the CIRAD-Forêt Guyane Wood Programme during on site quality control operations as part of the SPIOM (Overseas Pilot Innovation Sector) scheme between 1990 and 1995 has prompted the authors to put forward a better suited use of Guianese timber in construction, by way of a building project. This project is the culmination of an approach whose primary targets were:

- to encourage the use of locally available construction material
- to develop the timber sector and the local economy
- to encourage timber processing as end products
- to use quality wood
- to offer people in the trade better knowledge about Guianese timber

Characteristics of the main species selected:

Using the example of a building made with a system of posts and beams, based on traditional Guianese architecture, it is possible to highlight the characteristics peculiar to the different types of Guianese wood. Depending on the technique in question, the construction system proposed helps builders to apply "the right species in the right place" - there being eight selected species and several economic and technological criteria.

The availability of the species is a major criterion. In French Guiana, just three species represent 65% of current production. Certain species which are sometimes plentiful in forests, such as the Wapa (20% of the volume inventoried), are little used, and should be used for specific purposes (roof shingles); other less common species should find a slot based on available quantities.

The mechanical features of the different types of wood and the performance of each Guianese species are described and compared to two major families of metropolitan species frequently used for structural purposes: oak and "the softwood". The species selected for the project all have mechanical properties greatly superior to those soft metropolitan wood. This "advantage" should help architects to optimize their geometric calculations and produce more accurately dimensioned structural pieces.

Implementation limitations:

The application of wood in the natural climatic environment of French Guiana can only be planned on a year-in-year out basis if certain elementary rules governing the construction plan are laid down. Examples include : the choice of orientation of the building in relation to prevailing winds, protection of façades, insulating or protection of the building against the risk of "termites", architectural design doing away with any "water trap" risk which might lead to deterioration by rot-causing fungi, and so on.

The natural durability of the species proposed is a crucial factor in the Guianese context, and makes it possible to offer an initial solution to these risks. The concept of biological risk classes is determined by the situation of each constructional element in use. Many Guianese species have a place in construction as a results of their natural durability. The aesthetic look of some species also helps to lend a decorative role to structural pieces and to certain filling elements (frames, visible structure, clapboards, cladding).

The architecture proposed retains certain fundamental configurations which help to combine the material with functionality and comfort (steep wooden roofing, height beneath ceilings, natural ventilation), while at the same time stressing the "long-lived" aspect of the structure.

This project highlights the possible uses of one of French Guiana's main resources, wood, in a context of eco-materials for construction, where the main being sought is that the buildings constructed should last a long time.

5.03.00 Protection of Wood from decay and fire

Preservative Treatment of Golla Cane (*Daemonorops jenkinsiana*) by Pressure Process

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The treatability of Golla Cane (*Daemonorops jenkinsiana*) has been studied by pressure process using water-borne preservatives. Samples of three different lengths were treated at different pressure and duration to evaluate the feasibility of preservative treatment. It was observed that the complete penetration was not possible for 3m length sample using 7kg/cm^2 pressure and 1 hour duration. Samples of small (1m) and medium (2m) length can be treated satisfactorily by the pressure process following a moderate treatment schedule with conventional water-borne preservative.

Variation in Nitrogen Content in Wood Samples of Three Clones of Rubber (*Hevea Brasiliensis*) Trees in Malaysia and its Effect on the Activity of *Botryodiplodia theobromae, Aureobasidium pullulans* and *Aspergillus niger*

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A wide variety of wood-inhabiting fungi adapted the nitrogen (N) content of their mycelium to that of the substrate on which they grow. This study is of importance since the low nitrogen content in wood is a major limiting factor controlling fungal decay. The present study was conducted to determine the variability of N in three selected rubberwood clones (GT1, PB217 and RRIM600). The activity of the fungi was examined for 4 weeks on 40x20x5mm wood samples, inoculated with the test fungi (*B. theobromae*, *A. pullulans* and *A. niger*), and placed in a humidified petri dish assembly under aseptic conditions. The sapstain was quantitatively assessed by spectrophotometry. The mean nitrogen content of clone RRIM 600 (1.06mg/g) was significantly higher than clone GT1 (0.73mg/g) and PB217 (0.78mg/g). *B. theobromae* spread significantly faster on RRIM600 (4.3 days) than PB217 (5.6 days) and GT1 (5.8 days). The prominent blue stain of *B. theobromae* is significantly darker (absorbance: 56.5%) when compared with *A. niger* (38.24%) and *A. pullulans* (35.88%). Clone RRIM600 (41.85%) had significantly higher mean darkness when compared to clone PB217 (38.49%). N content does affect rate of mycelial growth and staining.

Keywords: clone, nitrogen, sapstain, Hevea brasisliensis, quantitative assessment.

Antifungal Activity of Sesquiterpenoids from Taiwania (*Taiwania cryptomerioides* Hayata) Heartwood

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The antifungal activities of cadinane skeletal sesquiterpenoids from Taiwania (*Taiwania cryptomerioides* Hayata) heartwood were demonstrated and compared. By spectral analyses, the absolute structures of three main cadinanes, namely T-cadinol, T-muurolol, and *-cadinol, isolating from Taiwania with HPLC, were identified. The total amount of these cadinanes was also quantified by using GC. The results showed that the total amount of cadinanes extracted from heartwood with n-C6H14 (6.49 mg/kg, based on wood weight) was much more than the essential oils that collected by water distillation from leaves (0.04 mg/kg), sapwood (0.36 mg/kg), or heartwood (1.77 mg/kg). Moreover, results obtained from the antifungal assays demonstrated that the order of antifungal index of three compounds for both *Coriolus versicolor* and *Laetiporus sulphureus* was *-cadinol>T-cadinol>T-muurolol*. -Cadinol completely inhibited the growth of *C. versicolor* and *L. sulphureus* at 100 ppm. Comparison of the configuration of these cadinanes reveals that cadinanes skeletal sesquiterpenoids with an equatorial hydroxyl group at C-9 and a trans configuration at the ring junction, *-cadinol exhibited the strongest antifungal activity.

Preservative Treatment of Rubber Wood: A Way to Couple Quality with Production

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Rubber wood is a prime timber resource in the ASEAN countries and also in India. Industrial utilisation of this perishable timber is mainly through vacuum-pressure impregnation of preservatives such as borates or copper-chrome-arsenates (CCA). The moisture content of wood at the time of treatment, the impregnation schedule and the concentration of treatment solution are the parameters that affect the quality of treated wood. The best option for an economical and quality production is to use the right concentration of treatment solution rather than reducing the moisture content of wood, or increasing the duration of the impregnation schedule; as the latter utilise additional energy. Extensive work was carried out at the Kerala Forest Research Institute on the effect of various treatment schedules, moisture content of wood, concentration of treatment solution and the thickness of wood as well as their interactions on the achievement of desired dry salt retention (DSR) of preservatives in the treated rubber wood led to development of an economical schedule of 15 minutes initial vacuum of 85kPa followed by a pressure of 1000kPa for 15 minutes and a final vacuum of 85kPa for 5 minutes (denoted by 15'/15'/5'). This time-and energy-saving schedule was found to achieve desired threshold level of boron preservative in the treated wood [0.2% boric acid equivalent (BAE) in the core with an overall retention of 0.4% BAE and about 6.5 kg/m 3 DSR]. Further, the schedule enabled treatment of rubber wood in any moisture condition [air-dried to green], provided the right concentration of treatment solution was employed (3-6% BAE). As CCA is still under use for protecting perishable timber for exterior applications, the applicability of the schedule 15'/15'/5' was tested for CCA impregnation of rubber wood. It was able to give the desired DSR level (about 6.5kg/m^3) in any moisture condition, provided the right concentration of treatment solution was employed (3-6%). The applicability of this short duration schedule has been tested in commercial scale treatment plants for both boron and CCA chemicals. The retention of chemicals in the treated wood was chemically analysed and found satisfactory. At present, different industries employ lengthy schedules for the treatment of rubber wood with boron or CCA. Adoption of this newly developed short duration schedule can couple ensured quality with higher production and can save energy in the rubber wood industries.

Keywords: Preservative treatment of rubber wood, Boron and CCA preservatives, Treatment schedule, Moisture content, Concentration of treatment solution.

Heartwood in Pine (*Pinus radiata* D. Don) Growing in Chile: A Contribution to the Durability

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Keywords: durability, *Pinus radiata*, heartwood

The study, inserted in a complete caracterization about the pine (*Pinus radiata* D. Don) growing in Chile, is related with the heartwood developed (% of the log diameter) for three age of trees (20, 25 and 30 years old) for different sites in one zone of the country (sandy).

Samples about 3x3cm by diameter length, were cutted including the pith of the log at BHD (Breast height diameter). The indicators to determine the heartwood presence were selected in relation with other studies (Kutscha, 1962; Poblete, 1991; Dietrichs, 1964; Chattaway, 1952; Rudiger, 1975; ASTM 3507-92). The normalized is done with ferric chloride at 10% concentration and the reaction was evidenced when brown color is developed in the heartwood zone. After that, the annual ring involved were measured by WINCELL software (Regent, 1998) in both sides of the sample.

The earlier results observed was a high variation for the bad sites in relation with the heartwood percentage (24.2-32.5%) and for young trees (20 years old). When the tree is older the heartwood zone reaches to 43.2% of the diameter (30 years old for the good sites) and only 38.9% for the bad sites at the same age.

Like a contribution to the pine durability studies and with the aim to decrease the pine preservation treatment usually used in construction, we exposed for a month pine samples, including heartwood and sapwood, to mold (*Penicillium* spp) using a standard methodology and the results have been variable. The older trees present a durability higher than younger ones. The difference between sites was difficult to determine. The relationship with another pines extracted from different zones was not established yet.

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The Influence of Gaseous Oxygen Concentration on Fungal Growth Rates, Biomass Production and Wood Decay

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The effect of air and several levels of O_2, on fungal growth rates, biomass production of mycelia, and wood decay were investigated. The best technique for daily measuring of fungal growth in anaerobic condition was found to be by using 40mm petri dishes which attached to the walls of the jars. At the end of the test period, the same petri dishes were also used for determining the dry weight of the fungal mycelia. The results showed that 5% O_2 was very favourable for white and brown rot fungi. When O_2 reduced from 1% to 0.01%, fungal growth and dry weight of mycelia were steadily decreased. In the case of soft rot fungi, decreasing of oxygen, was not caused which to create big differences between their growth rates and biomasses.

When *Basidiomycetes* transferred on beech and Scots pine, air was best condition for their degradation. On the other hand, reduced O_2 (0.25, 1, 5, and 10%) caused wood decay to be decreased. However, weight losses by soft rotting fungi, in air and other levels of oxygen, all were below 5%.

Keyword: Oxygen, *Coriolus versicolor*, *Coniophra puteana*, *Chaetomium globosum*, Biomass production, Wood decay

The Manufacturing of Fire-retardant Plywood and its Efficiency on Fire Resistance

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Keywords: Oxygen index, Flame inhibition parameter, Fire retardant, Plywood, Surface flammability test.

Red lauan and radiata pine veneers were used as raw materials, soaked with eleven chemical mixtures, at 10% concentration to screen out potential fire retardants by oxygen index (OI) method. Three screened mixtures (designated as D, G, and I) of higher OI, together with CNS Type C (designated as C) were impregnated into veneers to produce 10mm thick fire-retardant plywood. The spread amount of melamine-urea-formaldehyde (MUF) adhesives varied from 161.5 to 204.5 g/m^2 during manufacturing. A 3rd grade incombustibility national standard was used as a criterion to test the combustibility and fire-retardancy improvement of each treatment. The flame inhibition parameter for the selected D, G, I and C mixtures were 0.98, 0.98, 0.95, and 0.94 respectively for red lauan, and 1.21, 1.18, 1.30, and 0.94 respectively for radiata pine. These showed that D, G and I results were much encouraging than the recommended C as one of the national standards. The improvement in fire-retardant efficiency of the treated plywood on surface combustion for the three screened mixtures at 183.0 g/m^2 MUF spread amount were: 0.34-2.79 sec (kg/m^3)-1, 3.87-8.75°C. min (kg/m^3)-1, 1.45-2.08 (kg/m^3)-1, 2.40-3.93 sec (kg/m^3)-1 and 0.23-0.39% (kg/m^3)-1 respectively when ignitability, heat release, smoke generation, afterflame time and weight loss percentage were considered. The application of G and I not only showed a better improving efficiency for the treated plywood in fire retardancy than current standard (C), their estimated least absorption amount required to meet the 3rd grade fire-retardant specification were also 15.1% less than that for C. Therefore, the two screened fire retardants (G and I) formulated in this study are the best choice in terms of economics and fire-retardancy improvement.

Natural Durability of Ten Bolivian Hardwoods

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Evaluating natural durability is important for the efficient and wise use of tropical woods. Generally, natural durability is determined in field stake tests that require many years of exposure especially for moderately durable or very durable woods. For our study, we selected the following commercially available and lesser known Bolivian species: *Amburana cearensis, Anadenanthera colubrina* (syn: *A. macrocarpa*), *Aspidosperma cylindrocarpon, Astronium urundeuva, Caesalpinia pluviosa, Diplotropis purpurea, Guibourtia chodatiana, Phyllostylon rhamnoides, Schinopsis quebracho-colorado*, and *Tabebuia* spp. (*lapacho* group).

Two matched sets of heartwood samples (blocks 19mm [3/4 in.] on each side) of the Bolivian species and sapwood control samples of red pine (*Pinus resinosa*) and yellow birch (*Betula alleghaniensis*) were prepared. Each set contained four replicates for a total of eight samples per species. Both sets were placed in standard soil-bottles (two blocks per bottle) in a decay chamber (25ø C and 80% RH) and exposed for 12 weeks to pure cultures of two brown-rot fungi (MAD 6137, *Tyromyces palustris* and MAD 617, *Gloeophyllum trabeum*) and one white-rot fungus (MAD 697, *Trametes versicolor*). After 12 weeks, one set of samples was removed, ovendried, and weighed to determine weight loss. This procedure follows the normal ASTM soil-bottle test. After weighing, the ovendried samples were steam sterilized, transferred to freshly prepared soil-bottles, and returned to the decay chamber for an additional 12 weeks. The other set of samples was not ovendried, but was steam sterilized, transferred to freshly prepared soil-bottles, and returned to the decay chamber for an additional 12 weeks. After the second 12-week period, both sets of samples were ovendried and weighed.

After the first 12 weeks, all Bolivian species showed less than 13% (mostly less than 10%) weight loss to the white-rot fungus (*Trametes versicolor*). For both brown-rot fungi, *Phyllostylon rhamnoides* had more than 30% weight loss. In all other Bolivian species, *Tyromyces palustris* caused less than 18% weight loss, and *Gloeophyllum trabeum* caused less than 10% weight loss. We compared our soil-bottle test results to reports in the literature. In some cases, the literature reports laboratory, graveyard, or stake tests, but more often, the literature only cites general observations and experience in service as the information sources. For *Caesalpinia pluviosa*, *Guibourtia chodatiana*, and *Phyllostylon rhamnoides*, very little information was available. For *Aspidosperma cylindrocarpon*, we compared our results with results from a 1970 soil-bottle test. In both studies, the white-rot and one brown-rot fungus (*Gloeophyllum trabeum*) caused less than 10% weight loss. However, in 1970, Tyromyces palustris caused 8% weight loss, and in our study, it caused 17% weight loss.

With ASTM designation D-2017-63, all species were highly resistant to white-rot, except *Amburana cearensis*, which was only resistant. All species were highly resistant to the brown-rot fungus *Gloeophyllum trabeum*, except Phyllostylon rhamnoides, which was moderately resistant. For the brown-rot fungus *Tyromyces palustris*, the highly resistant species were *Astronium urundeuva*, *Caesalpinia pluviosa*, *Schinopsis quebracho-colorado*, and *Tabebuia* spp. (lapacho group); the resistant species were *Amburana cearensis*, *Anadenanthera colubrina*, *Aspidosperma cylindrocarpon*, *Diplotropis purpurea*, and *Guibourtia chodatiana*; and the moderately resistant species was *Phyllostylon rhamnoides*. Results from the second 12-week period are pending, which might show some additional species separation for durability.

The Possibility of Some Sulawesi Wood Species for Substitution of Marine Construction

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This study was conducted to provide basic information on the treatment of sixteen Sulawesi wood species using Cooper-Chrome-Boron preservative. Sixteen wood species of Sulawesi were planned to final specimen dimension of 2,5 cm x 5 cm x 30 cm, and were drilled at the middle (the diameter of hole around 1 cm). Then all specimens except control, ulin (*Eusideroxylon zwageri* T.et B.), besi (*Metrosideros petiolata* Kds.) and Kandole (*Diploknema oligomera* H.J.L.) were treated by full-cell process with pressure 150 Psi about 4 hours. All specimens (control and treated) consisted of thirty specimens for every species. Each of these was differentiated into three groups and arranged into rafts. Group I was installed in the sea for 4 months, group II was installed for 8 months, and group III was installed for 12 months. The test agains marine borers was conducted in the waters of Ballang Lompo Island. At the end of the treatment for every group, observation of specimens were conducted by spliting each specimen into two parts and determining the attack intensity using the Nordic Wood Preservation Council (NWPC) standard No. 1.4.2.2/75. The attacking borer species can be identified from the traces of boring hole, type of cutting ang pallet on the aatacked specimens. The results of the study indicate that preservation were able to prevent manine borer attack. All the untreated specimens were attacked by marine borer, especially kolaka (*Parinari corymbosa* Miq.), kandole (*D. oligomera* H.J.L.), besi (*M. petiolata* Kds.) and ulin (*E. zwageri* T. et B.). On the other hand, those treated specimens showed greater resistence to marine borer attack. Moreover, *P. corymbosa* Miq., *D. oligomera* H.J.L., *Pterocarpus indicus* Willd. *Eucalyptus deglupta* Bl. and *Elmerrillia ovalis* Dandy. can substitute marine wood species such as *E. zwageri* T.et B., *Metrosideros petiolata* Kds., *Vitex cofassus* Reinw. and *Tectona grandis* L.f. Untreated wood specimens were attacked by *Bankia cieba* Clenth/Turner., Teredo bartschi Clapp., Dicyathifer manni Wright. belongs to Teredinidae family and Martesia strata Linne. belongs to Pholadidae family. There were no symptoms of crustacean infestation on the specimens. However, many crustaceans were found clinging to on the specimens when they were taken from the sea. This crustacean belongs to *Sphaeroma sp*.

Keywords: Sulawesi wood species, preservation, marine borers, Indonesia.

The Influence of Hygroscopic-range Moisture Content on Treatability of Red Maple

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The objective of this study was to measure the effect of moisture content (MC) on treatability of red maple (*Acer rubrum* L.). The MC variation studied was in the hygroscopic range, i.e. between about 0 percent and 30 percent MC. Treatability indices studied were penetration, retention, and distribution. Polymerizable monomer was used as the impregnation fluid. It was polymerized and its location was studied using microscopy. Impregnations were carried out in different flow directions.

Results showed that treatability indices increased with decreasing MC. A significant difference was found between retention at 30 percent MC and other MC levels. Penetration depth in radial flow at different MC had the same trend as retention, i.e., inverse relationship with MC, but in other flow directions penetration did not change with MC. Distribution of fluid was best when penetration had occurred radially and tangentially. Since retention and penetration in tangential flow were better than those in radial flow, the best treatment was thought to occur in tangential flow.

Changes on the Structure of Ring Porous Tree Species Caused by High Temperatures

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High temperatures, in some materials, really mean change of the crystallitic structure, state of matter, or changes on chemical composition. In wood, it is the temperature of about 200°C which causes the changes. The process of ignition and burning of wood is influenced mainly by the individual chemical composition and physical properties. This work is concerned with a more detailed study of the influence of structure of individual ring-porous tree species on the process of burning. The following tree species have been chosen:

- Sessile oak - *Quercus petraea* (Mattusch.) Liebl.
- Mountain elm - *Ulmus Montana* Stokes
- European ash - *Fraxinus excelsior* L.
- Black locust - *Robinia pseudoacacia* L.

These tree species were exposed to radiant heat sources with the intensity of 750 W. The process of heating was controlled in order to prevent the ignition of specimens and to observe only the influence of the radiant heat. In general, it can be concluded that the source caused changes in structure being macroscopically observed as colour changes. Boundaries of these changes limited zones of our observation. Individual microscopic observations are shown in various figures.

Laboratory Assessment of CCB as an Alternative to CCA Against Drywood Termite, *Cryptotemes cyanocephalus*

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Copper-chrome- arsenic (CCA) is the most established wood preservative in this country especially for termite protection and for ground contact application. The termicidal properties of this formulation derives from arsenic compound. However, due to various criticisms with regard to possible danger associated with the arsenic content either for mammal and environment, other woodpreservative such as copper- chrome-boron(CCB) has been tested as an alternative to CCA. The study based on the laboratory scale is included the leaching properties of the individual salt of copper, chrome, arsenic and boron and their effect on one of the two species of drywood termites encountered in Peninsular Malaysia, *Cryptotermes cyanocephalus*. The chemical content in the treated wood block will be expressed in kg m-3 and the effect of CCA and CCB on the *Cryptotermes cyanocephalus* will be expressed in percentage of weight loss.

Improved Preservative Delivery and Treatment System for Timber Treatment

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Copper-chrome-arsenic (CCA) preservative for timber treatment has been used in Malaysia for more than thirty years. This preservative is utilised in the vacuum-pressure treatment of hardwoods for use (mainly) in construction. The timber preservation industry has progressed rather slowly both in terms of technology and productivity when compared to the other timber processing sectors.

Since its introduction CCA has been sold to the end-users in drums of (mainly) 100 kg in the form of a paste. The problems associated with handling the paste formulation at the treatment plants include, hardening of the paste during storage, disposal of the drums after use, spillage and difficulty in transferring to the mixing tanks and concerns on safety of the workers.

An improved delivery system for CCA, which has been used in Australia and New Zealand, was introduced to the timber preservation industry in Malaysia in recent years. The system overcomes some of the problems associated with the handling of "paste formulation" and will thus improve the health and safety of workers as well. The system consists of the delivery of an aqueous formulation of CCA of known strength to the end-user. This product is contained in a delivery tank and every batch (tank) delivered to the customer is sampled for analysis at the factory before delivery to ensure that the concentration required and other specifications of the CCA preservative are met. At the treatment factory the treatment plant facility is modified to accommodate the mechanical transfer of the CCA solution delivered to ensure minimal handling by the operators and less impact to the environment. This system fits in with the "Responsible Care" initiative adopted by chemical companies to continuously improve environmental health and safety performance of the industry. The improved delivery system will also ensure a greater consistency of quality of treatment, which is vital in improving the quality of timber treatment in the country. The paper describes the improved delivery system and discusses the advantages compared to the existing system that is practised now.

Performance of Treated *Gigantochloa scortechinii* in 24 Months Ground Contact Tests

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Bamboo has been widely used in the construction and dwelling purposes for hundreds of years. However, recorded information on their performance in the ground contact tests are lacking. A study was conducted on the ammoniacal copper-quat and copper chrome arsenic treated *Gigantochloa scortechinii* in a ground contact tests in Melaka, Malaysia. The tests covers the different ages of the bamboo culms, treatment techniques, type of chemical and the strength of chemical used. The result of the study indicated that the 4 year-old bamboo stakes were more durable than the 2 year-old. Stakes treated with CCA performed slightly better than the ACQ treated stakes. The stakes treated with CCA at all levels of chemical strength performed extremely well having little decay. While stakes treated with 2%, 4% and 8% ACQ performed well in the test. On the culms portion, the result indicated that the stakes taken at the top were more durable than the stakes taken from the middle and bottom.

Micrographic Evidence for Degradation of Rubberwood (*Hevea brasilliensis*) Fibre Walls by the Common Sapstain Fungus *Botryodiplodia theobromae*

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Keywords: Blue-stain, Sapstain, *Botryodiplodia theobromae*, Rubberwood, TEM, *Hevea Brasiliensis*, Cell wall degradation, Fibre lumen wall erosion, Soft rot decay.

Sapstain is a serious biological degradation in newly felled (damp) sapwoods of saw logs and sawn timbers in the humid tropics that needs to be overcome during primary processing of these timbers. Some fungi of the Ascomycotina and Deuteromycotina groups are the causal agents, however in the tropics, the Deuteromycete *Botryodiplodia theobromae* appears to be dominant. The resultant bluish discoloration (termed Blue-stain) of the otherwise natural light/cream-coloured sapwood, is clearly unsightly in decorative wood products. In Peninsular Malaysia, freshly-felled plantation-grown Rubberwood (*Hevea Brasiliensis*) represents the many species of light native hardwoods which are readily susceptible to bluestain. Normally blue-stain in such woods is controlled using proprietaryanti-sapstain preservatives and/or prescribed timber drying schedules, and therefore the possibility of other forms of degradation by this fungus is not considered. Recently however, *Botryodiplodia theobromae* has received renewed interest worldwide because of its ability to significantly degrade wood cell walls in certain sapwood species as well as the gelatinous (i.e. non-lignified) fibres of "tension wood cells", appreciably reducing certain wood strength properties. Similarly, evidence for degradation of the normal (i.e. lignified) fibre walls in rubberwood by *B. theobromae* needs to be satisfactorily obtained, via light microscopy and transmission electron microscopy (TEM) of the wood after exposure to *Botryodiplodia theobromae* for about four weeks. Light microscopy revealed relatively large diameter hyphae to be abundantly present in parenchyma cells. The hyphae were also present in other types of wood cells, including fibres. TEM provided evidence of degradation of the normal fibre walls in rubberwood in the form of lumen wall erosion (type-2 soft rot decay). The fibre walls were thinned in the region of contact with fungal hyphae which appeared flattened when in contact with the wood cell wall suggesting enzymatic action of the hypha as a mode of lumen wall erosion. Another novel feature of hyphal activity was the direct penetration of hypha into and traversing lignified fibre wall. These observations suggest that the ability of *B. theobromae* to degrade lignified wood cells walls should be viewed with concern when utilising rubberwood after prolonged exposure to this fungus.

5.04.00 Wood processing into the next millenium

Cleaner Production In The Pulp and Paper Mills In Malaysia

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The pulp and paper industry is normally associated with the high consumption of water, energy and chemicals which can be expected to contribute to substantial environmental impacts unless it is properly managed. For the last three years, the industry particularly in the Asian region has adopted and practised the concept of cleaner production, which was advocated by NIEM (Network for the Industrial Environmental Management) under the UNEP (United Nations Environment Programme). Cleaner production in this context refers to the continuous application of an integrated preventive environmental stratefy to processes, products and services to improve eco-efficiency and reduce risks to humans and the environment. In 1996 three mills in Malaysia became the pioneer of cleaner production in the pulp and paper industry. To date a total of eight mills have participated in the cleaner production programme. Training on the concept of cleaner production was carried out by holding workshops and conducting mill audits. For each mill a cleaner production team o about 10 members comprising personnel from functional divisions of the mill was formed. During the conduct of the mill audit, all cleaner production options were noted. The options generated were discussed and classified into environmental and economic benefits were reported by the mills involved. This paper will discuss the methodology in conducting the cleaner production exercise in the mills and also the barrier expected during the implementation. This paper will also highlight success of the participating mills in conducting cleaner production mills in conducting cleaner production and the benefits gained in terms of environmental and economics.

Studies on Uses of Alternative Extenders for Plywood Manufacture

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The purpose of this work is the testing of alternative extenders in the adhesive composition, replacing wheat flour in the urea-formaldehyde formulation to give similar, or better, properties and efficiency as the tradicionally used wheat in the plywood industries. Moreover the other objective of this work has been the manufacturing of plywoods, using alternative extenders in the adhesive formulation, and the shearing tests in the glueline.

The alternative extenders used in this work were: wheat flour, soya and oat. The selection of these flours was based on the market available facilities and on accessible price. The resin used was urea-formaldhyde and the catalyst was sulphate of amonium based.

The plywood production employed 30×30×0,2cm veneers of *Eucalyptus cloeziana*, and 320g/cm² of spread amount (double line). The shearing tests were realized in a universal machine of mechanical tests. The statistics outline was of randomic type, and variance analysis was made through F and Tukey-tests at 5% probability level.

The oat (24,80kgf/cm²) is statistically equal to the wheat samples (testimony) at dry conditions. The soya treatment presented the highest medium value (14,89kgf/cm²) of shearing at wet conditions, but, at dry conditions, presented the lowest medium value (17,82kgf/cm²).

From the results, it was brought to a conclusion that the soya treatment at wet conditions presented the highest value of shearing in the glueline, followed by oat and wheat values. The soya treatment at dry condition presented lowest values than the others, because this treatment presented a mixture with a very high viscosity.

Therefore it is recommended studies with new formulations, changing the percentual quantity of extenders in these adhesive formulations, in order to find an ideal consistency, with a better flow, transfer, penetration, wetting and solidification of the adhesive, when applied over veneer surface as well as an appropriate relationship with the glue applicator rollers.

Influence of Steaming on the Chemical and Physical Properties of Wood

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The green wood of *Larix gmelinii* were exposed to steaming at normal atmosphere from 1 to 96 hours and the influence of steaming on the chemical and physical properties of wood were analyzed. The results of the experiments are given as follows: (1). Steaming is a nessary pretreatment process for lumber drying of *Larix gmelinii*, during steaming the resin contained of wood were removed and the water soluble matters which are mainly arabinogalactan were removed too, the PH of wood was reduced from 4.85 to 3.9, the color of wood became darker; the holocellulose content showed a slight decrease and the lignin content increase gradually; the hemicellulose were changed large, a small amount of them were degradated violently and removed from the surface of sample. (2). The air density, specific gravity and the equilibrium moisture content (EMC) of wood were reduced with the steaming process; for the beginning 1 hour of steaming, shrinkage (tangential, radial and volumeric) reduced slightly, then increased, the maximum shrinkage value arrived at 64 hours of steaming.

The Utilisation of SDR (Saw-dry-rip) Concept to Processing Sawnwood from *Eucalyptus cloeziana* F. Muell.

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The mechanical processing of eucalypts wood is problematic due to the high levels of growth stresses. Those stresses cause splits and warps during sawing and resawing, with reduction in the yield of sawed wood. The main objective of this work was to study a method to reduce the intensity and frequencies of those defects, mainly during the resawing operation of sawnwood from *Eucalyptus cloeziana*. The tested method, called SDR, based on the concept of saw-dry-rip, consisted in saw the logs and resaw the boards in the final dimension only after air drying. For comparison, another method was used, called conventional, where the boards ripping was made right after sawing the logs. Six trees were collected from where it was obtained 12 logs (1st and 2nd logs). The logs were transported by truck to the Instituto de Pesquisas Tecnológicas do Estado de Sao Paulo (IPT), where they were sawed in a reciprocating gang saw. The boards originated from six logs were immediately resawed in a multiple circular saw, characterising the conventional method. The remaining boards were resawed after air drying, characterising the SDR method. The defects were evaluated after resawing and also after air drying. The evaluation consisted of determination of the deflection produced by the respective defect. The pieces produced by both methods were also classified to evaluate their quality. The SDR method, was effective in the reduction of the frequency and intensity of crook in dry ripped boards for both positions, in comparison to the conventional method. For bow, the SDR method reduced its frequency slightly, but it was not effective with the specie and it increased the intensity of the defect. However, the SDR method reduced in 62% the rejected pieces in comparison to the conventional method. After the pieces classification by crooking, it was observed that the SDR method produced dry ripped boards with better quality than those produced by the conventional method. However, when classified by bowing, the dry ripped boards produced by the conventional method presented better quality than those produced by the SDR method. It was observed, also, that the log position in the tree didn't influence the intensity of the defects in dry ripped boards produced by both methods. Concluding, it is recommended the SDR method to processing sawnwood from *E. cloeziana*.

Warp Curvature of Scots Pine Sawn Timber Predicted by a Density-based Model

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The result of this study shows that there is a good agreement between the warp curvature of bow and spring and the density distribution within dried sawn timber of Scots pine. The density distribution is expressed as the distance between the density centre of gravity and the geometrical centre of gravity in thin cross sections over the length of the sawn timber. The result is based on two Scots pine (*Pinus silvestris*) studs of the dimension 50 by 125mm and a length of approximately 150 cm and a moisture content of 6.5%. The two studs contain varying amounts of compression wood both in respect to each other and within themselves. In this study the model assumption is based on the difference in moisture related longitudinal shrinking properties between normal wood and, primarily, compression wood. Especially the latter shows a positive correlation between density and shrinking property. The denser the compression wood the higher its volumetric density, up to 1.8 times as high as normal wood, due to an increase in cell wall thickness. The relation between density and the longitudinal shrinking property of compression wood makes it possible to use the density distribution as an indicator of warp curvature within the dried sawn timber. The hypothesis is that asymmetrically distributed differences in the longitudinal shrinking properties of the material must act on the cross sections to develop a warp of the sawn timber. For example, if compression wood with greater moisture-related shrinking properties than normal wood is located close to one side of the cross section, the longitudinal shrinkage will be asymmetric and the plank as a whole will warp towards the compression wood. The larger the amount of dense compression wood the higher the degree of asymmetricality and thus the more rapid the change of the total warp curvature. On the other hand, if the compression wood is symmetrically distributed in the cross section no warp of the plank will occur since the total shrinkage is symmetrical irrespective of the amount of compression wood present. Both the warp of, as well as the density distribution within, the sawn timber were measured with the aid of a medical CT-scanner, Siemens Somatom AR-T. The CT-scanner measures the average density in small volume elements with a resolution of 0.3 x 0.3 x 5mm, one scan per cm over the whole length of the stud. To quantify the degree of asymmetric density distribution in each cross section of the plank, the distance between the geometrical and density centres of gravity is calculated for each CT-scan. Since the CT-scans are evenly distributed over the length of each stud they can be regarded to be approximately continuos measurements of the density distribution within the stud. The calculated distance between density and geometrical centres can furthermore be regarded as the second derivative of an unknown function, by integrating the distances twice, the curve form of the function is revealed and is used as the prediction of the stud's warp of curvature.

The Use of Nigerian Grown '*Hevea Brasiliensis*' in the Mechanical Wood Industry

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The weaknesses and shortcomings of *Hevea Brasiliensis* as raw material for household wood products were examined. These include: availability for mass production, the tree size, susceptibility to insect and fingal attack, seasoning defects, dirt absorption and the resistance of the populace to embrace it. The physical and mechanical properties were studied to rank it with trees from natural forests, which are facing depletion. The wood at 12% moisture content has a density of 640 kg/m^3. The bending strength and modulus of elasticity were 65 N/mm^2 and 9250 N/Nm^2 respectively while the compression parallel to grain is 32 N/mm^2. The total shrinkage was 3%. These properties point to its bright future as an acceptable addition to the species that are presently used in the Nigerian wood industry. On the bases of these findings some solutions were recommended:

1.A survey of available plantation and year of planting of different stands. New establishments must be preplanned for mechanical processing when the latex production becomes unrentable.

2.Small dimension machines must be procured to handle the conversion into useable boards. Many of such machines are now available for different processes in the wood industry.

3.Apart from the available preservatives, timely seasoning after conversion has shown a lot of promise in preventing discoloration and even some beethe attacks.

4.Conversion into short lengths have prevented warping, while longer dimensions can be achieved by the use of established technology of lamination.

5.The presence of large vessels is the main cause of obsorption of dirts and this can be prevented by end coating with sealers to fill up the large vessels.

6.The more publicity given to the products through exhibitions can assist in convicing people more so that species from the natural forests are dwindly by the day.

Planing Characteristics of some Ghanaian Lesser-Used Timber Species

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Keywords: Planing, Characteristics, Lesser-Used timber species, Ghana.

The current rate of expansion of the Timber Processing Industries in Ghana coupled with the dwindling nature of the primary species has made the current Annual Allowable Cut insufficient to satisfy the increasing demand. One major area, which has been highlighted in forest policy, is the introduction of Lesser-Used Timber Species (LUS). This is to broaden the natural resource base and to conserve the biodiversity of the major commercial timbers, particularly the six endangered species of Mahogany (*Khaya* spp.), Wawa (*Triplochiton scleroxylon*), Odum (*Milicia excelsa*), Sapele (*Entandrophragma cylindricum*), Hyedua (*Guibourtia ehie*) and Utile (*Entandrophragma utie*). Knowledge on the working qualities of timbers as well as improved fabrication techniques is of paramount importance. Therefore, lack of information concerning their machining properties will be an obstacle to their use. It is therefore necessary among other properties, to establish the planing characteristics of the LUS to enhance their promotion both locally and internationally.

The study sought to determine the planing characteristics of sixteen species classified as Lesser-Used timbers, which were selected, based on their relative abundance by volume in the Ghanaian natural forests.

Under an ITTO sponsored project PD179/91, the species were obtained from both the dry and moist semi-deciduous forests in Ashanti and Western regions of Ghana where most of the country's timber is obtained. Fifty test samples were prepared for each test operation. A Planer machine with one 2-knife cutterhead was used. Four cutting angles, three feed speeds and one cutterhead speed were considered. Each test sample was examined for planing defects using a hand lens and graded.

From the results, chipped and torn grain defects were prevalent on *Danta, Dahoma, Okan, Celtis, Essia*, *Opepe* and *Ayan*. Raised grain was observed on only Yaya and Sterculia (white). More defective samples were noted on all the species as the cutting angle increased form 15 to 30°. The high-density species like *Afena*, *Okan*, and *Essia* require cutting angle of 150 or less in order to avoid some of the planing defects. *Ceiba, Bombax, Antiaris, Canarium* and *Ofram* are planed to a better quality within a wide range of cutting angles. Low feed speeds of 6m/min & 9m/min and high cutter marks of 43 & 29 per 25mm generated high percentage of good to excellent samples for all the species. The rate of generation of defective samples is higher with cutting angles of 30o and 25o at feed speeds of 6m/min and 9m/min as density increases. Planing quality decreases with increasing density using feed speeds of 6m/min, 9m/min and 14m/min.

Performance Testing for Furniture - A Quality Control and a Marketing Tool

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Keywords: Furniture, Performance testing, Performance standards, Quality control.

The designing and manufacturing of furniture are governed by two broad categories of standards. The first category of standards specifies the various dimensions and design details, while the second category specifies the performance requirements for various types of furniture. Performance testing to evaluate the capability of a piece of furniture to perform its intended functions is an important step in the designing and manufacturing of furniture. It will ensure that the furniture has been designed and manufactured to meet specific performance requirements. Simulating the loads and forces that a piece of furniture will be subjected to during its service life, the various performance tests mirror image the behaviors of the furniture performing the intended functions. Weaknesses and defects detected by these tests could assist the designer and/or manufacturer to improve subsequent production. In addition, most standards will have different levels of performance requirements that can be used to classify furniture into different categories according to frequency of usage, or different market segments. The certificate awarded to furniture that passed the tests is therefore a testimony guaranteeing consistent quality and reliability of the piece of furniture. This testimony can thus further enhance the marketability of the product besides boosting the reputation of the designer/manufacturer.

Mechanical Processing and Products of Birch, Aspen and Alder

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Keywords: birch; aspen; alder; wood property; mechanical prosessing; wood product

The utilization of birch (*Betula verrucosa*, *Betula pubescens*), aspen (*Populus tremula*) and alder (*Alnus incana*, *Alnus glutinosa*) in mechanical wood industry in Finland is imperfect. At the moment birch is the most important species and it is mainly used in plywood industry but also in furniture and parquet. The use of aspen and alder is considerably lesser. The problems concerning mechanical processing and the insufficient knowledge of wood raw material properties of these species have restricted the use of them and lowered the value of raw material. However, during last few years an interest in more effective utilization of these species has increased. The first paper mill using aspen as raw material has started in 1997. The growing and use of aspen is increasing and therefore it is even more important to know the use possibilities of aspen also in mechanical wood industry. Birch as well as aspen and alder could be widely used, if their properties, mechanical processing and suitability for different products were better known.

The aim of this study is to clarify the mechanical processing properties of birch, aspen and alder, on the one hand their effect on the quality of end-use products and on the other hand their dependence on raw material, the properties of tree stem and growth site and on wood procurement. The most suitable end-use products for each species are defined considering the properties of raw material, end-use products and processing and the profitability of manufacturing.

The annual use and the most common and potential use objects for birch, aspen and alder as well as the worst problems related to the raw material and manufacturing of products were clarified using literature, inquiries and interviews. The results of this survey have indicated that most of the problems appear in sawing, planing and especially in drying. Deformations, shakes, cracks, colour changes and differencies of moisture content after drying are the most typical problems that affect the quality of the wood raw material of birch, aspen and alder. The problems are often the same regardless of which end-use product is manufactured. According to this survey the most suitable end-use product for birch is furniture, for aspen sauna benches and panels and for alder panels and furniture.

According to the results of this survey the empirical part of the study concentrates on the most promising end-use products of birch and grey alder and solves the problems appearing in processing of them. The most essential processing methods to concentrate on are drying, planing and gluing. The focus changes according the species, end-use product and processing problem. One of the most important tasks is to compare the high-frequence-vacuum drying to the typical condense drying. Another project is studying the aspen and common alder wood properties after warm air drying, condense drying and high-frequence-vacuum drying. In addition to the planing and gluing also the heat treatment will be one of the subjects.

The study increases knowledge of the possibilities to use birch, aspen and alder wood in mechanical wood industry. The most suitable end-use products for the species, their quality and processing properties and profitability of processing are clarified. Recommendations to process the wood raw material of the species are compiled. Birch, aspen and alder may be better utilized in mechanical wood industry, the use of them may increase, new products may be found and for example in the furniture industry they may replace foreign species.

An Approach to the Surface Hardness Enhancement of Chinese Fir Wood

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The paper involves a research on the effects of two kinds of pre-treatment on the surface hardness enhancement of plantation Chinese fur wood. It was designed that wood surfaces pre-treated with laser incision and chemicals were penetrated with Hardening Treatment Solution (HTS) in 1-2mm to enhance the wood surface hardness. The heartwood that is penetrated difficultly was used as sample in the experiment. It was found through a lot of experiments we made: 1) When incised with laser vertically to the growth direction of tracheids beneath wood surface in 1-2mm, then HTS was applied to sample by means of vacuum, the uniform penetration was formed in 20 cells depth. The wood surface hardness was changed from less pencil hardness 6B to H or HB. 2) After chemically pretreated, HTS was penetrated uniformly on the wood surface in 4 cells depth under vacuum. 70% of earlywood lumens was filled with HTS in 10-20 cells depth. The wood surface hardness achieved to pencil hardness 2B to 3B. 3). Regarding to enhancement of wood surface hardness, it plays more important role to achieve the uniform penetration than to obtain deeper penetration and increase the weight gain of HTS.

Floorboard Manufacturing from Small Diameter Coppice Trees of *Quercus ilex* from Southern France

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Quercus ilex is a very widely spread species in southern France and north Africa. In French Mediterranean regions, since fifty years, both surfaces and standing tree volume are strongly growing as shown by the three last successive forest inventories. Wood from *Quercus ilex* has both a very high specific gravity and hardness, but its specific modulus is rather low. Besides, its light colour, its smooth grain and its figurative aspect are interesting to respond to the present demand of raw material from flooring industry.

A study has been launched to determine for this species the availability level in forest, the optimum processing parameters, the technological characteristics according to the local origin, and the economic feasibility of floorboard manufacturing at a regional level. Wood privates firms specialized in fuel wood logging, timber sawing, joinery and floorboards manufacturing which have shown an interest in this project have been involved and associated to the operations. Several plots have been sampled in the Languedoc-Roussillon region in order to select trees representative of the regional forest resource quality: larger diameter trees from parks, remaining trees from ever exploited coppices for fuel wood, small diameter trees from young coppices.

Sawing tests have shown that yields widely vary according to the origin of the trees, their quality, but the diameter has a low effect on this parameter. Bandsaw with stellite must be used but even though hardness is very high, this wood did not appeared very abrasive and did not require particular sharpening operation. Boles are not straight. Thus, sawing of short length logs leads to obtain higher yields, but needs adapted saw carriage. This wood is considered as very "nervous" but small size elements as floorboards dried well with very few distortions and splits. Economic study highlighted that flooring made in *Quercus ilex* has to be considered as an up-market product, at the same level that some tropical wood flooring which are in great demand because of their interesting aesthetic appearance.

Kraft Pulping of "*Acacia ferruginea*" for Paper Making

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Keywords: tensile strength, tear index, opacity, burst index, folding endurance

Acacia ferrugenia, posses a medium size tree, quite straight with 9-12 meters in height. Its leaves will fall from time to time. The bark is gray in color, with bipinnate leafs and pale yellow flower. Like other hard wood material, which contains high amount of lignocellulosic materials, this species is found to be one of the best raw materials for pulp and papermaking.

The present study was conducted to determine the mechanical and physical properties of paper produce using Kraft pulping for this species. The normal conventional methods were followed: 13% of alkali active (NaOH), 25% sulfidity (NaS) were cooked together with 600g. *Acacia ferrugenia* wood chips for 3.5 hours. The ratio of liquid to wood chips oven dry weight was 3.5:1. After removing the black liquor, the pulps were wash thoroughly with plenty of water and were spin-dried. The pulps were beat at 3,000, 6,000 and 9,000 rpm and tested for physical properties such as tensile strength, folding endurance, burst, tearing and others.

The yield obtained was 39.5%; with the kappa number value was 24. The CSF at non-beating, 3,000, 6,000 and 9,000 were 649, 490, 342 and 244 respectively. The tensile strength, folding endurance, tearing strength and burst index at 64 g m^{-2} for non beating, 3,000, 6,000 and 9,000 rpm were as followed: - tensile strength indexes (Nm/g) results were 29, 67, 80 and 83 respectively. Tearing indexes (mNm^2g-I) were 2.8, 8.5, 8.9 and 8.4 respectively. Burst indexes were ($kPam^2g$-1) were 0.7. 3.6, 4.6 and 4.8 respectively. While the folding endurance results (numbers of fold) were 2, 35, 124 and 135 respectively. The bond strengths (Mpa) were 5, 13, 21, and 25 respectively. The air permeabilities (seconds) were 2,4,14 and 23 respectively. The fibers lengths were in between 0.8 to 1.23mm, with the density of $1.1.gcm^3$. The paper opacity was 90% for all beating parameters.

The results suggested that this species is suitable as an option for raw material in paper making which could be included in the mix tropical pulp in which currently produce by one of the integrated paper mill in Malaysia.

Cellular Manufactoring System and its Computer-aided Application in a Furniture Factory

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Keywords: Cellular Manufacturing System, Group Technology, Furniture Industry

Recently, market demands compel the firms towards producing a variety of goods in smaller quantities. For this reason, many companies, which manufacture a variety of products with large quantities, suffer from many problems in designing, planning and production stages. Cellular Manufacturing System (CMS) and Group Technology (GT) suggest radical solutions to these problems. CMS and GT have been increasingly arousing interest in many countries and wide variety and successful applications are especially known in Japan and USA. CMS is an accepted solution to the problem of productivity in batch-production systems. Parts are classified into part families and machines into machine cells, based on the sameness or similarity of operations. GT is a manufacturing philosophy. It emphasizes that many problems are essentially similar and collecting the similar problems in a group and finding just one solution to them provide us with time and effort saving. The classification method is used to group parts into part families based on their design features. Since the GT problem is NP complete, heuristic algorithms are most likely to be used for solving large-scale industrial problems. The grouping results lead to the physical machine layout and/or logical machine layout. The latter is used when the production content changes rather frequently. In this case GT makes the tool management and part scheduling easier and this improves the efficiency of production planning and control.

The aim of this study is to simplify the part flow, save area and shorten the transportation distances by the help of CMS and GT. Here, clustering problems were solved by using King's Algorithm. The computer program written in BASIC is introduced into seven stages.

- Entering the data
- Running the program
- Solving the assignment problem by using King's Algorithm
- Determining the machine cells
- Determining the part families
- Solving the problem of common facilities
- Determining the performance of CMS

This manufacturing system was established in a furniture factory by setting up four different cells using group technology clustering technique. The layout of the machines within the cells were U-shaped layout. Later, CMS was simulated by Siman simulation language and determined its performance. It has appeared that performance values of CMS are suitable to apply.

Having CMS, the flow of parts was simplified, the transportation distances between machines were shortened about 44.3% and, the area needed for the production was reduced by 36%.

5.04.06 Wood drying

Influence of Moisture Sorption on the Physical-mechanical Properties of Caoba (*Swietenia macrophylla* King) Wood.

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Caoba wood is appreciated for its dimensional stability. This stability is associated to the moisture sorption properties of wood, which gives adsorption and desorption curves from the oven-dry and green initial conditions, respectively. Wood in service is exposed to a range of relative humidity. Twelve matched groups of thirty adjacent specimens each of caoba wood from Peru were selected to perform moisture sorption tests at 25°C. These experiments were combined with dimensional measurements and perpendicular to the grain tangential compression tests. For a given equilibrium moisture content, tangential and volumetric swelling were greater after desorption than after adsorption. When equilibrium was reached by gaining moisture, the wood was stiffer in tangential compression compared to when the equilibrium was reached after losing moisture. This behavior, called second-order effects of moisture sorption, has been established for the physical and mechanical properties of caoba wood. The swelling effects are proportionally greater in the tangential direction of the wood than in its radial axis. It seems that second-order effects of moisture sorption associated with tangential to grain compression strength are not explained by those related to the transverse swelling of wood.

Effect of Haze on Solar Timber Drying

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Solar radiation is an important factor in solar timber drying. Its availability is subject to seasonal variations and thus the solar drying performance is predictable to a certain extent based on annual weather data. Malaysia is a maritime country located in the tropics, the climate is characterized by uniform temperature, high humidity and abundant sunshine throughout the year. The performance of solar timber drying is not expected to have high variation. However, the effect on the performance due to factors such as prolonged haze is not reported. A substantial amount of solar radiation is reflected or filtered by the suspended particles during hazy weather conditions. This study investigates the solar drying rates of timber dried under normal and hazy weather conditions experienced in Malaysia.

The solar dryer used in this study is a modified greenhouse type solar dryer. A solar collector is incorporated into the roof system of the dryer and there is recycling path below the solar absorber. Two axial fans are installed at the central wall dividing the drying chamber into two compartments.

Solar drying trials of kapur (*Dryobalanops aromatica*) were carried in the Forest Research Institute Malaysia during normal and hazy weather conditions. Each trail comprised 4 m^3 of kapur of dimensions 30x125mm. The timbers were filleted with 25x25mm stickers into two stacks. The weight or moisture loss of the whole timber stack was monitored continuously using load cell measurement. The moisture content of the timber at any time during the drying process was calculated based on initial moisture content determined using the oven drying method. The air speed through the timber was maintained at about 3m/s throughout the drying process. Due to high ambient relative humidity, venting was carried out between 10.00h and 12.00h and again between 14.00h and 16.00h daily except when it rained.

The average ambient temperature and relative humidity were not significantly different for the two drying periods. However, the average daily solar radiation during hazy weather condition was 56% lower than that during normal weather condition. The solar drying rate of kapur during hazy weather condition at below the Fibre Saturation Point (FSP) was found to be about half the drying rate at normal weather condition. For drying at above the FSP, the drying rate under hazy condition was 45% lower than the normal drying rate.

5.04.07 Adhesives and wood gluing

Rapid drying of Laser-incised Sugi Square Lumber by Steam Injection

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Keywords: Laser incising; Square lumber; Steam injection; Drying

Drying of laser-incised square lumber has been tested by an induction heating method such as microwave and high-frequency heating. It became clear that water comes out drastically from laser-incised holes and thus laser incising can be used as a pretreatment method for rapid drying by induction heating. However, a laser-incised hole acts only an outlet of water in lumber for these drying methods. So, we tried to give another role to a laser-incised hole using a steam injection press.

Several posts of Sugi (*Cryptomeria japonica* D. Don, Japanese cedar) square lumber were used as a specimen. Specimens of 60 cm long by 100mm wide by 105mm thick were cut out from 105 by 105mm, 4 m length square lumber. Thin sections from both ends of each specimen were cut to measure the initial moisture content and its distribution. Their moisture content ranged 88 to 167% before laser incising. Specimens were incised through 105mm thickness by CO_2 laser with incision density of 5,000 and 10,000 holes per square meter. All ends of specimens with and without incising were sealed with silicon adhesive. Steam of 120, 140 and 160°C was passed through the incised holes of a specimen with a steam injection press. Injection times were a time till a specimen reaches the steam temperature, two and four times as much as the time. Temperatures at the center of a specimen were monitored with a thermocouple during the steam injection. The weight of a specimen was measured several times interrupting the injection during the whole process. Average moisture content and its distribution of a specimen were measured at thin sections cut from the specimen after cooling sufficiently. Five hours of continuous injection with 140° was also achieved measuring the weight change.

The temperature of a specimen reached at almost the same temperature as the injected steam within a few minutes for the steam injection of higher temperatures. The densely incised specimen showed faster temperature rise and milder distribution of moisture content. A trial of 140°C steam injection lowered the moisture content of a specimen from about 100% to about 30% within 300 minutes.

Market-orientated Process of Defining Timber Processing Value in Sawing: The Case of Grey Alder (*Alnus incana*)

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Utilization of so-called special timber has been an increasingly interesting issue in the official discussions of Finland and strategic plans of the small and medium-sized saw mill industries during the recent years. Despite the interests of many parts in the forest sector, only a small part of the research has been focused on this issue. Utilization of the special timber is naturally a more marginal alternative than that of the timber of the three main species in Finland, pine, spruce and birch. However, product diversification provides small saw mills with considerable benefits.

The purpose of this study was to construct the requirements for the quality of saw logs of grey alder and to determine the industrial value of the stems for mechanical wood processing. The goals were achieved by researching following issues:

1. Inventory of the resources of alder in Finland: forest areas and timber volumes.
2. Sampling experimental forest stands and alder trees in each stand for the study.
3. Measurement of the external quality factors of the experimental alder trees.
4. Determining the significance of external quality and dimensions (diameter, length) of the logs of alder for sawing.
5. Determining the relationships between the value of sawn goods and the external quality factors of trees and logs.
6. Exploring the potential markets for the mechanical products of alder by a limited market analysis in Central Europe.

The results showed that in the current market situation, the small saw mills operating with the main species, especially pine and spruce, are not able to compete with the big saw mills as regards the production of so-called bulk sawn goods. Despite the slow speed and low yield in sawing alder, the production is profitable, because raw material is fairly low-priced but the products have relatively high prices. This study yields essential information to predict the quality of alder for sawing by using the external characteristics of the trees. Furthermore, this information can be used to channel the raw materials of alder to the most suitable production from the entire start of wood procurement.

Use of Sago Flour as an Alternative Filler to Wheat Flour in Plywood Manufacturing

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The feasibility of using sago flour as an alternative filler to replace wheat flour in the manufacture of plywood in Sarawak is investigated. From the determination of viscosities of varying quantities of sago and wheat flour, straight sago flour having low viscosity is not suitable but a partial replacement of up to 50% may be possible and needs to be explored. The trial was conducted by fabricating five-ply plywood test panels using an urea formaldehyde-melamine urea formaldehyde adhesive resin mix, varying quantities of sago and wheat flour and Red Meranti (*Shorea* spp) veneers for surface and core layers. The test specimens from these panels were tested for tensile shear strength and wood failure in accordance to Japanese Agricultural Standards (JAS) for their relative compliance. A comparison was also carried out with that of a commercially produced plywood sample. Generally, all the test specimens can fulfill the minimum strength requirement stipulated in the Standards. The preliminary investigation shows that sago flour can be used as a partial replacement for wheat flour.

Effect of the Knife Jointing on the Gluing Properties of Sugar Maple Wood

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Jointing is a common practice required to produce a same cutting circle for all knives mounted over a cutterhead of a peripheral knife planer. This is also realized to refresh slightly dulled knives. The jointed land at the cutting edge has a 0° clearance angle, but becomes negative due to the workpiece motion as well as the cutting edge wear occurs. The jointing operation could crush the superficial layer of the planed board, affecting its quality and performance at service. Four jointing land widths were considered to evaluate their influence on the gluing properties of sugar maple wood. Knives were used up to four levels of wear. The results showed that a wider jointed land decreased the surface quality at different degrees in terms of the gluing shear strength performance. The effect of knife jointing was more evident where the moisture content of the samples fluctuated.

The Formaldehyde Emission of Plywood Made from Different Wood Species and Glue Types

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Experimental plywood were made from tusam (*Pinus merkusii*) and manii (*Maesopsis eminii*) glued with Urea Formaldehyde (UF), Melamine Urea Formaldehyde (MUF) and Phenol Formaldehyde (PF). The formaldehyde emission determined by desicator method according to American Standard and Japanese Standard. Plywood made with PF glue has the lowest formaldehyde emission (1.49-0.63 mg/l), whereas plywood made with UF has higher formaldehyde emission (0.49-6.63 mg/l), and if using MUF glue the formaldehyde emission is in between (0.42-4.69 mg/l). The reason is free formaldehyde content of UF resin is higher than that of MUF and PF resin, while free formaldehyde content of MUF is higher than that of PF resin. The formaldehyde emission of plywood made from manii (0.26-2.99) is lower than formaldehyde emission from tusam plywood (0.42-6.63 mg/l). The extractives content, which solved in alcohol-benzene of tusam (6.40%) is greater than that of manii (1.27%). These extractives have non-polar properties, so that could not bond the free formaldehyde of the resin.

Keywords: formaldehyde emission, glue types, plywood, wood species, desicator method.

5.04.08 Milling and machining

Machining Properties of Plantation White Spruce Wood

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The machining properties of wood vary with the type of cutting process as well as with factors related to the raw material. The machining properties of white spruce wood coming from plantation were evaluated according to the ASTM D 1666-87 standard. The cutting processes studied were as follows: planing, boring, mortising, turning, and shaping. Wood specimens were machined at 8% of moisture content using the different tools and visually graded on a scale of 1 to 5 (excellent or defect free to very poor). The results were generally reported as the percentage of defect free specimens. For the planing test, four rake angles and four feed speeds were used in order to evaluate the influence of these variables on the surface quality. In that case, the maximum depth of the defect due to planing was also measured for each cutting condition. The preliminary results obtained in the planing test show that a 15 degree rake angle yielded better results than rake angles of 20, 25 and 30 degrees.

Optimizing the Sawmills' Activities Through Simulation Software

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The increasing demand for wood based products and their large spectrum of utilization has been along the time one of the major cause of the world deforestation phenomenon. Therefore nowadays it becomes more and more evident that only a judicious management of our forest resources and a tenacious enhancement of the conversion chain from forest to the end-users can avoid the uncertainty of our forests' future.

The numerous researches carried in the field of the improvement the sawmills' activity have clearly shown that one efficient instrument in the betterment of the wood conversion sector is the simulation technique. This kind of approach is an effective tool in studying and understanding how different parameters affect the sawing process in its entirety.

In our study the number one target was to simulate the whole production of a sawmill for one-year period and to confront the results with the real output data obtained in the sawmill. This comparison will further allow us to have a good overview upon the sawmill's production process and in the same time to settle which and were improvements have to be done both on the simulator and sawmill's chain.

In the first step the work was based on the data from the Swedish Stem Bank, which is a unique database for different silvicultural and wood properties. The basis of the Stem Bank project is

computer tomography (CT) scanning of 200 carefully selected Scots pine (*Pinus sylvestris*) stems from 33 plots all over Sweden. This technique allowed us to measure in a non-destructive way the internal defects and the outer shapes of the logs.

In the next step, in order to be able to utilize the parameters files issued from de CT-scanner a software for the simulation of the log disintegration, the virtual-SawMill (vSM) has been developed. The simulation model is written in the C++ language primarily for Macintosh computers. The vSM has an "open architecture", that gives the possibility for users to add their own code for different applications.

The volume of logs virtually sawed with the vSM corresponds to the total volume of the row material sawed annually at a sawmill in Northern Sweden. The distribution of the logs (in both case Scots pine) in quality and diameter classes has been the same in both situations.

5.04.10 Production systematics

Effect of Tree and Log Characteristics on Quality of Radiata Pine Random Width Boards

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This paper links radiata pine characteristics selected from the grower's perspective to the quality of random width boards for appearance markets. It also describes the effects of pruning, log height class, and saw pattern on frequency of occurrence of defects, average defect size, and percentage of clear wood area in random width radiata pine boards.

The first objective was to analyze the potential of standing tree characteristics that can be observed by tree growers as predictors of board quality parameters. Although this "shooting from the hip" estimating approach yields only approximate results, several board quality parameters, such as trends in frequency and average area of defects can be predicted. For example, the smaller the tree diameter at breast height, the higher the frequency of intergrown knots in boards from both pruned and unpruned logs of that tree; a large tree diameter at breast height signals large areas of clearwood in side boards from pruned logs, etc. A database of 392 random width radiata pine boards (17.10 m^3 or 7,245 board feet) was used for the analysis. These boards came from 10 different clones of New Zealand *Pinus radiata* D. Don. Thirty one percent of the boards came from pruned logs while the remainder came from unpruned logs. Nine defect categories were identified.

The second objective was to analyze the effect of log and processing characteristics on board quality parameters. Generally, all defects except resin pockets were less frequent and smaller in boards from pruned logs. Resin pockets, on the other hand, were more frequent in boards pruned logs and had larger average area than in boards from unpruned logs. Boards from pruned logs also had a higher percentage of clear wood area. Apart from a few exceptions, increasing log height class of unpruned logs caused higher defect frequency, larger average defect size and smaller percentage of clear wood area. Of two saw patterns, cant and live, the live saw pattern resulted in higher defect frequency, larger average defect size and smaller percentage of clear wood area. This occurs because boards from the center zone are included in live sawing.

Using Information Technology (IT) in Forestry - A Case Study

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This paper discusses the results of a case study carried out jointly by the Forestry Department of Peninsular Malaysia (FDPM) and the Forest Research Institute of Malaysia (FRIM) into the use of Information Technology (IT) in forestry. The case study was initiated to explore the possibility of using IT to capture the information gathered through the Sawmill Shuttle Returns IV maintained by the FDPM.

The FDPM was concerned over the long lagged time (often 6 to 9 months) needed to process and produce the various statistics and reports required from the Sawmill Shuttle Returns. Furthermore, it was found that the system of reporting was rigid and information that is outside the prescribed format could not be obtained easily. It was realized that an efficient data processing system is needed to ensure that timely and accurate reports are generated for management purposes.

This led to the development of the Sawmill Information System. This paper described the problems encountered during the planning and development stages and the importance of getting the users involved at all stages. The case study indicated that training of users in the use of the

Sawmill Information System was a major factor that contributed to the success of the system. User's initial resistance to change (old work habits) and unfamiliarity of new system was a major problem encountered.

Data validation and accuracy of the data improves tremendously with the implementation of the system. Data captured could be immediately validated, by running the data validation menu and errors could then be corrected.

5.04.12 Surfacing and finishing

Evaluation of Chemical Staining as Wooden Furniture Finish

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Staining of wooden furniture to enhance its appearance has been a long established practice in Ghana. Stains are applied to change the colours of inexpensive wood, as well as to improve the uniformity of colour, particularly in wood that has a naturally variegated colour.

The three commonly used conventional strains in the country are the oil, water, and the non-grain raising. There are a number of constraints found associated with the use of these stains on Ghanaian Wood Species. These include non-uniformity of colour, bleeding solubility in the coats, penetration, grain raising and rate of drying.

The paper assesses the application of the conventional stains in the furniture industry. Methods of application of the stains include base staining to the prepared wood surface or the tinting of compatible lacquer before spraying. Chemical stains on wood prone to fungal attack deteriorates faster than wood surfaces exposed to sunlight. The utility consideration of cleanliness or resistance to water and steam are of greater importance to customers of stained wood for kitchen, bathroom and nursery furniture, than the aesthetic value of the wood. Stain durability factors need further study particularly for the Lesser Utilised species for furniture.

Analysis and Calibration of Time Dependent Colour Changes on Wood Surfaces with PLS and Multiplicative Signal Correction

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Partial Least Squares to Latent Structures (PLS) (Martens & Naess, 1989) and Multivariate Image Projections to Latent Structures (MIPLS) (Hagman, 1996) are methods introduced in chemometrics (Espensen et al., 1992) and in multispectral image analysis and classification of wood (Hagman, Grundberg, 1993). PLS strategies make it possible to handle multivariate data and identify and separate noncorrelated mechanisms within the image data set such as physical properties, fibre direction and moisture content, or chemical properties such as chemical composition and concentration.

In reflectance spectroscopy, Multiplicative Signal Correction (MSC) was introduced as a method to correct for light scattering variations. In diffuse reflectance spectroscopy, light scattering leads to interference effects that have both an additive and a multiplicative component effect and hence cannot just be divided away with a shading calibration operation. Both offset and scaling must be estimated and corrected for. The basis for MSC is that the wavelength dependency of light scattering is different from that of chemically based light absorbency. Thus, many wavelengths can be used to distinguish between light absorption and light scattering (Martens et al., 1989f). Using MSC on spectroscopic data reduces the physical mechanisms and reveals the apparent chemical variations, thus making the final model less complex.

When using an imaging spectrometer (Hagman, 1997) such as the PGP together with CCD-cameras(Hagman, 1997) or a smart sensor (Hagman, 1996) an interference problem is apparent that might be a problem when modeling and that perhaps can be corrected for by means of MSC. Scattering effects may also be corrected for. On the other hand, the literature survey indicated a rather monotone chemical composition and colour for wood, thus with relatively large in-tree variation, indicating that the model may have to take all sorts of variations into consideration to be successful. This paper reveals two tutorials when correcting for spectral changes in the wood surface when interacting with production processes and storage, indicating possibilities to calibrate for time dependent spectral changes in the wood surface.

These are:
-Changes in the colour spectrum for scanned wood surfaces induced by artificial drying and surface treatment.
-MSC correction for time-dependent behaviour of wood surfaces interacting with the surrounding atmosphere.

The Economics of Rubberwood Abrasive Sanding Processes

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The use of Rubberwood (*Hevea Brasiliensis*) in the manufacture of wooden furniture has grown tremendously over the years, especially in the South East Asian region. The wood, a plantation wood resource conforms to the requirement of being environment friendly wood resource. Despite its wide acceptance as a furniture raw material, its use in the manufacturing process is plagued with low yield. Poor rough mill conversion and the inconsistent sanding quality has been cited as the primary attributes of this problem. This study attempts to provide some insight into the fundamental sanding characteristics of the material, using variables commonly employed within the industry. The material is sanded using a twin head wide belt sander, and the economics of the process was evaluated from three perspectives, i.e. namely sanding performance, surface quality and cost. The results suggest that when sanding solid Rubberwood, the optimal feed speed of 10 m/min provides the best sanding performance. Further, silicone oxide mineral based coated abrasives perform up to 17% better than aluminium oxide mineral based coated abrasives when sanding solid Rubberwood. The abrasive belt life is prolonged and optimised, when the feed speed is maintained within the 10 m/min range. From the quality dimension, a sequence of sanding grits will provide the best surface quality. From the study, a grit sequence of 120-150-180 is recommended for sanding of bare solid Rubberwood. The results of this study has several industrial implications. Firstly, in order to reduce the inconsistent sanding quality of the material, the feed speed must be kept lower than what is currently practiced within the industry. A feed speed of 10 m/min has been found to provide the best result. Secondly, silicone carbide mineral based coated abrasives gave better performance on solid Rubberwood. This suggests that the use of such coated abrasives will improve the productivity of the process as a whole, by lowering the cost. Thirdly, keeping the feed speed within the recommended range will enhance the belt life, which inevitably reduces the cost.

5.04.13 Industrial engineering and operations

Multistage Optimization Technique for Enhancing the Profitability of Vertically: Integrated Wood Products Manufacturing Operations

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This paper presents a solution technique for dealing with complex production and inventory problems inherent in vertically integrated wood products manufacturing operations. More specifically, a linear programming (LP) model of a multistage production-inventory system will be presented. The efficacy of such a model in generating objective information for making management decisions will be discussed through a case study involving an integrated hardwood lumber-cabinet manufacturing operation in the southeastern region of the United States of America. To be underscored is the invaluable assistance that the model provides in increasing or maximizing system profitability through the resolution of many important issues including the following:
1) desired level of production and end-of-period inventories at each stage of the integrated operation in each planning period;
2) desired quantity of finished products to be sold in each planning period;
3) level of resource utilization at each stage and the incremental cost and benefit of providing additional resources or productive capacity at each stage; and
4) impact of changes in manufacturing variables and input/output pricing and quantity on system profitability.

Using the model, it was determined that under current operating conditions the study mill would be economically better off (approximately 156% increase in net revenue) operating at full capacity (20,000 board feet of lumber per 10-hour shift) and implementing a two-week instead of the traditional one-month minimum log inventory policy. Furthermore, another 12% increase in net revenue would be realized if input logs have a 12-inch instead of the usual 10-inch minimum small-end

diameter. Also, the model proved to be very useful in analyzing log procurement issues such as determining the most profitable species, sizes, and grade of logs that should be procured and what could be offered as maximum price premium incentives to ensure the delivery of these logs and still achieve a target return on investment. Through parametric analysis, it was also determined that system profitability is most sensitive to sawmilling cost, kiln-dried lumber prices, and log input prices. Furthermore, it was determined that small improvements in lumber recovery and drying degrade percentage would result in large increases in net revenue for the current mill setup. For instance, a 6% improvement in lumber recovery would increase net revenue by about 20% and a 6% reduction in drying degrade would increase net revenue by more than 30%.

An Optimization Model in Plywood Production By Minimum Cost

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In this study, a linear programming model was based for an integrated plywood plant with minimum cost-producing both veneer peeling and plywood. This model comprised two stages and the first stage was (n1) the production of veneer peeling. Obtained boards from (n1) would be used for different thickness plywoods in second stage (n2). It was desired that, the demand for each plywood kinds would be compensated at right time in the certain period. Sources, such as machine times using in each stages at different production centers (headquarters), raw materials and opportunity of style production, were known. Intention of study was compensated the demand of plywood in different thickness with minimum production and inventory cost in accordance with source restrictions in each stages.

Le reflet de la qualité sur le volume d'affaires d'une industrie de parquets au Brásil

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La qualité et la productivité deviennent de plus en plus les préocupations essentielles d'une organisation qui cherche le succés. Un des grands pas a donné pour produire efficacement et pour que le process soit économiquement viable, est la detection de la non-qualité, l'analyse des côuts et l'implantation des mesures préventives, évitant les défauts et les gaspillages inutiles en matériaux et en hommes affectés a la retouche des erreures et aux piéces de réchanges.

Les pertes dans une entreprise peuvent encore servir de base pour la prise de décision par la direction de l'entreprise (TORRES JUNIOR, 1993) mais aussi comme une arme contre l'implantation d'un système de Qualité (BONDUELLE, 1997).

Dans cette étude, l'objectif principal a été de determiner la non-qualité et le côut qu'il implique dans le processus productif de l'industrie du bois notamment dans le demain de l'équarissage (rabotage, tronçonnage).

Ce travail fût realisé dans une entreprise fabriquant du parquet en bois massif situé dans la commune de São José dos Pinhais dans l'état du Paraná au Brésil. Cette entreprise utilize du bois de diverses espéces telles que jatobá (*Hymenea* spp), cabreúva (*Myrocarpus* spp), tauari (*Couratari* spp) goiabão (*Pouteria* pachycarpa) et angelim (*Hymenolobium* spp) dont la production finale est classée en 2 qualités: extra (10 choix) et commerciable (20 choix).

De juin a aôut 97, il a été collecté les données du secteur du rabotage et du tronçonnage de l'entreprise en question, Avec les informations de base fournies par l'entreprise, telles que les dimensions des piéces avant, pendant et aprés l'usinage, nous nous sommes fixés une méthodologie de travail, adaptée au système d'évaluation des côuts de la non-qualité (Norme AFNOR NFX50-126) en considerant les particularites de l'industrie brésilienne.

L'étude experimentale a englobé les données de production de 8 raboteuses et 5 tronçonneuses en considerant chaque machine comme un échantillon, réalisant 8 répétitions par échantillon respectant une heure de prise de donnée. La fonction des tronçonneuses concernait déja une reprise du bois en sortie des raboteuses.

Nous avons obtenu un rendement de bois rabotés de 68.64% de bois que ont été classifié extra et 15.58% commercial resultant un rendement total de 84.22% sachant que les 15.78% restant se divisent en 4.45% de rebuts et 11.33% de retouche. De ce dernier pourcentage, nous retrouvons les bois rejetés en tant que extra mais qui, repris, peuvent être vendu comme commercial. Pour ce retravail il y a perte a 2 reprises: les bois n'est pas vendu au prix du produit extra, e il y a de plus, necessité de reprendre les produits à la tronçonneuse additionant d'avantage de côuts au process.

Les calcules efectués ont montré que le côut de la non-qualité est l'equivalent a 18% du volume d'affaires de l éntreprise.

Les causes de la non-qualité du processus de rabotage est en raport a mauvaise qualité de la matiére-premiére et aussi aux arrêts, consequence d'un manque de plannification de la production. Le temps d'arrêt machine équivaut à 16% du temps total du travail corresponant au temps utilisé pour alimenter les machines, par manque de matiére-prémiere, pour classer les produits suivants 2 qualités et par d'autres raisons diverses liées a non-qualité.

Nous pouvons concluir que est important qu'il existe un système de gestion efficace de l'entreprise, coordonant la production et le marché dans lequel elle fait compétition.

5.05.00 Composite and reconstituted products

On the Wettability of Medium Density Fiberboard

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Keywords: MDF, Wettability, Surface tension, Contact angle, Roughness, Profile density.

The wettability, density and roughness of surfaces of MDF were measured on samples cut from them either in the press direction or at right angle to it. The boards had been manufactured industrially using different amounts of urea-melamine-formaldehyde resin and mixtures of spruce and beech wood.

The wettability was expressed in terms of critical surface tension according to the method by Zisman using contact angle measurements. When using water-isopropanol mixtures, the longer term static measurement of the contact angle provided a good indication of the wettability and penetrability of MDF surfaces while, in the shorter term, the dynamic contact angle measurements seemed somewhat more accurate.

It could be shown that the surface tension was more closely correlated with the density of the boards' surfaces than with their roughness. Values of surface tension of MDF were lower than those reported on particleboards and solid wood.

Hydration of Gypsum bonded Agroforest-waste Composites

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For this study the plaster used as binder raw material, under the conditions with different water-gypsum-ratio (0.65,0.75,0.85,0.95) and three kinds amount slurry (50g, 100g and 150g) to examine their hydration temperature of pure gypsum slurry. The results showed that the hydration temperature increased, when the water-gypsum-ratio decreased and slurry amount increased. When the hydration time between 40 and 53 minute, it showed the temperature peak for 47–54°C. The water-gypsum-ratio 0.65 as example to test the hydration phenomenon during 5 steps (A-stage forming time, B-stage start-bonding time, C-stage surface-curing time, D-stage temperature peak meeting, E-stage end-bonding time). After examinated by CHUNG-HSING simple hydration tester, the moisture content showed 73.4% at A-stage and 17.9% at E-stage. When the water-gypsum-ratio of plaster as 0.65 bonded Agro-forest-waste to make cylinderic sample (diameter 7 cm, amount 150g) the mixed ratio from Agro-forest-waste to gypsum as 5:100, 15:100, 25:100 and 35:100. The results showed that the rice hull particles as fast one curing (38 to 58 minute, hydration temperature from 39 to 50C), secondary wood particles (from 64 to 125 minute, hydration temperature from 37 to 53C). If the using amount with more gypsum, it could find higher hydration temperature.

Surface Roughness of Medium Density Fiberboard and Hardboard

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In wood composites such as medium density fiberboard (MDF) and hardboard, surface roughness plays an important role when these panels are used as substrate for thin overlays or to have acceptable surface finish for furniture industry. Any irregularities on the surface will show through thin overlays reducing quality of finished products.

The objective of this study is to quantify surface roughness and stability of commercially produced MDF and hardboard panels by using stylus and pneumatic methods. Measurements were taken on 15 cm by 15 cm board samples. Six roughness parameters, namely average roughness (Ra), mean peak valley height (Rz), maximum peak-to-valley height (Rmax), reduced core roughness (Rk), reduced valley depth (Rvk), and reduced peak depth (Rpk) were obtained from the stylus method and statistically compared to roughness values from pneumatic Sheffield Tester. Density profiles of each type of board were also determined on a X-Ray device if there is any relationship between surface roughness and density characteristics of the samples.

Based on results of this study, both methods can be used to evaluate surface roughness of MDF and hardboard as a quality control tool. It also seems that measurements from two different techniques can be related each other. Consequently, roughness values of such products can be geometrically interpreted from pneumatic measurements.

Medium Density Fibreboard from Oil Palm Lignocellulosic Materials

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The Malaysian oil palm industry generates a substantial amount of lignocellulosic residues in the form of trunks; fronds and empty fruit bunches. Currently these residues are either burnt or used for mulching in the fields for the next crop rotation but these methods are not sufficient and the residue are creating environmental problems as well as expenses to dispose. These materials are however potential stock that can supplement the wood resources for wood industry especially for wood-based panel products (e.g. particleboard and medium density fibreboard - MDF).

Medium density fibreboard (MDF) is a reconstituted or composite panel product that is manufactured from fibres obtained by fibresing wood or plant materials under heat and pressure. A bonding agent or resin is used to coat the surface of the fibres. The resinated fibres are dried and then formed into a mat, which is finally hot pressed to form a homogeneous board. The density range is usually between 660-850 kgm-3.

The manufacturers of mouldings and strips first used MDF. It is ideal not only for lacquering but also for covering with veneer and these films. Since MDF is composed of a densely compressed and finely distributed fibre structure across the entire profile of the board, the homogeneous edges permit many types of machining operations such as sawing, moulding and boring to take place. It is also possible to cut patterns directly into the boards.

Formaldehyde Emission From Wood Based Panels Of Tropical Timbers

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Methods for the determination of formaldehyde emission from wood based panels are presented. The effect of wood species on the formaldehyde emission values are discussed with reference to plywood manufactured from tropical hardwood veneers. Efforts to reduce the overall formaldehyde emission values are also discussed. It is found that the lighter coloured tropical woods in general give relatively higher formaldehyde emission values than darker coloured woods and that any of the three procedures: glue modification, incorporation of formaldehyde captors and a combination of both are equally as effective to reduce the formaldehyde emission values to acceptable levels.

Medium Density Fiberboards From Plantation Grown *Eucalyptus saligna*

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The production of industrial wood from natural forests is predicted to decline in the future due to a number of factors. Some of these include changes in land use patterns, depletion of resources in many parts of the world, and the withdrawal of forest areas from production in order to provide for environmental, recreational and social needs. There is a shortage of information on the suitability of fiber from many plantation grown species for alternative composite products.

This research was conducted to determine the suitability of plantation grown *Eucalyptus saligna* from Brazil as a raw material for medium density fiberboards (MDF).

Panels were made and tested using 10 percent phenolic resin, and 1 percent wax. The thickness of experimental panels was 6mm, 13mm and 19mm. The mechanical, water resistance and dimensional stability properties of panels were tested according to American Society for Testing and Materials (ASTM) standards.

Test results showed that nearly all mechanical properties of the panels at three tested thickness levels were above minimum requirements for interior and even exterior MDF specified in the ANSI-AHA standards.

This laboratory study indicates that it is entirely possible to make MDF type panels using wood fiber from *Eucalyptus saligna*. Additional work is needed to ascertain the performance of MDF panels from this species when pilot and production scale trials are conducted.

Preliminary Assessment of *Acacia mangium* grown in Sarawak, Malaysia for Manufacture of Oriented Strand Board

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Three-layer Oriented Strand Boards (OSB) with target board densities of 600, 700 and 800 kg/m^3 were made from 12-year-old *Acacia mangium* wood strands of mean dimensions 42.5mm length, 9.7mm width and 0.7mm thickness using melamine urea formaldehyde resin as binder. Two sets of boards were fabricated, one with resin adhesive used homogeneously at 10% for all layers and another with 12% and 5% resin for surface and core layers respectively. The mechanical strength and dimensional stability properties of these boards were determined and compared for their relative compliance to Base particleboard Type 24 -10 of Japanese Industrial Standard JIS A 5908-1994. For bending strength test, two types of specimens, namely parallel with and perpendicular to the direction of strands were prepared. These boards were found to satisfy most of the minimum strength requirements stipulated in the Standard. An increase in board density generally increases the mechanical strength properties and reduces thickness swelling. The discussion also included a comparison of their board properties with that of *Pinus radiata*. The preliminary findings are that 12-year-old *Acacia mangium* is a suitable material for OSB manufacture and possesses better dimensional stability than *Pinus radiata*.

Improvement of *'Quebracho blanco'* Sawn Timber Stability by Using Vegetable Tannin Solutions

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In the Chaco Region of Argentina, several valuable wood species have been misused in spite of their good technological properties, because of certain timber limitations such as log size, difficulty of drying and stabilizing, etc. One of these hardwoods is "Quebracho blanco" (*Aspidosperma quebracho blanco* Schlecht. *Apocinaceae*), that is also one of the most abundant wood species in Argentina. At present the main uses of its timber are pallets, wire fences sticks and charcoal.

In this work the authors show laboratory results of the improvement of the dimensional stability in quebracho blanco small planks by impregnation in green condition with a 30% cold water commercial vegetable tannin solution using a modified Bethel process, with a preliminary 130 mb vacuum and a work pressure of 9 Kg/cm^2 and 10 -15 minutes times. After that, the planks were oven dried at 50o C temperature until constant weigth was reached.

In general this technique is found promissory as a cheap, environmentally friendly non conventional technology to prevent shrinkage and swelling and improving the dimensional stability 70% up. However as a result of the process, light timbers become dark red in colour. Because of that, at present the authors are carrying out a special research in order to prevent this disadvantage (colour change).

Keywords: Quebracho blanco. dimensional satability. vegetable tannins.Chaco Región.

Modulus of Rupture and its Importance in the Design of C4(M) Particleboard Used in Domestic Flooring

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The research work presented into this paper is part of a bigger project called "Determining and modeling the effects of concentrated loads on C4(M)- 18mm thick particleboard". Some objectives of this project are; to determine the effects of concentrated loads in the critical areas, of a particleboard floor, which are the unsupported Tongue and Groove (T&G) joints and then to create a FE model of the T&G joint and its behaviour. In the design of floor decking the Modulus of rupture (MOR), often referred to as bending strength, is specially important not only in calculating design values (according to EC5), but also in predicting the ultimate failure strength of the material. A good agreement between the MOR values derived from the standard three-point bending test and the ultimate failure strength, of the boards subjected to a centred concentrated load was found. This fact was further used in a simplified design method based on the equivalent beam concept. This method relates the complex problem of a plate subjected to a concentrated load to the classical bending calculations of a beam of same span and an equivalent beam width for which the ultimate bending strength are equal. Finite element analysis has been used to determine the maximum tensile stress on the bottom face of particleboard plates subjected to a central concentrated load of 1kN (within the elastic range of deformation). The span of the plates was kept constant while the width was increased up to four times the span size. The equivalent beam width values were increasing up to a width/span ratio of 2 after which they stayed constant (about 0.7xspan). This fact shows that the upper limit of the equivalent beam width is the value for which a full-plate effect is reached.

Effect of Compaction Ratio on Oriented Strandboard Properties Made from Sengon and Tusam Woods

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Three layer oriented strandboard with perpendicular to grain orientation of each layer were made from sengon (*Paraserianthes falcataria*), tusam (*Pinus merkusii*), and mixing of equal parts of both species. Phenol formaldchyde was used as adhesive, the amount was 6% based on oven dried strand, and added with 0%, 1% and 2% paraformldehyde as hardener based on liquid adhesive. Oriented strandboard size was 40 cm by 40 cm by 1 cm with pressing temperature 150°C, and pressure 25 kg/cm^2 for 15 minutes with compaction ratio 1.1, 1.3, and 1.5. This experiment used three factors, i.e. wood species, compaction ratio and percentage of hardener. The wood species affected the physical and mechanical properties of the oriented strandboard. Compaction ratio and percentage of hardener affected these properties, except moisture content. Interaction of these three factors affected physical and mechanical oriented strandboard properties, except thickness swelling. The physical and mechanical properties of oriented strandboard improved as compaction ratio and percentage of hardener increased. Oriented strandboard made from tusam at 1.5 compaction ratio and 2% percentage of hardener had the best physical and mechanical properties.

Oriented Strand Board: A New Outlook for Malaysia

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The demand for plywood is expected to decline over the next 10 years, caused by the rising prices of good quality logs. As an equivalent product to plywood, OSB is rapidly increasing its market share of the world's structural market. Malaysia, with the reputation of being one of the leading wood panel exporters, has greater opportunity to establish OSB mills compared to the other Asian countries. Since the technology does not differ much with that of particleboard MDF, OSB production could be commercialised immediately. Two important factors to be considered for the manufacture of OSB in Malaysia are (1) wood raw material and (2) market potential. Most of the plantation wood species which are currently categorised as "utility grade" such as *A. mangium. A. Crassicarpa*, *A. Auricurliformis*, scenting and rubberwood, can be used for OSB manufacture. Hence, converting these woods into OSB of structural grade gives added value to the end products. OSB is set to win over customers from plywood and particleboard traders due to lower raw material cost and to wider product range. Some of the applications for OSB include timber frame housing , furniture, and automative, panelling, concrete formwork. Shuttering boards etc. This replacement trend is made easier by continuing attempts to improve quality and by the introduction of quality assurance programmes, as well as by the establishments of standards for OSB in Europe and UK.

5.05.01 Lignocellulosic-based composites

Moisture Resistant Oil Palm MDF

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Malaysia is the world's largest producer of crude palm oil with about 2.5 million ha of oil palm, *Elaeis guineensis*, under cultivation. The oil palm industry generates about 30 million tonnes of residues annually. Much of this material (the fronds, empty fruit bunches and trunks) contains valuable fibre that can be utilised for the production of medium density fibreboard (MDF).

After several years of laboratory and pilot plant work culminating in full scale factory trials in 1997, a commercial plant to manufacture MDF panels from oil palm fibre was set up in Gemas, Malaysia. This plant uses the empty fruit bunches as the fibre source.

Although low cost MDF panels suitable for interior use have now been successfully produced, there has been little work undertaken on the use of oil palm fibres to make moisture resistant products. These products have added-value and are more suited for high humidity, wet and exterior type conditions.

This study describes work comparing the performance of several types of moisture resistant oil palm MDF products. Particular emphasis is on the type and application of the adhesives for optimum performance and properties with oil palm fibre.

In particular, the study compares the properties of panels produced with melamine-urea-formaldehyde (MUF) and phenol-formaldehyde (PF) binders and the effectiveness of the glue system and gluing conditions for an oil palm MDF process with respect to: physical properties, water resistance and durability.

The results show that the European V313 requirements for internal bond and thickness swell are not difficult to meet with these resins, the German V100 is met by the more durable of the resins and the wet bending strength requirements of the Japanese JIS5905 demand the most durable resins at high loadings, particularly for the highest moisture resistance class.

Keywords: Oil palm, moisture resistant MDF, melamine-urea-formaldehyde, phenol-formaldehyde.

Bamboo Cement Board

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The compatibility of portland cement with finely ground bamboo was determined. Hydration tests were conducted to determine the maximum hydration temperature and the time required for the mixture to attain a maximum hydration temperature. The pulverized bamboo was subjected to such treatment as hot water extraction and the use of chemical additive, calcium chloride to enhance its compatibility with cement. The untreated bamboo was observed not to be inhibitory to cement setting but the addition of chemical additive substantially improved cement setting time. Air-dried bamboo flakes were used for board production at cement-bamboo ratio 3:1, 2.5:1 and 1:1 at nominal board density of 1,200 and 1000 Kg/m^3 respectively. The effects of cement/bamboo ratio and board density on bending strength, internal bond and thickness swelling of cement bonded particleboard from bamboo were investigated. The boards produced at cement-bamboo ratio 1:1 failed due to poor bond strength. The bending strength of boards produced at 3:1 and 2.5:1 bamboo-cement ratio increased with bamboo-cement ratio. There were no significant variations in the internal bond strength of the boards irrespective of bamboo-cement ratio. Boards produced at 3:1 cement-bamboo ratio and 1000 kg/m^3 nominal density had the lowest mean thickness swelling.

Production and Utilization of Wood Briquettes from Sawmill Residues in Nigeria

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Wood is the major source of domestic fuel in the rural areas in Nigeria. About 86% of people in Nigeria use wood for their domestic cooking and for keeping their surroundings warm. The annual consumption of fuelwood in the country is about seventy million cubic metres. The current rate of fuelwood utilization in Nigeria and several tropical countries surpasses the rate of production of wood in plantations and natural forests. Thus there is the problem of deficit supply of fuelwood in some parts of the country. The main objective of the study is to produce briquettes from wood residues in the forest industries for fuelwood supply to areas where there are acute shortage. It was estimated that about 55% of wood biomass processed in the sawmill end up as mill residue. It is expected that the problem of deficit in supply of fuelwood would be alleviated if wood briquettes are produced from about 1.72 million m^3 of wood wastes generated in the wood industries in Nigeria per annum. Wood residues from forest based industries in Nigeria were assessed in terms of availability, combustion characteristics and their potentials for energy production. Wood briquettes were produced from air-dried sawdust and carbonized wood samples collected from sawmills in Akure, Nigeria. Locally produced starch from cassava and clay were separately used as binders at 15, 30 and 40% weight of substrate. Combustion related properties of the briquettes, Viz: moisture content, heating value and energy captured during water boiling tests were determined. The moisture content of the air-dried briquettes ranged from 13 to 17%. Starch bonded briquettes generally had lower moisture content than clay bonded briquettes. The gross heat of combustion of the briquettes ranged between 19.50 and 20.20 MJ/Kg. Briquettes produced from carbonized wood had comparatively greater gross heat of combustion than ordinary sawdust. The highest energy captured during water boiling test, 2.67 KJ/g was recorded for starch bonded briquettes while the least energy captured 1.43KJ/g was recorded for clay briquettes. Briquettes produced from starch based carbonized wood had the best combustion characteristics. The burning properties of starch bonded briquettes were generally better than those of clay based briquettes. Clay based wood briquettes were cheaper and more attractive to the rural people because of the simple production technique. Urban dwellers prefer starch based charcoal for domestic cooking and barbecue production. All the charcoal briquettes produced have high heat of combustion and low ash content.

Research on Medium Density Fiberboard Manufacturing Possibilities from Cotton Stalks (*Gossypium Hirsitum* L.)

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Raw materials in the world are gradually decreasing. As the population increase will enhance raw material consumption, maximum gain must be obtained from natural sources. When using initialized cotton stalks in the manufacture of medium density fiberboard (MDF) a new solution will be found for raw material shortage.

In this study, cotton stalks obtained from Adana province were used as raw material. 8% and 10% urea formaldehyde resin and 3.25 hydrous ammonium as a strengthening agent were used on the basis of dry fiber weight. Also 1% paraffin solution was used as hydrophilic material on the basis of dry fiber weight. 15% moisture content chips were cooked under 7 atmosphere pressure during 3 minutes and defibered by a defibrator in two minutes.

Chemical analyses results of cotton stalks which is volume density of 0.286 (g/cm^3) were as follows: cellulose content 51.8%, holocellulose 76.8%, lignine 20.7%, pentosan 22.3%, alchol benzene solubility 3.8%, ash content 2.6%. Specific gravity values obtained were higher than expected. Moisture content values vary between 5.38% and 6.00%. Within 0.05% confidence limit there was no significant difference water absorption swelling with specific gravity and resin ratio used.

At 8% resin ratio minimum and maximum bending strength were 12.283 (N/mm^2) and 21.009 (N/mm^2) respectively. On the other hand at 10% resin ratio the same values were 15.054 (N/mm^2) and 23.085 (N/mm^2) respectively. Bending strength was increased with resin rate used and specific gravity. The same result was obtained from perpendicular traction strength. Traction strength values at 10% resin ratio were higher than those of 8% resin rate.

Oriented Strandboard from Pinus taeda and Aspidosperma quebracho blanco Schlecht.

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The results of the evaluations of some mechanical properties of oriented strand board from *Aspidosperma quebracho blanco* Schlecht (QB) and *Pinus taeda* (P) are presented in this paper.

The panels were built using a mixture of strands of both species in different proportions to establish the maximum quantity of strands of QB that it can be used in the production of OSB panels.

The values obtained from the machanical tests were analyzed through technical statistics in order to identify the best panels. The experimentals values were compared with those demanded by the Canadian norm CSA O437.0.

As expected, the statistical analyses showed that no single panel is the best for all tests. However, based on the comparations with the values demanded by CSA O437.0, it can be concluded that it is possible to elaborate OSB panels with a mixture of two kinds of strands with the quantity of white quebracho in it, not exceeding of 40% for the external layer and of 60% for the internal layer.

Effects of Density Profile on the Dimensional Stability of Particleboard and Fiberboard

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Two types of particleboard and fiberboard, namely homo-profile and conventional boards, were produced via manipulation of hot pressing method, using lauan (*Shorea* spp.) particles/fibers and isocyanate resin. The density profile of homo-profile board is homogenous and flat, whereas that of conventional board resembles a typical U-shape. Further, the density profile of the conventional board was varied by changing the hot pressing method and mat moisture content.

After conditioning at 20+- 1øC and 65+-% relative humidity (RH), the changes in board thickness and weight of 50mm by 50mm specimens were determined after each stage of dry/wet cycle. In addition, the equilibrium moisture content, thickness changes, and linear expansion (LE) of 50mm by 300mm specimens were measured after exposure to 33.66 and 95% RH levels.

Generally, particleboard recorded higher thickness swelling (TS) and water absorption compared to fiberboard irrespective of density profile. Specifically however, conventional particleboard had a higher TS than homo-particleboard, whereas a reserved trend was observed in fiberboard. Under increasing RH, except at 95% RH, particleboard registered higher LE than fiberboard, irrespective of their density profiles. Homo-profile particleboard had a higher LE than conventional board, but fiberboard showed reversed trend. Peak area was found to affect the TS of board, but no specific trend was observed for density profile-LE correlation within the conventional boards.

5.05.02 Recycling and recycled products

Potential Utilisation of Mill Residues in Peninsular Malaysia

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This paper discussed the major findings conducted by Malaysia-DANCED project 'Study on Extraction and Processing of the Forest Residues and Small Dimension Logs in Peninsular Malaysia'. The objective of the project was to optimise the utilisation of forest residues including small dimension logs and mill residues as raw materials in Peninsular Malaysia for sustained social, economic and industrial benefits. The State of Terengganu was chosen as the area for pilot study. Among others, the major activities were to survey the quantity of mill residues available in Terengganu during primary processing and to recommend the future industrial use of these mill residues. Log production in Terengganu has been gradually declining from 1.50 million mü in 1990 to 0.76 million mü in 1998, at a rate of 82,000 mü per year. With the decreasing log production, it has become increasingly urgent to address the issue concerning the large amount of logging residues and also mill residues. The study shows that forest residues constitutes about 2 times the volume of logs removed in Terengganu and the available mill residues including bark constitutes about 1/3 of the volume of logs processed in sawmills and plywood mills. Mill residues are presently being used for kiln drying to generate steam, moulding, finger jointing and downstream processing to produce blockboard. Recommendations are being made by the project to convert the mill residues to wood chips or as fuel in co-generation plant to produce steam and electricity. The wood chips produced can be exported by chartered vessel or used locally as raw materials for manufacturing particleboard, floorboard and medium density fiberboard.

Changes of Wood Components of Sugi (*Cryptomeria japonica*) Chip under the Treatment of Garbage-degradation - Their Effect on Recycling-

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The treatment of waste is one of the most serious problems. In particular, the treatment of garbage (food related organic waste) is the most difficult problem because it easily rots and smells. Previously, ability of newly developed system for garbage degradation reported. In this system, sawdust plays an important role as excellent bioreactor and the residual sawdust changed into effective fertilizers or soil-conditioners.

This paper deals with the possibility of wood chip (Sugi: *Cryptomeria japonica*) instead of sawdust and the characterization of physical and chemical properties of wood chip.

It was found that wood-chip also can adapt to the bioreactor, being a matrix for the biodegradation of garbage in the container. The residual chip showed the properties of flexible, thermal softening and de-watering. In addition, binderless board can be made from this chip by hot pressing at 150 degrees centigrade.

To investigate the change of wood main components and extractives, in addition to chemical, elemental and microscopic (under polarized light) analysis, the alkaline-nitrobenzene oxidation products were analyzed by means of GLC, 3H-, 13C-NMR spectroscopy.

Following results were obtained.

* Crystal structure of cellulose was partially changed.

* Hemicellulose was partially hydrolyzed.

* Lignin was polymerized with condensation reaction.

* Norlignan (extractives) was also polymerized and changed to methanol insoluble fraction.

These facts would effect on the physical properties of the surface of chip. In this report, it is evidenced that considerable chemical and physical changes in wood chip caused by biological reaction under the treatment of garbage-degradation and the newly obtained properties of chip will influence new recycling process.

Modification of Lignin Containing Wood Processing Wastes for Plant Development Activation. Environmental Impact

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Review of new data in lignin behaviour in soil and its influence on development of plants, including wood species, and soil quality has shown that lignins potentially could fulfil all functions of humic substances (accumulative, transport, regulative, protective and physiological). Activity of lignins in these lines depends, from one side, on their structure and chemical properties, i.e., biological and chemical prehistory and, from other side, on soil characteristics and species of plants.

At present investigations of silicon role in soil biocenosis and plant development is of special interest due to the novel data obtained on this element necessity for full cycle of plant ontogenesis as well as increasing soil silicon deficiency. In spite of high total silicon content in soil (33%) the content of it in form available for plants is very low (1-3%). The most intensive desilication is taking place under conditions of hot and humid tropical climate. However silicon-deficient soils exist also within the moderate temperate climate zone.

The present study is focused on the modification of wood processing wastes with silicon containing compounds, aimed at obtaining of plant growth activators and/or complex organic fertilizers of high efficiency. Wastes/by-products of chemical and mechanical wood processing: kraft lignin, hygrolysis lignin and wood sawdust were the objects for modification with silicon-containing organic and inorganic oligomers. Effect of products synthesized was tested under indoor and outdoor conditions on agricultural and ornamental plants, including tropical plants, and on silvicultures planted into swar-podzolic soil or different soil substrata. Plant samples were taken at varying dates during one/two growing season for biometric measurements, estimation of the root system development, chemical and biochemical analysis (silicon, nitrogen, chlorophyll, carotenoids, amino acids, auxins content). Soil samples were characterized with soluble silicon content, mobility of macro- and micronutrients, microbiological activity, humic substances composition. Consideration of the unmodified/silicon-modified lignin containing products (LP/LSP) effect was made on the basis of LP/LSP complexing and sorption properties, functionality and structural characteristics and data of an analysis carried out according to the methods used for the characterization of the humus group composition. Further amorfization of lignin matrix under influence of modification due to formation of Si-O and Si-O-Si bonds resulted in a faster turnover of LSP in soil than unmodified lignin samples. A gradual silicon transfer into soil solution has been proved by analysis of soil and plant samples. Positive influence of LSP on plant development was higher than the additive effect of unmodified lignin-containing products and silicon-containing compounds used for modification. LSP promoted rootability of plants, production of more strong and vital sprouts/seedlings, development of a vigorous and branched root system and the ground part of plants, enhance crop yields.

The results obtained have shown that plant's resistance against diseases and stress (e.g. transplantation), temperature fluctuations and drought enhances, food value of agroproducts goes up, the quality of ornamental plants improve (increase flower size and blades area, strengthening floriferous stems, prolonging the blossoming period) when LSP are used. Results of LSP application for silviculture growing from seeds have shown that 1 years old spruce plants have better developed root system (root mass and amount of secondary roots increased), the diameter of stem increases and amount of plant defeated by *Fusarium* sp. decreases. Besides above mentioned positive influence on plant development, significant environmental impact from LSP application covers increase in microbial activity of soil, positive changes in macro- and micronutrient mobility, including release of phosphorous from its insoluble compounds, suppressing of phytopathogenic microflora development and enhanced ability for decontamination from soil pollutants. Usage of wood processing wastes modified with silicon-containing compounds for production of new wood and other phytomass and soil quality improvement enhances the harmony of wood processing industry with environment.

5.05.03 Wood/Non-wood combinations

Investigation of the Possibility of Use of Cotton Stalks in Particleboard Manufacture

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Cotton is one of the main agricultural crops being cultivated in Egypt. The annual yield of cotton stalks (CS) from about 420,000 ha of cotton being cultivated annually is estimated to be 1.6 million tons (air-dry weight). Cotton stalks are an important lignocellulosic renewable resource in a country that suffers from an acute shortage of wood resources. Cotton stalks were traditionally used as a fuel in rural ovens. This traditional pattern of CS utilization is associated with the renewal of the cycle of cotton boll worm, which resides in the unopened bolls in CS, causing an annual crop loss of about 20%. As a result of the cotton boll damage, CS are being burned after cotton collection. This practice is very environmentally unfriendly and uneconomic. This study suggests the use of CS as a furnish in particleboard, especially in light of the fact that particleboard factories in Egypt face an acute shortage of furnish supply. Field experiments have indicated the possibility of the use of tractor-operated threshers and bale presses in the milling and transformation of CS into bales of appropriate dimensions, weight, and bulk density (~0.25 ton/m^3) for transport to particleboard factories. This method will guarantee lower investment in equipment, lower energy and transportation costs, and labor opportunities in villages. Laboratory particleboard specimens were manufactured from air-dried CS (~10% MC). CS pieces were processed by a hammer mill, and the resulting particles were classified via a sieving unit into coarse and fine particles. The particle mix was blended with a urea-formaldehyde resin in a blender, hand-formed into a mat, and introduced into an automatic press using a wet cycle to cope with the large MC of the CS particles. One- and three-layer specimens were thus prepared. In a series of experiments on the one-layer particleboard, CS were used with the leaves and bolls intact. CS particleboard specimens were manufactured under different pressing conditions (25 to 35 kg/cm^2) and glue levels (9 to 14%). Static bending (SB), internal bond (IB), face strength (FS), and thickness swelling (TS) tests were conducted on CS particleboard specimens and the density of the specimens determined.

The values of modulus of rupture (MOR) varied from 18.1 to 24.1, 11.7 to 18.5, and 11.3 to 15.7 N/mm^2 for the three-layer, one-layer, and one-layer CS particleboard with leaves and bolls, respectively. The density varied from 0.7 to 0.8 gm/cm^3 for all board types. The values of the modulus of elasticity (MOE) varied from 2,457 to 3,237, 1,698 to 2,727, and 1,779 to 2,406 N/mm^2 for the three CS particleboard types. The values of IB varied from 0.64 to 1.1, 0.70 to 0.74, and 0.86 to 1.21 N/mm^2. The values of FS for the three-layer CS particleboard varied from 1.38 to 1.72 N/mm^2. The values of TS after 2 hours varied from 3.6 to 8.3, 7.1 to 26.1, and 8.4 to 14.0 percent for the three investigated CS particleboard types. These results indicate that the three-layer CS particleboard fully satisfies the requirements of the Egyptian standard 906/1991 for particleboard (similar to BS 5669-1979). Under most of the investigated conditions, the one-layer CS particleboard satisfied the requirements of the aforementioned standard. An increase in adhesive level had a positive significant effect on MOR, MOE, IB, and TS for all board types. The addition of leaves and bolls decreased the mechanical properties but improved the TS of the CS particleboard. The results from this study suggest that there is a real potential for the use of CS particleboard in the manufacture of three-layer particleboard without any sacrifice in product quality.

Bio-concrete. Wall Elements Produced from Wood Residues

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Experimental small manufacture of hallow and massive blocks (bioconcrete) are described with the objective to find a solution to the utilization of waste forest biomass at saw mill industry and to use this potential raw material source in low cost housing in order to improve local people conditions. This study was conducted by mineral bonded wood composite methods using *Pinus caribaea* More. chips mixed with slaked lime and Portland cement weighed proportion 1:1:1,5. The production of blocks consisted of a modular frame measuring 40 x 20 x 15 cm compacted by hand and cure at temperature room. Details are given of the properties of prototypes and raising partition wall based in comparison with the conventional Cuban ways of masonry. The results indicate that incorporating chemical aggregates (CaOH2) as a partial substitute of cement consumption was possible to obtain acceptable mechanical and physical properties of specimens. The wood cement blocks exhibited high dimensional stability when exposed to 24 water soaked and mean modules of rupture (MOR) ranged from 1,0-1,5 N/mm^2. It is concluded that the blocks technology involves minimal investment and therefore offers an important alternative from building process by forest products as well as confirmed the favorable influence of use of waste residues from biomass exploitation and sustainable forest.management. Also, this technology can be used as a rapid technique for production of wood blocks while the sawmill residues are being produced.

Compatibility of Some Wood Species With Portland Cement and its Enhancement Using Varies Treatments and Chemical Additives

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Hydration and compression experiments were carried out to investigate the compatibility of wood-cement mixtures made of four wood species, namely, eucalyptus (*Eucalyptus camaldulensis*), casuarina (*Casuarina glauca*), European redwood (*Pinus sylvestris*), and poplar (*Populus* spp) as affected by treatments (hot water and 1% NaOH solution extraction), and chemical additives (CaCl2 based on 3% of cement weight).

Based on the results obtained from hydration and compressive strength experiments under untreated conditions, poplar and European redwood showed the same behavior in hydration and compressive characteristics and they classified as suitable under limited conditions, while eucalyptus and casuarina behaved differently and they need some treatments to improve its compatibility with cement. Substantial improvements in cement setting can be achieved by using either hot water or 1% NaOH treatments, specially for eucalyptus and casuarina that reclassified them from unsuitable to suitable under limited conditions. However, slight improvement in compatibility were obtained for poplar and European redwood. The addition of CaCl2 to either untreated or treated wood enhances compatibility of wood-cement mixtures.

Hydration characteristics had high correlations with compressive strength characteristics and they can be used as suitable estimates for the compatibility of wood-cement mixtures.

Properties of *Acacia catechu* Kraft Fibre As A Reinforcement In Wood Plastic Composites

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The main objective of this project is fabrication and improvement of the mechanical properties of wood base composites blend with LLDPE as a binder. To approach the aesthetics value of wood, a newly found natural fiber, *Acacia catech* had been utilized to maximum weight fraction in the matrices of LLDPE and comparison had been made with the weight fraction of synthetic fiber kevlar 49. Besides of this, theoretical and practical formulation had been established for the pulping processes and to obtain better quality of fibers and composite, fibers separation system and modified compression mold were conceptually designed and fabricated. Since the reliability of characteristics would determine accuracy of estimation, relationship between impact properties to tensile strength and strain, as well as modulus of composite to Brabender rotor's torque were established. By utilizing micromechanical approach (Page Theory), the bond strength within fibers and tensile strength of *Acacia catech* fibers were found. Further mechanical improvement had been carried out on the aspect of reinforcing interfaces properties of *Acacia catech* fibers with LLDPE after the main weakness of this composites was found as due to poor interaction of *Acacia catech* fibers with LLDPE. In this study, compatibility of silane Z6032 that has been found hypothetically capable to couple the lignin of natural fibers had been used to treat the wood fibers. The interaction between wood fibers and LLDPE was observed using SEM, impact and tensile tests.

Effect of Exposure Conditions on the Durability of Oil Palm Fibre Cement Composites

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The durability of oil palm fibres cemes composites produced from oil palm trunk (OPT) and found (OPF) fibres was determined. Both OPT and OPF fibres produced by an oil palm fractional, possess fibres length 15-21mm length and 0.2-0.5mm thickness were used as reinforcement material in fibre-cement composites. The durability of these composites on internal and external exposure to typical Malaysian weather conditions was evaluated based on the retention or loss of their mechanical and physical properties for a period of up to 300 days. Results showed that generally the MOR, MOE and tensile strength properties of OPT fibres cement composites increased during the early stage of exposure before they slowly decreased towards the later stage of exposure. However, in the case of OPF fibre cement composite, all the MOR, MOE and tensile strength were generally lower than in OPT fibre cement composite during the initial stage before slowly increasing towards the later stage of the exposure. The water absorption of the OPT and OPF fibre cement composite was significantly higher during the early stage of exposure prior to stabilising after nearly 300 days of exposure. An almost similar trend was observed on the thickness swelling of the composite after soaking in water for 24 hours. The density of the composites increased as the duration of exposure increased. Generally, the mechanical and physical properties of both OPT and OPF fibres cement composites satisfied the minimum requirements of the Malaysia Standard (MS 934:1986) and International Standard (ISO 8335:1989) specifications for cement-bonded particleboard.

5.05.04 Modification of lignocellulosics

Crystallinity Of Oil Palm Empty Fruit Bunch Treated By Steam Explosion Process

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Oil palm empty fruit bunch (EFB) is a by product of palm oil, and is available in large quantities (about 8 millions ton per annum) at palm oil mills.

Due to its natural properties, low cost and readily collected and continuous supply at palm oil mill, the EFB has been seen as a potential precursor for making products based on lignocellulosic materials. For this purposed the precursor has to be processed, for example through refining for making medium density fiber board, pulping for making paper and stem explosion for cellulose production. In this study, the EFB fiber were refined, classified into different fiber length and added with a minimum amount of deionized water for steam explosion treatment which was conducted at 190°C and 210°C for 10 minutes. The treatment at 210°C was found to break the EFB-fibers into individual libriform fibers. The crystallinity of cellulose in the untreated and treated EFB fiber was estimated using X-ray diffraction technique. The results show that the cellulose in untreated EFB. Treated at 190°C and 210°C have 36.42 and 47% crystallinity respectively. This indicates that the steam explosion process increases the crystallinity of cellulose in the EFB-fibers.

Modified Wood by High Temperature Heat Treatment

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The poor dimensional stability of wood under variable atmosphere and the low durability of many species have originated research for stabilization treatment inducing the limitation of moisture absorption of the lignocellulosic material. One of the processes under study for the last decade in France and in Europe consists in submitting wood to heat treatment at temperatures ranging from approximately 180-250°C depending on the type of species and the physico-mechanical characteristics to reach. This theme was the subject of a European research program in which several research centers and private companies from the industrial sector participated.

The main objective is to reduce the hydrophilic behaviour of wood by modyfing the chemical structure of some of its components through heat treatment in controlled atmosphere in the form of a soft pyrolysis reaction.

The way the pyrolysis is conducted and the selection mode of the various parameters involved in the process have an influence on the characteristics of the final product. Operating conditions are essential, and such parameters as atmosphere-temperature-processing time-rate of heating-species-weight and dimension of the pieces-original moisture of the wood should be taken into acccount, for they can strongly affect the final properties. The aim is to reach the optimum balance between the improvement of the moisture resistance and the decrease of the mechanical characteristics depending on usage. The way hardwood and softwood species are affected by those parameters is reviewed. It has been observed that when submitted to heat treatment at high temperature, the kinetics of humidity absorption is noticeably modified resulting in a major reduction of the volume retraction and a lowering till a certain extent of some mechanical properties, depending on the treatment applied.

On the whole, the results show a weakness and a loss of plasticity of the wood treated at such temperatures, which especially affects tensile strength. The mechanical loss does not impede non structural uses. However, it's imperative that this property be taken into account for applications requiring high level mechanical characteristics in bending and tensile strength.

One of the potential ways of conferring an enhanced value to the wood through heat treatment concerns species with low natural durability, especially those which are resistant to conventional treatment by impregnation. Resistance testing on wood rotting fungi responsible for decay showed that spruce, fur, poplar and some tropical species as for example *Curupixa* had developed strong resistance to fungi after heat treatment at 250øC for twenty minutes. Trials performed on Scotch pine sapwood heated at 260øC for 15 minutes gave excellent results as well. Beech treated at 250øC resists quite well to cubical butt rot which is very active in tropical regions.

On the contrary, heat treatment does not improve resistance to termites.

Improved durability results from the combination of two factors induced by thermal treatment:

A noticeable reduction of moisture absorption. Rot fungi need a minimum of 20% of humidity to develop. elimination of some of the nutrients required by wood rotting fungi.

It should be noted that heat treatment induces chemical modifications in the wood which are responsible for the darkening of the original colour over the whole material.

This research has highlighted the potential of the process as well as some limitations at the present state of the art.

The different industrial processes in use today in Europe are described:

- processes under inert nitrogen atmosphere
- processes under low oxygen mixture
- processes under saturated water vapour atmosphere
- treatments which consist of two stages, one hydro-thermal stage followed by a dry atmosphere stage.

Technological solutions in terms of process control are dicussed.

The applications targeted by the different processes are thoroughly addressed as well as the corresponding market opportunities.

Modification of Wood by Treatment with Low Molecular Phenol-formaldehyde Resin Properties Enhancement of Neutralized Phenolic-resin and Resin Penetration into Wood Cell Walls

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Keywords: Low molecular phenolic resin; Resin penetration; Cell wall; m-bromophenol-formaldehyde resin; Dimensional stability; Decay resistance.

To enhance the dimensional stability and the biological resistance, the low molecular-weight phenolic resins of conventional alkaline type and neutralized type were impregnated into Japanese cedar wood (*Cryptomeria japonica* D. Don) and heat-cured.

The treatment with the neutralized type resin retained the original wood color whereas the alkaline one changed the color of wood to red-brown. The concentrations of the resin solutions and the weight gains due to resin loading of wood after treatment were highly correlated, and the target resin loading could be assessed from the solution concentration. High dimensional stability at 60% of antiswelling efficiency was attained when both types of resins were impregnated at about 30% resin loading and no significant difference was recognized between the two. To suppress the decay attacks by the brown-rot and white-rot fungi, 15% and 10% resin loadings due to treatments was required for the neutralized and alkaline types of phenolic resins, respectively.

On the other hand, the penetration of resin into wood cell walls was investigated by means of light microscopy, scanning electron microscopy, and electron probe X-ray microanalysis, using m-bromophenol-formaldehyde resin with three different number average molecular-weights as a signal of bromine to detect the presence of resin.

The phenolic resin with small and middle molecular-weights (290, 470) proved to penetrate mostly into the cell walls, contributing to the enhancement of dimensional stability and decay resistance in resin-impregnated wood. Also, for phenolic resin with large molecular-weight (820), the resin components with smaller molecular-weight only was suggested to be present in the walls, having little contribution to the dimensional stability.

Wood Torrefaction in Europe: An Overview and its Perspectives

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Torrefaction is a thermal treatment with the temperature higher than drying but lower than carbonisation. This treatment produce wood with different properties than untreated wood due to chemical modification. In France, this treatment in the beginning has been studied for energy purpose then later it has been developed for improving the quality of wood as lumber. Some research conducted in CIRAD show that torrefaction can be utilize as alternative treatment for improving the quality of wood in term of durability and dimensional stability although it reduces some mechanical properties. The aim of this paper is to present an overview of wood torrefaction which include torrefied wood properties identification, the review of development of its technologies and its market opportunities in Europe.

Catalytic Degradation Processes of Cellulose

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Keywords: cellulose, pyrolysis, 1,6-anhydrosaccarides, levoglucosan, levoglucosenone

Commercialization of thermochemical processing of renewable biomass is of increasing interest owing to production of biooil which is an alternative to oil. Beside energy production the conversion into valuable chemicals is of special interest due to the higher-added value. The thermal degradation monomeric products of cellulose such as 1,6-anhydrosaccharides, levoglucosenone and levoglucosan are the most important ones. Unique biologically active and biodegradable oligomers and polymers, identical with natural compounds, can be synthesized on the basis of 1,6-anhydrosaccharides.

The present investigation concerns both the studies of the thermal degradation process and the composition of the main volatile products of slow and fast pyrolysis of various celluloses impregnated with phosphoric acid (3.5-7 mass% on raw material). The studies involved several types of microcrystalline cellulose, celluloses obtained from sulphate and sulphite pulping as well as recycled cellulose.

We have shown that two main competing reactions such as dehydration and depolymerization are catalyzed in the presence of phosphoric acid. During catalyzed slow pyrolysis within the temperature range 200-300°C dehydration reactions are prevailing due to re-esterification reactions. Under conditions of catalytic slow pyrolysis levoglucosan never formed and levoglucosenone was the main product of cellulose depolymerization. The maximum levoglucosenone yield, more than 20 mass % on cellulose was observed at 350°C.

At fast heating rates (fast pyrolysis) the total yield of volatile products increases, and their composition as compared with slow pyrolysis is redistributed. Both 1,6-anhydrosaccharides (levoglucosan and levoglucosenone) are simultaneously detected. Their mass ratio in the bio-oil can be regulated by varying the impregnation and pyrolysis conditions. Total levoglucosan and levoglucosenone content in biooil is 75-85 rel. % irrespective of the impregnation conditions and cellulose structure under investigation.

It has been shown that the biooil yield during cellulose catalytic fast pyrolysis depends on cellulose supramolecular structure and polymerization degree and are determined by a series of factors regulating the development of depolymerization and dehydration reactions. Among these factors, the amount of phosphoric acid applied for the impregnation and the temperature of impregnated cellulose pre-treatment are the main ones. The highest yield of levoglucosenone (30 mass% on cellulose) has been observed from microcrystalline celluloses.

Preparative obtaining of levoglucosenone was carried out using a fast pyrolysis installation with a fluidized bed reactor and it was shown that this valuable monomer can be produced with the yield of more than 20 mass% on cellulose from different cellulose containing raw materials including recycled cellulose.

Probing Red Maple Pit Membrane Pore Size at Fiber Saturation Point and Oven Dry Using Polystrene Macromolecules

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A modified solute exclusion technique was used to pressure impregnate a polystyrene molecular weight (MW) series dissolved in styrene into red maple samples at approximately the fiber saturation point (FSP) and oven dry (OD). Radial penetration was less than tangential and FSP less than OD. There was a marked change in radial OD penetration at 900,000 MW. There was no marked penetration change with MW in the tangential direction at the higher MW tested.

Corona Treatment: Applications to Wood Material for the Improvement of its Protection

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Keywords: Wood; Protection; Corona

Plasma treatment and corona discharge treatment are widely used in polymer industry, in metallurgy or in card board and paper production, to improve adhesion of resins, to clean the surface or to deposit a new film with well-defined physical and chemical properties. The films of polymers such as polypropylene, polyethylene and polyvinylchloride are treated in a few seconds, and are wetted by ink, varnish or glue. For wood material which is porous and which have a complex and variable chemical composition, our interest is to find a convenient, easy, cheap technology to activate its surface, different from the others existing treatments.

Plasma treatment was recently used in wood industry. Particularly, oak is well-known to be difficult to glue or to varnish sometimes. For the present research, oak is selected and is treated by a corona discharge. The first step is to build a corona treatment apparatus, then the treatment procedure is adapted for wood materials and the surface energy of treated surfaces are characterized by the wettability as a function of various parameters (time and voltage of corona treatment, nature of gas). The corona treatment system is composed of a generator, a transformer, and a closed cell in which two rectangular inox plates spaced by 6mm for the electrodes are settled. The electrodes are covered with glass plates. A wood sample is introduced between these two glass plates. The samples are treated at voltage between 9 and 15 kV up to two hours in dried air or in nitrogen gas. Contact angle measurements involve a 5Aø thickness outer layer; and the wettability of wood is improved by the corona discharge treatment, not in a few seconds like for synthetic polymer films, but in a few minutes. Cosine contact angle increases as an exponential function with time, and attains a plateau after 30 minutes of treatment. The high voltage treatment is more drastic than low voltage treatment. In the same way, dried air treatment improves the wettability better than nitrogen treatment. In summary, the most efficient parameter is the treatment time, voltage and nature of gas have a very small influence. As a conclusion, the optimum conditions for the wettability are: 5 minutes at 9 kV in dried air. These results are in agreement with those of some reports. The presence of ozone in air corona discharge treatment can explain a better oxidation of the wood surface. But the nitrogen gas is more efficient than the oxygen gas to create radicals to the surface, which can react after with air to oxidize the surface. Other applications are also possible for corona discharge treatments. Wood material is dimensionally stabilised by thermal treatment. Wood is placed during half an hour at 150øC, but, unfortunately, its surface energy is lowered. Corona discharge treatment is able to increase the wettability of this thermal treated wood. A polyethylene-wood surface composite is also possible by treatment of wood in ethylene gas. Wood is then becoming waterproof. These few applications, not only for treatments for synthetic polymers but also for woods itself, are evidence of a large perspective in wood industry for corona discharge treatment. A good wettability is necessary for improving the adhesion of a varnish and the durability of outdoor panels. A wood protection without varnish is also possible by the formation of a polyethylene film on the wood surface.

Dimensional Stabilization of *Aspidosperma quebracho-blanco* with Polyethylene Glycol

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Keywords: *Aspidosperma quebracho-blanco*; PEG; Impregnation; Dimensional stability; Shrinkage

Nowadays, the most abundant species of the region of the "Parque Chaqueno" in Argentina is *Aspidosperma quebracho-blanco* Schlecht. This species is used mainly in the making of pallets and charcoal in spite of its characteristic pale yellow colour and high density, which are highly sought after within the national and international floor and furniture markets. It cannot be used for production of high added-value goods because of its dimensional instability.

The aim of our investigation was to examine the use of organic polymers and impregnation processes to dimensionally stabilise *Aspidosperma quebracho-blanco* for application in high added-value goods.

In this research we used sawn samples which were the same size as those used in industry. These had a radial cut and were impregnated in their green condition using the Bethell method. Treatments were done in a pilot plant using polyethylene glycol (PEG) with molecular weight of 300 and 600 at different concentrations and different treatment times. The samples were dried to 10% moisture content and then stabilised under specific Argentine Institute of Material Rationalisation (IRAM) standards. Each of the treatments was performed under a full factorial experimental design.

To measure the influence of PEG treatment on dimensional stability, differential swelling and shrinkage coefficients were adopted as control parameters. These parameters were analysed using the adopted experimental design and results were compared with those of untreated samples. The PEG treatment method produces the cell wall bulking which keeps the wood in its swollen condition, even after drying. In this way shrinkage can be totally or partially eliminated.

The best differential swelling and shrinkage coefficients (0,069% and 1,95% respectively) of the species *Aspidosperma quebracho-blanco* were achieved by impregnating the wood with PEG 600 using a 50% aqueous solution following the Bethell process at a pressure of 12 kg/cm^2 over two hours. These results represent a decrease of 58,7% in swelling compared with the untreated samples.

The best dimensional stability was achieved with a PEG 600 retention of 73,7 kg/m^3 in the impregnated wood, which would allow its use in some industrial applications.

Determination of Diffusion Properties, Sorption and Permeabililty to Gases on *Popula Robusta* after Thermal Treatment at High Temperature

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One of the selection criteria for packaging materials intended for fresh foodstuffs is the knowledge of their functional properties and, more particularly, their properties regarding gas and water vapour flow. Depending on the external conditions, the relevant physical properties that characterise the ability to mass migration are permeability and mass diffusivity. Consequently, the knowledge of packaging materials implies the determination of these parameters as well as the effect of its structural and morphological characteristics that affects these properties.

Poplar wood, *Populus*, used in packing was classified among materials suitable for food contact. The chemical modification, with partial deterioration of its components, during a thermal treatment at high temperature (200°C) under inert atmosphere enhances the material behaviour (better durability and dimensional stability) but also significantly modifies its diffusion properties, sorption and permeability to gases and water vapour.

The objective of this study is to quantify this effect. The gaseous permeability is determined on samples of green poplar (content moisture: 20 and 12%) and on the same samples after thermal treatment. The sampling has been determined in order to perform the same comparison for mass diffusivity. The stake of this study is to open new ways of valorisation for this specie in the domain of light wooden packaging.

5.06.00 Properties and utilization of tropical woods

The Lesser-used Timber Species of Ghana. A Success Story

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The alarming rate at which the primary wood species have been dwindling from the Ghanaian forest has been a topic for discussion for sometime. Many serious debates have been held within the timber industry sector since the early 1990s with emphasis on the imminent shortage of raw material supply to the industry. As a consequence of these debates, this project proposal was designed to address the utilisation of the Lesser-Used (LUS) and Lesser-Known (LKS) timber species to replace some of the primary species.

The general aim of the project was to encourage the forest products industry of Ghana and the sub-region to better utilise their forest resources in order to help aide the development of the Ghanaian society while also attaining ITTO's target 2000 i.e. to achieve complete sustainable forest management by the year 2000. Specifically the overall objectives were to find a way of removing pressure from the over exploited primary species like the Mahoganies, Irokos etc. by increasing the use of Lesser-Used species whose availability was considered to be of potential economic interest and whose properties could match those of the primary species.

Due to the complex nature of the project, the work was divided into three main components:-

1. Forest Ecology - to study the ecological impact on the forest, the rivers and wild life after extracting the various species.

2. Wood Technology, Processing and Product Development - to look at the physical and mechanical properties of the wood, the wood machining characteristics as well as the product development expertise.

3. Forest Products Marketing - to study how best the species and products from them can be market

14 LUS of Ghana were selected from three ecological forest zones of Ghana for the studies, i.e. The wet evergreen forest zone, the moist evergreen forest zone, and the dry semi-deciduous forest zone.

The felling damage assessment indicated that the falling tree creates more opening per felled tree perha followed by skid trials and roads. The regeneration studies which followed indicated that disturbance due to logging markedly reduce pre-existing tree seedlings in falling gaps and skid trial, but the stimulation of new seedlings establish significantly exceeds the loses.

Product development was concentrated on outdoor furniture i.e. mostly garden furniture. It was identified among others that garden furniture wood be the most suitable prototype furniture to be able to compete well on the wood market. Furniture products from Kyenkyen (*Cylicodiscus gabonensis*), Celtis (*Celtis mildbraedii*) and Essia (*Petersianthus macrocarpus*) turned out to be most suitable for various outdoor or garden furniture. Other products which also attracted interest were Deckboards for gardens. Parquet flooring and pallets. A new method of production using dowels was introduced.

Formal market research conducted in the user countries of UK, USA etc. revealed that most important factor for successful marketing was reliable and continued source of supply satisfying a given level of quality, good technical data and a good introductory discount pricing. Results of the studies and the spontaneous positive reactions from the industry and the market give a clear and solid indication that LUS has a future as raw material for a wide range of products. The introduction of new production techniques e.g. dowel joints deserve a continual dissemination to the industry. Transfer to dowel joints could result in a raw material savings of about 15% and increase productivity.

Physic-Mechanicals Properties of the Wood Related Growth to *Eucalyptus grandis* and *Eucalyptus urophylla*, used as Indicators for Lumber Production

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The wood industries trends has been based in replacement forest which increasing is fast. The *Eucalyptus* genuses exploration attend quite soon to the genetic improvement and because of it a well stablished handling is very important. There is a growing demand by the wood processing industry to change and improve the quality of the *Eucalyptus* spp. lumber resource, as the brazilian native trees will be no longer put a wiser use in the future, since the brazilian government efforts is trying to protect them. At this moment, the genetic improvement has been closely associated to the biotechnology and molecular genetics, so the association of these techniques seeks selection and gains and a considerable advance on chronologic time, as well.

On the other hand, the interaction between biometric genetic and sylviculture assure a higher proportion of solid products associated with a high agregate value, enphasizing this activity by a genetic improvement (for sawmill), as in Brazil, so far, standing forest is destinated in its great totality for pulp and paper industry.

This study was carried out using 18 clones of *Eucalyptus grandis* and 15 of *Eucalyptus urophylla* as genetic material, where was studied the wood properties and lumber defects related to growth stress, aiming to evaluate their responses to the genetic improvement techniques, especially the variabilities causes seen on this genus timber, that is supposed to be reserved for sawmill.

With the objective of getting selection gain on those properties or defects, it were studied 11 genetic variables, among them, saw timber yield, end splitting log and lumber, shear, deflexion, basic density, compression, traction strenght, bend strenght and modulus of elasticity. From this, it was possible to get genetic correlations and so the research on the wood features in which the measurements are easier, show the best genetic variable, leading to a more efficient selection program.

The mechanical properties and also the defects from growth stress are highly heritable and so lead to a wood technologic quality breeding program. It's very important to emphasize that there's no correlation between any of those properties or defects in relation to the phenotipics tree features, that permits the wood technologic quality improvement from a basic population composed only by well perfomed trees. There are high genetic correlations between these defects derived from growth stress, what permit the technologic improvement troughtout indirect selection.

The main purpuse of this work is to present these research results well detailed, showing the heritable values to the wood technologic characteres, as well all favorable genetic correlations which have been found between them.

Near Infrared Analysis as a Rapid Screening Tool for Some Major Wood Characteristics in *Eucalyptus*

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The ability to assess wood quality is of primary importance to the forest industry. In the case of intensive management forest such as clonal plantations of *Eucalyptus* where the heterogeneity of the raw material is huge, it is fundamental to be able to predict whole-tree values for wood properties from non-destructive samples. For some wood characteristics conventional methods of measurement are too time-consuming and expensive. One of the methods most likely to be adaptable to rapid measurements on wood is Near Infrared (NIR) diffuse reflectance spectroscopy. NIR spectroscopy is known for its good ability to identify compounds as it is mentioned in a lot of publications. This study evaluated the ability of NIR spectrosocopy for the assessment of some major wood characteristics within a full-sib family of a hybrid *Eucalyptus*. NIR diffuse reflectance spectroscopic methods is used for substitution of conventional wood analysis procedures. In this paper, the data are analysed using principal component analysis (PCA), the Mahalanobis distance and partial least squares regression (PLSR) models for measuring eight characteristics from the eucalyptus wood's NIR reflectance spectra. These characteristics are:

- Extractives content
- Lignin content
- Relative proportion of lignin monomers
- Basic density
- Longitudinal growth strains
- Shrinkages in longitudinal, radial and tangential directions
- Modulus of elasticity
- Fracture energy

The first four characteristics are linked with pulp industry, the last five properties are linked with solid wood uses. On 300 samples coming from 200 trees, visible and NIR reflectance spectra are observed on a scanning spectrophotometer, and span the 400-2500 nm range. Calibration models are produced using partial least squares regression and the resulting models are validated using test sets. The root mean square error of prediction (RMSEP) is discussed. The results are critically examined.

TECFLOR: A Dream Which Became Reality

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In 1994, after doing some prospective work in Russia and Chile, the President of Gutchess International Incorporated-GII from Cortland, New York, USA, decided to analise the potential of the eucalypt plantations in Brazil for solid wood products. From 1994 to 1997 several forest companies and eucalypt plantations were visited personally by the President of GII and his brazilian adviser from the Department of Forestry of the Federal University of Vicosa. After choosing the three most promising companies and their eucalypt plantations, the President of GII hired two new consultants an specialist in wood technology and an expert in sawmill design and operation to compose his team. Several tests were conducted at the three chosen spots where the eucalypt logs were sawn according to the specifications of the future and desired products. The results shown that eucalypt plantations in Brazil are a very good source of raw material for solid wood products even to replace valuable tropical timber such as mahogany. Drying and preservation treatments were developed by the expert in wood technology of the State University of New York at Syracuse and Morrisville. In 1997 a joint venture was formed by GII and Aracruz Celulose S.A. and TECFLOR Industrial Ltda was founded. This new company, perhaps the biggest and most modern eucalypt based sawmill of the world is located in Posto da Mata at Mucuri in South Bahia. TECFLOR will start operating in march this year and will put on the domestic and international market 76,000 cubic meters of kiln dried and treated eucalypt sawntimber when fully operating. This will promote a very strong influence in the furniture and construction sector of the Brazilian economy in the next years.

Technological Valorization of the Four Lesser Known Species of the Amazonian Forest

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The wide forest patrimony of the Amazonie places the Brazil in a well known worldwide position, not only because of its wood potential, but also because of its ecological and social importance. The basic condition for economical and ecological utilizations of the Amazonian forest is its sustainable management which the technological characterization of the unknown species is part of. The technological characterization of four unknown species in the national forest Jamari - Rondonia - Brazil: Fava Amargosa (*Vataireopsis speciosa*), Jequitiba Rosa (*Cariniana micrantha*), Peroba d'Agua (*Rauwolfia paraensis*) et Peroba Mico (*Aspidosperma macrocarpum*) according to there anatomy, chemical components, color and there physical and mechanical properties allow us to determine the potential utilization. The major part of our study was to determinate the variability of anatomical elements, chemical composition and color as well as their correlation with wood physical and mechanical properties so as to characterize the wood's technological quality.

In order to ameliorate the existing technics, some new ones were used such as image analysis, quantitative colorimetry and ultrasons. The main causes of the variability of wood physical and mechanical properties, are anatomic elements and chemical elements especially wood extractives.

The results of this study show that these four species have good technological properties and could be valorized in differents sections of wood industry. These promissing new technics, practical, fast and accurate, are not yet known in Brazil.

Keywords: Forest Amozonian, Fava Amargosa, Jequitiba Rosa, Peroba d'Agua, Peroba Mico, anatomy, chemistry, colorimetry CIELAB, image analysis, physical and mechanical properties, ultrasonic technique and utilization

Recent Developments in the Utilisation of *Acacia catechu* Wood

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Acacia catechu (Khair) has got importance, as its heartwood is used for katha and cutch extraction. The former is mainly used for chewing with betel nut and later for dying and tanning. The annual turn over of these industries is more than two thousand million rupees. The spent heartwood chips as well sapwood which form about 85-90% of total weight are considered as waste.

Recent research findings has shown that the yield of katha and cutch can be increased by maintaining the moisture content of the wood with better storage condition of wood as the yield is directly related with the moisture content. The chip size has also got positive correlation with the yield of extractives and proper size recommended is of 0.75-1.00mm thickness.

The spent heartwood chips as well as sapwood can be utilized for the preparation of kraft paper using sulphate pulping, as such or on mixing with other cellulosic materials like bamboo.

The hardboard prepared separately from spent chips and sapwood without using any sizing agent do not confirm the requirement of specification of their water absorption, however paraffin wax emulsion as sizing agent improved the water resistance characteristics. The water resistance characteristics of oil tempered board are also satisfactory. The oil tempered hard boards also match the requirement of Indian standard specification for modules of rupture.

Based as the rate of heat evaluation of wood cement system, it has been found this spent chips of *Acacia catechu* after katha extraction are compatible with cement for wood cement composite. The compatibility can further be enhanced by using calcium chloride as additive.

These experimental finding clearly show that the yield of katha and cutch (extraction) can be increased with proper storage of raw material and having 0.75-1.00mm thickness of chips. The waste sapwood as well as spent chip can be used as a raw material for paper, hard board and wood cement composite industries.

Natural Durability of Some Common Timber Species of Sarawak in Marine Environments

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A total of 28 hardwood and 1 softwood species of Sarawak were assessed for their natural durability in marine environments. The results indicate that none of the species was durable. Belian (*Eusideroxylon zwageri*) the most durable timber species of Sarawak, has a durability of 4 years. Three species failed within 1 year while the majority (23 species) failed in less than 0.5 year. Siliceous timber such as Kembang semangkok (*Scaphium macropodum*) has a mean durability of 1.5 year. The test specimens were destroyed by a combined action of teredine borers and pholad.

Keywords: Natural durability, timber species of Sarawak, marine environments, marine borer.

Variation in Wood Characteristics of *Robinia pseudoacacia* Linn. Managed under High Density Short Rotation System

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About 78% of Indian population reside in rural areas and are dependent largely on biomass to meet their requirements of energy for daily chores. The commercial sources of energy like fossil fuels, natural gas, coal, coke and electricity influence the urban centres of industrial production though contribute but insignificantly towards the rural population. This leads to the destruction of forest so much that they are now confined to remote and inaccessible areas only. The rhythm of growth in the forest is slow and scarcely perceptible. The per capita forest cover is only 0.09ha in India as against the world average of 1.0ha and the growing stock of our forest is only 32m^3/ha as compared to world's average of 110m^3/ha. The productivity of our forest is only 0.5 m^3/ha which is far behind the world average of 2.1m^3. Today the consequences of this all are reflected not only in the wide gap between demand and supply of forest based products but ecological disasters as well. To counteract this impending crisis a strategy that envisage improving productivity of lands already under agriculture and forests and reclaiming lands so as to reduce deforestation, needs greater impetus.

Research on trees is a multidisciplinary long term effort and the task of producing fuel wood in large quantities cannot be solved entirely through long term research programmes. So, the use of fast growing and high yielding plant species managed with intensive cultural operations in tree farming have opened up new vistas in wood biomass production. High density short rotation (HDSR) and short rotation intensive culture (SRIC) are considered the befitting systems having potential for producing more biomass per unit area and time. So, it was thought imperative to study the effect of HDSR *Robinia* plantation on wood properties for maximum benefits.

In the present investigations fibre length, specific gravity, calorific values, extractives and lignin content of wood decreased with the sampling height while holocellulose and pulp yield observed positive relationship with different levels of height. The effect of density was found non-significant for specific gravity and calorific value of wood. Extractives increased with the increase in spacing. Hollocellulose and pulp yield has exhibited positive relationship with spacing, however, on perha basis the yield was more for lower spacing.

Meeting Needs for Wood Products in Vietnam

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Since 1994, the author has developed several contacts during several field visits to Vietnam. The paper is a synthesis of professional experiences working with Vietnamese government and university scientists, as well as international partners including the International Crane Foundation, the Royal Holloway Institute of Environmental Research, Counterpart International, and the US forest products industry. The paper will address the key environmental issues that Vietnam faces, the opportunity for utilization research to meet the needs for wood products, and opportunities for trade with Vietnam as an emerging market. As a case study, the author will focus on utilization of Melaleuca sp. surrounding the Tram Chim National Park in the Mekong Delta as a key element of sustainability.

Tram Chim National Park contains the last remnant of the original patterns that once characterized the vast Mekong Delta, which has been extensively modified, primarily for rice agriculture. After the war and upon intallation of strategically placed dikes and replanting of melaleuca, a flock of Eastern *Sarus* cranes returned in the dry season. Since then, the area has attracted international attention, especially the investment by the International Crane Foundation. Recently, the Vietnamese Government declared Tram Chim a national park because of its uniqueness as the only remaining wetland forest in the Mekong Delta. The central management issues for this national park are: 1) Water management, 2) Fire Management, 3) Control of *Mimosa pigra* and 4) Socio-economic development in the buffer zone.

Water management has been the key issue since the beginning. The system of levees and dikes enables park personnel to mimic historic hydrological patterns, although the debate about these patterns and target conditions has been intense. Nevertheless, it is clear that maintaining high water levels throughout most of the park, intended to avoid fire, is degrading the melaleuca and other plant communities that are essential as shelter and food for the crane. The realization that a dry season must be restored to save the park is now shared, with trepidation because of a lack of fire control experience, expertise and equipment. A decision had been reached to begin a drawdown of the water level to coincide with the next dry season. Prescribed fire will be conducted in small steps to gain expertise and to reduce fuels. Meanwhile, Mimosa pigra, a non-indigenous species, has spread throughout the drier areas of the park and the surrounding rice fields, and it threatens to dominate the vegetation once water levels are drawn down. Kakadu National Park, in Northern Australia, has initiated a management program to combat a similar invasion of this species, involving management of water and fire. A strategy for controlling it has been proposed by the Head of Wetland Research at Kakadu, Max Finlayson, and a public education effort is being launched to involve people in the buffer area to take appropriate actions to control its spread.

5.06.02 Quality teak timber from plantations

Veneer/Gluability of Brazilian-Grown Teak

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Teak (*Tectona grandis* L.f.) is one of the world's best known and most highly valued timbers. Being native to south-eastern Asia and being planted extensively in many other tropical areas, plantations in Brazil, in the southern part of the state of Mato Grosso, near Caceres, are relatively unknown. Industry orientated research results of young teak material from Latin-American plantations, independent of growth areas, are rather scarce.

For the benefit of different end-uses of decorative plywood panels in western-Europe, sliced veneer from about 12 years' old Brazilian-grown trees, was tested for their suitability of surface veneer in industrially manufactured plywood. The aim of this test was to perform a comparative test of the gluability of veneers of surface veneer quality as obtained from the Brasil-grown teak trees in particular relation to the traditional teak veneer as obtained from mature trees grown in south-east Asia (Myanmar, in particular). Industry orientated tests were performed by gluing 18mm thick ornamental plywood panels from Brazilian and south-east Asian sliced veneer, respectively, and produced under the practical conditions as ruling in a large-scale and high-quality plywood factory. Type of glue and pressure conditions were in agreement with the usual production methods for such a type of composite.

For examning the bonding qualifications, samples were tested in accordance with the European standard EN 314-1. The test results of this informative project show the following qualitative indications:

- there are hardly or no differences in the bonding quality between plywood manufactured from the Brazilian and the south-east Asian sliced teak veneers
- there are no signs that any pretreatment of the surface of the Brazilian teak veneer, is required
- there are no significant indications that veneer of the juvenile trees of Tectona grandis produces a qualitatively lower grade of bonding strength in the plywood than in such a product made from veneer obtained from Asian mature trees.

5.06.03 Improving the utilization of plantations of Eucalypts

Variability of Selected Wood Basic Properties within a Full-sib Family of a Hybrid *Eucalyptus*

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In making recommendations for the development of sampling strategies it is important to understand the patterns of variation of the wood properties of interest. Information on the variation of important properties across sites, and within and between trees, is vital to obtain the best commercial advantage from the plantation resource of *Eucalyptus*. In this study the variation in several wood properties within a full-sib family of a hybrid *Eucalyptus* (*E. grandis* x *E. urophylla*) is examined. This family comes from the second generation of the plant breeding program leaded by CIRAD/UR2PI in Congo Brazaville. 200 trees are assessed for the following major characteristics for practical use:

- Longitudinal maturation strain
- End splits proportion
- Modulus of elasticity
- Shrinkages (L, R)
- Basic density
- Fracture energy
- Lignin content

For end splits proportion the measurements are recorded on three logs per tree. All the measurements are performed at the same height (2m), and excepted for lignin content and longitudinal maturation strain, all the measurements are sampled along a diameter of the stem. This procedure allows to compare the pith-to-bark variation of the properties between the trees, due to the juvenile effect. The objective of this study is to describe the variability of the properties measured within the full-sib family and also to describe conceptual patterns of variation, and then develop a general mathematical equation that accommodates the variation. The discussion examines how this model is affected by genotype, in order to select clonal material for commercial plantations. Some consequences for plant breeding strategy are also discussed.

5.07.00 Energy and chemicals from forest biomass

The Carbohydrates in the Oil Palm Trunk and Sago Waste and their Potential Utilisation

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Preliminary studies has shown that the carbohydrates in the oil palm trunk and sago waste are more labile to acid and alkaline conditions compared to those of other dicotyledons. Both palm trunks contain higher short chain and less crystalline polysaccharides. A large number of chemicals can be derived from the monomeric sugars of these polysaccharides. Fine chemicals and industrial intermediates could be produced by fermentation, oxidation, dehydration and/or hydrogenation processes. Xylans and xylooligosaccharides can be converted by chemical or enzymic hydrolysis into xylose and subsequently into a whole range of fuels and chemicals while glucose from the glucans could be used as fermentation substrates for production of cellulolytic enzymes, biodegradable polymers, citric acid and others. Many studies have been carried out to convert these material into value added products. Though the processes were technically feasible, they were not economically feasible due to the low yields of products. The yields can be improved if basic information on the carbohydrates present is known.

This study looked into the basic structures of the carbohydrates of both palm wastes. The types of glycosidic linkages of the carbohydrates of both palm trunk wastes were determined using methylation analysis. The method involves total methylation of the free hydroxyl groups followed by hydrolysis of the methylated derivatives. Hydroxyl groups formerly involved in the interlinkages were characterised and identified using GCMS. The nature of sugar residues occurring as non-reducing end groups, chain units and branch points were then established.

The partially methylated constituents afforded by the water insoluble material of both palm trunk wastes were similar. In sago palm waste more than half mole percentage of $(1\rightarrow4)$-linked glucopyranosyl residues were afforded whilst in the fibre samples of the oil palm trunk only 33.5% were afforded. The methylation data also suggested that the oil palm trunk waste contained a higher percentage of hemicelluloses as shown by the variety of other sugar residues afforded. The (1→4)-linked xylopyranosyl residues was found to be afforded in quite a substantial amount by the fibres of the oil palm trunk indicating the presence of xylans. The (1→3)-, (1→5)-, and (1,3,5)-linked arabinosyl residues were also found particularly in the parenchyma sample but in much lower percentage. Other sugars residues such as t- Araf, t-Xlyp, t-Glcp and (1→6)-Galp were also afforded during the methylations. These were the side chains or end group of the branched polysaccharides.

Due to the heterogeneity of the samples, a large number of possible structures could be drawn from the methylation data. In order to elucidate the model structures of the polysaccharides and to establish their relationships, selective fractionation by purified enzymes is recommended prior to the analysis of the dissociated fragments. The possible linkages obtained would be useful for the selection of solvents for sequential fractionations and/or enzymes for structural analysis. Data obtained in this basic characterisation studies of these carbohydrates would enable researchers not only to explore potential products from these carbohydrates but also to develop efficient fractionation and saccharification methods which could optimise the yields of monomeric sugars. Cost effective utilisation of these carbohydrates can only be achieved by integrated applications and processes.

Biomass Energy Conservation in the Sudan

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Forests provide < 80% of the total energy needs of the population in the Sudan in the form of charcoal and firewood. Due to inefficient burning of charcoal and firewood, greater areas of forests have been depleted. The objective of the present study was to establish other more efficient and less depleting biomass energy substitutes for the current extremely inefficient ones. Cotton stalk charcoal briquette produced low-density charcoal but it proved to be very effective in the local mubkhar stove as well as in the improved mud stoves and ceramic stoves. Bagass/Molasses fuel blocks are 21x14x8 cm and weigh 2.2 kg. Most of the blocks produced are being purchased by bakeries and brick kilns in Khartoum and Wad Medani area. The cost of this alternative source of fuel is about 25% lower than the cost of using fuel wood. For sustainability, the Forests National Corporation constructed a commercial unit in Geneid sugar mill near the sugar cane factory to reduce the cost of transportation. Carbonization and briquetting of lentil stalks with the use of agglomeration was very competitive in price to charcoal. Other fuel alternatives were also discussed including non biomass energy alternatives.

L'Hévéa en Cóte d'Ivoire du Latex au Bois d'Oeuvre une Reconversion Prometteuse

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Avant 1990, environ 66.000 ha de *Hevea brasiliensis* avaient déjà été plantés dans le tiers sud de la Côte d’Ivoire pour la production de latex pour alimenter l’industrie du caoutchouc naturel.

La production de latex baisse avec l’âge des arbres et surtout à partir de 25 à 35 ans. Les plantations sont alors renouvelées avec des clones issus d’amélioration génétique nettement plus productifs. La Côte d’Ivoire a aujourd’hui, à l’hectare, une des meilleures productions mondiales de latex.

Pour renouveler les peuplements d’hévéa peu productifs, ils sont exploités à blanc étoc et de nouveaux clones sont plantés. Cette opération met sur le marché de gros volumes de bois qui est généralement mal valorisés. De nombreuses grumes transformables restent sur les sites d’abattage. Pendant longtemps, ce bois n’a servi que de source d’énergie pour les ouvriers avec peu de retombées économiques pour les planteurs industriels.

Pour la période 1990-1995, le volume grume de bois d’hévéa annuellement exploité était estimé à 40.000 m^3. A partir de l’an 2000, chaque année, environ 120.000 m^3 grumes d’hévéa seront exploités. Leur utilisation comme bois d’énergie n’est économiquement pas souhaitable. A la demande des planteurs d’hévéa, mais aussi à celle des industriels du bois ivoiriens qui sont confrontés à la raréfaction des bois de forêt naturelle, la division de recherche de technologie du bois du CNRA (Centre National de Recherches Agronomiques) a entrepris des études pour valoriser au mieux cette matière première abondante.

Des essais technologiques, de transformation et mise en oeuvre ont été réalisés au laboratoire du CNRA. Ils ont permis de définir les conditions optimales d'utilisation de l'hévéa de Côte d'Ivoire comme bois d'oeuvre notamment les contraintes de séchage et les problèmes de préservation du bois.

Hevea brasiliensis est parfaitement apte à être transformé en produits semis finis (frises, lattes, chevrons, coursons, bois massif reconstitué, etc.). Ces produits peuvent alors être utilisés par l'industrie pour fabriquer divers produits finis tels que: ameublement, articles ménagers, menuiserie intérieure, panneaux lattés, etc.

La forêt naturelle ivoirienne s'appauvrissant en bois tant en quantité qu'en qualité, l'exploitation du bois d'hévéa peut être une alternative pour les industriels du bois accompagnés par la recherche qui leur proposera des itinéraires adaptés.

Mots clés: *Hevea brasiliensis*, bois d'oeuvre, transformation industrielle, Côte d'Ivoire.

Soils stabilized with wood tar for forest road application

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The purpose of this study was to analyze the behavior of soil-wood tar mixtures from a forest road Brazilian application perspective, considering the following engineering parameters: CBR, unconfined compression strength and Atterberg limits: liquid limits (LL) and plastic limits (PL). Three soil samples from Vicosa county, Minas Gerais State, Brazil, classified by the HRB system as A-7-5 (16), soil 1, A-7-5 (10), soil 2, and A-2-4 (0), soil 3, wood tar contents of 0.25%, 0.5%, 1%, 2%, 4% and 6% and the AASHTO standard compaction effort were considered thorough the laboratory testing program. The preliminary data obtained in the research program support that addition of wood- tar to the soils was responsible for no significant changes in theirs Atterbergs limits and minor increase in theirs CBR and unconfined compression strength.

Key Words: Forest roads, soil-wood tar mixtures, CBR, Unconfined Compression Strength, Atterberg limits.

Utilization Possibilities as an Coloring Substance of *Rhododendron ponticum* L. Flowers.

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The aim of this study was to assess the utilization possibilities of *Rhododendron ponticum* L. extracts, which is an undesirable plant in the forest, as coloring matter for anatomical and cytological experiments. Collected flowers from mountainous regions of Bartin - Kumluca were sorted to different parts (petal, stalk, petal and stalk), and their extractions in alcohol, alcohol -benzene, and hot water were carried out. As a result of UV spectrum evaluation; peonidin, chlorophyll and carotenoids were detected. According to the results obtained, the amounts of matter dissolved in alcohol, alcohol-benzene and in hot water vary between 28,83-33,57%; 23,30-23,47%, 33,44-41,82% respectively.

Very low coloring effects were obtained with alcohol and alcohol-benzene extract solutions of *Populus nigra* L. tissue samples. Whereas, more coloring effect was obtained with hot water extract solutions of the same species. Consequently, as hot water extract solutions contain more coloring matter and are more suitable for coloration. It is concluded that further detailed studies need to be done to determine what are the effective dye pigments.

Influence of Selected operational Parameters on the Composition of Oil Produced from the Fast Pyrolysis of *Pinus radiata*

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The derivation of fine chemicals produced from the pyrolysis of biomass has inspired much interest in the scientific community. However, the inherent complexity and thermal instability of pyrolysis oils have hindered progress in this endeavour. The objective of the current research was to optimise the pyrolysis process such that the yield of low molecular weight phenols was maximised and the complexity and thermal instability of the oil was minimised.

The research was conducted on a bench scale fluid bed fast pyrolysis system deigned by Resource

Transforms International (RTI) LTD. The main operational parameters investigated were reactor temperature (250-320oC), reaction atmosphere composition, sample residence time, sample particle size (150-500*m), sample moisture content (oven and air dry) and product collection method. The reaction atmosphere was varied from inert to 20% oxygen. The sample residence time was controlled by the fluidising gas velocity. The product collection apparatus consisted of a specially designed quench/solid residue collection system and an electrostatic precipitator designed by RTI LTD. The feed stock used was milled *Pinus radiata*.

The product oils were analysed by GCMS and the data statistically compared with the operational parameters. It was found that the yield of phenols was inversely proportional to feed stock particle size. The moisture content was found to have little effect on the yield of phenols or on the complexity of the oil. The specially designed quench/solid residue collection system yielded a simpler liquid product. It was also found that the presence of oxygen caused an increase in the yield of phenols.

Unused Potential of Estonian Forests for Energy Production

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Based on profound analyses in 1996, the allowable annual level of cutting for Estonian forests securing the sustainable and environmentally friendly management of forests was determined to be on the level of 7,8 Mm^3s (million solid cubic metres per year). Though the Estonian forest industry has developed successfully during the years after re-establishment of political independence, as the level of cutting has tripled since the year 1992 and reached the level of 6 Mm^3s by the year 1998, the allowable limit has not exceeded yet. The growing cutting level has made possible to make investments to wood processing. The sawmill industry, where the technology has been modernised and the production per year has grown from the level of 0,2 Mm^3s in 1993 to 0,8 Mm^3s in 1998, has developed most rapidly. As a consequence, the share of rough logs in total Estonian wood export has dropped from 54% in 1992 to 29% in 1998. The pulpwood is mainly exported today, but the resources are sufficient to develop instead of this the local pulp industry.

A remarkable progress can be mentioned also in the utilisation of wood for energy production, but probably here are the biggest unused resources for the future. To guarantee the energy supply and relatively low price of that, during the first years of independence a lot of attention to conversion of boilers from Russia imported fossil fuels to wood and peat was given. A certain progress was achieved, as the number of wood-fuelled boilers increased and correspondingly grew the heat production based on wood fuels- from 384 GWúh in 1993 to 1148 GWúh in 1998. The share of wood fuels from energy balance of Estonia provided 10% in 1997. Now in the conditions of stabilised economy, the driving forces for the further progress are improvement of environmental conditions and solving the social problems of rural areas. According to the Long-term Development Plan for the Estonian Fuel and Energy Sector, the share of wood and peat is planned to increase in the energy balance to 13% by the year 2010. To reach the goal, such development should be supported by the legislation and reversing a tax policy, but the determinant factor is the sufficiency of biofuels resources and their more extensive use in future.

In the present study the supply-demand balance concerning the supply for raw material and the demand for wood fuel were analyzed. To calculate the quantities of wood fuel, the existing forestry inventory database was used. The results of the study can be considered preliminary, since the ownership reform in forestry has not been completed and it was complicated to get a comprehensive overview of all forest resources. For reliable results forecasted industrial consumption, environmental restrictions as well as technical and economic conditions, and possible use of wood fuels by various user categories were used. To find out distances between energy wood resources (forest stands and mechanical forest industry enterprises) and users, the co-ordinates were determined. The results of the calculation are visualized with GIS-software (MapInfo Professional 5.5). The data indicate that there are still remarkable resources of wood fuel, not used at the present moment.

Bioinsecticidal Properties of *Azadirachta excelsa*

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Azadirachta excelsa (commonly known as sentang in Malaysia), one of the two important congeneric species of neem (*Azadirachta indica*), is a little known tree found naturally in lowland forests of

Malaysia. Because of its multipurpose properties and fast-growing nature, the plant is currently a popular timber species and is intensively promoted by FRIM for large-scale commercial cultivation. The objective of present study was to examine the bioinsecticidal effects of sentang extracts on *Paliga damastesalis* (a teak pest), and *Plutella xylostella* and *Spodoptera litura* (vegetable pests).

The sentang leaf, bark and wood of tree age about 15 years old was obtained from FRIM's forest. The extraction was carried out by soaking the sentang samples in water or methanol for 24 hours. The aqueous extract was freeze-dried with a freeze-dryer whilst the methanol extract was first concentrated with a rotary evaporator and then subjected to vacuum drying. The dried sentang extracts, except the aqueous one which was dissolved in distilled water, were dissolved in methanol (1% v/v), dimethylsulfoxide (DMSO; 0.5% v/v) and diluted to the desired concentrations with distilled water. Tween 20 (0.5% v/v) was added in all sentang extract solutions as emulsifier. Leaf pieces treated only with methanol and emulsifier served as control. The antifeedant effect of various extracts was evaluated against 3rd instar larvae of *Paliga damastesalis* and *Plutella xylostella*, and 2nd instar larvae of *Spodoptera litura*. Aqueous and methanol extracts of leaf, bark and wood at concentrations 0.5, 1.0 and 2.0% (w/v) were used in this study.

Under no-choice condition, both aqueous and methanol extracts at concentrations of 0.5% or above produced significant ($p<0.05$) antifeedant activity on *Paliga damastesalis* and *Spodoptera litura*, with an inhibition of at least 50% when compared to control groups. However, a higher concentration, i.e. 2% of sentang extracts was required to inhibit the *Plutella xylostella* from feeding the leaves. A high mortality rate was found in all insects fed on treated leaves.

The present study demonstrated that both aqueous and methanol leaf, bark and wood extracts of sentang were active against a forest pest (*Paliga damastisalis*) and vegetable pests (i.e. *Plutella xylostella* and *Spodoptera litura*). However, *Plutella xylostella* seems to be less sensitive to the antifeedant activity of sentang extracts though many of them died at the end of 48 hr feeding. These findings suggested that sentang could be a potentially good source of botanical insecticides (e.g. as a growth inhibitor).

Air Freshener from *Manila elemi* (*Canarium ovatum*) oil

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A resin processing Company generates a waste by-product in a form of *Manila elemi* oil after processing *Manila elemi* from *Canarium* sp. Previous study confirmed that *Manila elemi* oil contains a very important essential oil called limonene. Limonene is utilized extensively as top note perfume component in fragrances where citrus odor is desirable. It is one of the most inexpensive perfume components but is not necessarily applied to cheap fragrances. The present study was conducted to establish optimum conditions of limonene extraction from *Manila elemi* oil and utilize limonene as component of air freshener.

The waste *Manila elemi* oil was subjected to fractional distillation under reduced pressure. Optimum conditions of limonene extraction was obtained at a temperature of 43+5oC and pressure of 15 inHg. IR and GC analyses were performed to determine the qualitative and quantitative properties of the distillates. The IR spectrum of limonene-rich distillate exhibited distinct similarity with commercial limonene isolated from citrus peel. Analysis of the limonene-rich faction using GC showed that the distillate contains 88.5% limonene. Further purification of the limonene-rich fraction was done by passing it through column using hexane as solvent. Hexane was recovered by rotary evaporation under vacuum. The purified limonene was utilized as component of spray-type air freshener. The experimental air freshener had coefficient of volatility similar with the commercial limonene prepared. *Manila elemi* oil is a promising source of limonene which the Philippines has an abundant and steady supply for the last two decades. Importation of orange and lemon oil for medicine and perfumery of 2.5M US $ could be reduced with the utilization of locally available limonene from *Manila elemi* oil, hence help conserve dollar reserves.

Note: An improvement in the process of extraction was conducted as follow-up to the previous study to produce limonene from the resin of higher purity, thus a limonene content of 88.5% was achieved compared with the previous 74%.

Supercritical Extraction of Wood: A New Way to Utilize Wood for High-priced Chemicals or Energy

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Man is facing a severe challenge with the population explosion, natural resources decreasing day by day and steady increase in society needs for chemicals and energy. Reserves of the fossil resources oil, gas and coal are limited, their exploitation and utilization can cause environmental pollution, and their supply is not reliable because of the influence of world political situation. Therefore, the production of chemicals and energy from renewable resources (e.g. wood) to replace expensive energy and petrochemicals from exhausted reserves of the fossil resources has been a forward and heated subject.

The extraction of wood with supercritical fluids has been receiving considerable attention for conversion of wood, the potential industrial applications are extraction of biomass as a source of organic chemicals or fuels. The extraction of some Chinese woods with sub- and supercritical ethanol or ethanol-water mixtures has been investigated in a semi-continuous apparatus and a batch autoclave apparatus for the purpose of wood conversion to chemicals or energy. In this paper, the following contents will be discussed: (1) the introductory remarks of wood conversion by supercritical fluid extraction; (2) the recent development of wood supercritical extraction; (3) the main engineering problems in the supercritical extraction of wood; (4) conclusion and suggestion.

Stem Oleoresin Yield as Influenced by Needle Characteristics and Effect of Tapping on Growth of Chir Pine (*Pinus roxburghii* Sargent) Trees in Himachal Pradesh

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The oleoresin industry in Himachal Pradesh (India) is based on suitable and renewable pine resources and the various operations are labour intensive, which offer employment to the rural people. At present, only chir pine (*Pinus roxburghii* Sargent) is being tapped but there is also a great potential to tap other indigenous or exotic pines. The exudation of resin is substantially influenced by various physical and technical factors and a score of scientific experiments have been conducted to develop a suitable approach in the tapping of trees. The need now is the application of the established scientific principles in the field. The fluctuation in oleoresin yield has created shortages in this commodity, which have to be met by imports thereby affecting the balance of trade of the country. India has become a net importer of both rosin and turpentine because of the shortfall in production due to the damage done to the trees by the use of incorrectly applied methods. The availability of an adequate number of mature pine trees is a fundamental requirement for smooth running of the oleoresin tapping work which, in turn, affect the downstream industries. The plantations are to be raised solely for oleoresin production by exploiting the indicators, which determine the natural variability in oleoresin production.

The present investigations were conducted to find out the influence of needle characteristics on the oleoresin yield and also to identify the needle colour markers for high oleoresin yield. The effect of tapping on the growth of trees is also a contentious issue and needs long term experimentation to determine its influence conclusively.

Thirty needles each were collected from bottom, middle and top of the tree crown and their average diameter and length were recorded. In total, 262 trees were tapped. The needle colour was compared with the colour chart of Royal Horticultural Society, Kew and four colour classes viz. Dark Green, Green, Yellow-Green and Yellow were identified. A simple correlation coefficient was worked out between needle diameter, needle length and oleoresin yield. A Chi-Square test was performed to find out the association between needle colour and oleoresin yielding capability (high, medium and low) of the trees. A 't' test was then used to test the significance of difference in subsequent growth rates of the tapped and untapped trees as measured by the incremental increase in diameter.

The diameter and length of needle were found to be positively and significantly correlated with oleoresin yield. The trees with Dark Green, Green and Yellow needle colouration were found to be in the higher resin yielding class than that expected in general. The trees with Yellow-Green needle colour were lower resin yielders than that expected in the high and medium resin yielding classes. It was found that this characteristic produced a greater number of trees in low resin yielding class than expected.

The mean diameter increment during 5-years (1993-1998) of tapping was 5.06cm for tapped trees compared with 7.80cm for untapped trees. The height increment was not found to be significant.

The needle characteristics on oleoresin yield exhibited significant effect. All needle colours except Yellow-Green produced higher oleoresin. The tapping of trees for five years have shown a significant effect on the diameter increment. The tapped trees grew slower than the untapped trees. The height increment showed no correlation possibly might be due to the fact that the trees had already reached the maturity stage.

Bioconversion of Agro-forestry wastes by Gamma Irradiation Treatments and Fungal Fermentations

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Utilizing and upgrading lignocellulosic wastes and by-products into more useful end-products may be one potential solution, necessary to recycle the forestry-agricultural resources and also to reduce the environmental pollutions, due to discarding, incinerating or under-utilizing them. Kume et al. (1998) have outlined. The Bilateral Program Kapan-Malaysia on Upgrading Cellulosic wastes by Radiation Technology and Biotechnology, mainly on conversion of irradiated oil palm fibres into animal feed by fermentation with Oyster mushroom *Pleurotus* spp. In Vietnam, large amounts of lignocellulosic wastes from forestry-agricultural productions were estimated approximately 90 million tons per annum or more, that requires actually to be rationally treated.

Our present studies were carried out on lignocellulosic substrates mixed with some kinds of wastes from fermentic and latex processing industries, irradiated with X rays of ^{60}Co and then fermented with various edible and medicinal mushrooms, able effectively wood-decaying, such as *Ganoderma* spp, *Amauroderma* spp., *Pleurotus spp*., *Auricularia* spp., *Trametes versicolor, Hericium erinaceum, Grifola frondosa, Schizophyllum commune, Lentinus edodes,* etc. Effects of microbial eliminations (initially contaminated bacteria and fungi) were confirmed at wide range of radiation doses (15-30 kGy) for substrates with sawdusts, sugar cane baggasse, rice straw, oil palm fibre and others.

Some changes of main components of basic polysaccharides and nitrogen sources in mixed substrates under irradiation and fungal fermentations have been examined to confirm effective conversions and assimilations of inorganic nitrogen into protein, particularly using ^{15}N tracer techniques. Biomass obtained by fungal fermentations would be used for animal feed production and spent composts were useful for biofertilizer production. Fruitful cultivations of wood-decaying mushrooms were promising and a Project for applications at large scales was suggested to contribute into expoitation of Industrial ^{60}Co Facility installed (February 1999) at Center of Radiation Technology in HoChi Minh City.

Do Environmental Values and Customer Opinions Effect on Fuel Choices in Power Companies?

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About 10-15 millions cubic meters of biomass, i.e., logging residues and small sized wood is available in Finlandïs forests annually. This wood biomass is suitable for energy production purposes, and its energy use is aimed to be increased in Finland. The Kyoto agreement from 1997 requires that CO_2-emissions should be reduced, and replacing fossil fuels with wood would clearly help Finland to reach this target. Increasing production of wood energy requires that power companies, in particular small to medium sized (SMS) companies, invest in new combustion capacity.

The purpose of this study was to describe the present use of biomass and the fuel choice criteria in the SMS power companies in Finland. Second aim is to describe the bioenergy and in particular wood energy related beliefs and investment plans of the SMS power companies management. The population of this survey study comprises 363 heating power companies having the maximum capacity of 40 MW. The data was collected in 1996 through a mail survey using structured questionnaire. The response rate was 43% (157 companies).

The results show that 30 respondent companies already used wood as their main fuel. The management in most respondent companies believed that use of biofuels will increase in the future, but they also assumed that subsidies will remain necessary to make biofuels competitive. About 20% of the respondent companies planned to start or increase their usage of wood within the next few years.

Factor analysis showed that on the background of the bioenergy attitudes of company management, there exists two major dimensions: A belief that 1) there exists insecurity related with biofuels, mainly due to unstable availability and quality, but that 1) the use of biofuels is beneficial for the society. The respondent companies emphasised especially strongly the environmental impacts in their fuel choices, even more strongly than customer needs. Environment was emphasised most strongly by companies located in the most heavily populated region and least by companies located in the most rarely populated region. But when relating various fuel choice criteria with fuel price, the relationship between price and technical suitability and availability of fuels seemed to matter most. The most ecologically oriented companies, however, found environmental impacts as more important than fuel price. The most market oriented companies emphasised customer needs as more important than price, which was also logical. It was generally believed that consumers support bioenergy production due to environmental reasons, but are reluctant to pay a price premium. Companies using wood were most assured that their customers support bioenergy, but few of these companies used bioenergy as a marketing argument.

The results of this study imply that SMS heating companies in Finland are investing to increase their heating generation capacity based on wood fuels. But these investment plans are small compared to the large potential of wood fuel usage in Finland. Environmental values seem to be fairly strongly emphasised by the SMS heating companies, and customers are generally believed to favour biofuels. However, emphasis on environment does not seem to be clearly reflected in the SMS heating companies actual fuel choices nor in marketing communication. Since major insecurity related with biofuel supply was a general belief in power companies, special effort should be put in securing stable availability and quality of wood biofuel in order to reach the potentially much larger markets of wood fuels. In addition, the SMS heating companies should put more effort in marketing of bioenergy since the companies believe that customers favour bioenergy. These efforts would probably benefit immediately at least those companies which already use wood as their main fuel.

The Extraction of Essential Oil from Indonesian Keruing (*Dipterocarpus*) Species

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Key words: Keruing wood, oleoresin, physical-chemical properties, essential oil, wood wastes, distillation technique

Woodworking or plywood industries which use keruing wood as their raw materials produce oleoresin and wood wastes that are not as yet utilized as raw material resources to produce Indonesian keruing oil.

The present study was conducted to determine the proper organic solvent to separate essential oil from the oleoresin and the effect of distillation techniques on the physical-chemical properties of essential oil.

The oleoresin, in the wood working industry, was separated from sortiments by soaking in 2 % boiling salt solution. It was then diluted in organic solvent consisting of petroleum ether and hexane with the ratios of oleoresin and solvent comprising 1 : 2, 1 : 3 and 1 : 4, respectively. The solution was centrifuged for 30 minutes and the removed supernatant was then evaporated until it became concentrated. The concentrated solution was added with enough water and afterwards the hydro-distillation was performed on the solution to separate keruing oil. Further, wood wastes, after being milled into small particles of 80 mesh size, were distilled using two methods, namely water and steam distillation, and water distillation, for 18, 24 and 30 hours, respectively. The obtained essential oils from both raw materials were then analyzed for their physical-chemical properties.

Results showed that the keruing oil yield separated from oleoresin was around 17,95 % (w/w) which had a 0.9735 –0.9771 specific gravity, a 1.4952 – 1.4989 refractive index, a –13.04 - -12.17 optical rotation, a 0.394 – 0.879 acid number, a 3.482 – 5.240 saponification number, and a 2.752 – 4.955 ester number, and a 1.013 – 3.910 % solvent residue. Both petroleum ether and hexane did not give a significant difference on oil yield and the properties of the oils. However, the ratios of oleoresin and solvent gave a significant difference on the specific gravity, saponification number and an ester number of the oils. The higher the oleoresin and solvent ratio, the lower the specific gravity, saponification number and ester number. Furthermore, compared to the water and steam distillation technique, the water distillation produced higher oil yield. The product had a 0.9111 – 0.9761 specific gravity, a 1.5022 – 1.5075 refractive index, and a 5.74 – 8.37 acid number.

The best condition to extract the essential oil from oleoresin is to use petroleum ether or hexane with a 1 : 4 ratio of oleoresin and solvent by volume. In terms of oil yield and simplicity, the water distillation technique is the better technique to produce keruing oil from wood wastes. This technique is suitable for producing keruing oil on a cottage industrial scale.

5.07.01 Fundamentals of wood carbonization

New Activated Carbon Produced from Olive Cakes by Steam Pyrolysis

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The increased exploitation of forest for energy needs is accompanied by problems of deforestation and ecological unbalance. In Morocco, experts estimate indeed that between 15.000 and 40.000 ha of forests disappear each year. For these reasons, we have opted for the valorization of olive cakes, which are a cheap product, abundant and under used in Morocco, in order to prepare a new activated carbon and their use for adsorption of pollutants from liquid phases in water treatment.

To achieve this study, an experimental design, using a Doehlert matrix, has been carried out to study the effect of temperature and activation time on the preparation of activated carbon. The choice of the Doehlert matrix is justified by a number of advantages such as:(i) the possibility of presenting a uniform distribution of experimental points in the space studied (ii) ability to explore the whole of the domain (extremes and internal field) (iii) usefulness of interpolating the response (iv) possibility of adding new factors without altering the quality of the matrix. The adsorption of iodine and methylene blue has been used as a primary indicator of the adsorption capacity of the activated carbons prepared. The choice of these molecules is justified by their properties. Thus, the mesopores of carbon are often studied by methylene blue adsorption and this also serves as a model compound for adsorption of organic contaminants from aqueous solution. The iodine molecule gives interesting information on the surface area contributed by pores larger than 1nm. All the pyrolysis reactions were performed in a thermolyne electric oven with a temperature control device linked to a thermocouple, a silice reactor and a water steam generator placed at the entrance of the reactor. At the end of the reaction, the oven was cooled to the ambient temperature. Activated carbon was recovered, boiled 30 min in distilled water, washed, ground and tested in water. The result obtained shows that:

- The experimental response studied varied between: 8.4-22.4% for the total yield, 131-396 mg/g for the adsorption of methylene blue and 778-1390 mg/g for the adsorption of iodine. In Morocco, the minimum required (for any activated carbon used in drinking water treatment) is 180 mg/g and 700 mg/g for methylene blue and iodine respectively.

- An increase in both temperature and activation time entails an opening and enlargement of pores, which enhances the adsorption of these molecules. The experimental conditions of preparation which permit a better adsorption of small molecules like iodine are those which also favor the adsorption of methylene blue.

- The interaction between activation time and activation temperature is important than the direct effect of each factor.

The response surface methodology using Doehlert's matrix is an appropriate tool to study optimization of the activation process to prepare activated carbons to be used in a given technological process.

The olive cakes are a good precursor for the production of activated carbons with interesting characteristics (great adsorption capacity.).

Keywords: activated carbon, olive cakes, pyrolysis, adsorption.

Comparison of Physico-chemical Properties of Charcoals Made from Australian Acacias with Charcoals Marketed Commercially in Abidjan

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The city of Abidjan, to satisfy its household energy demand, will continue to need an assured supply of charcoal even though the government is trying to introduce a policy of substituting charcoal with gas, of which deposits exist in the country. The annual demand for charcoal is about 300.000 tonnes, produced from 5 million tonnes of wood. This demand is difficult to satisfy from remaining forest resources as the forests that in 1960 covered 15 million ha of the Ivory Coast had shrunk to only 2.5 million ha by 1998. In parallel with the introduction of policies favouring substitution of charcoal by gas it is essential, in the medium term, if not in the short term, also to develop a new biomass-energy resource. This resource could be developed quickly by using Australian Acacias, notably *Acacia mangium* and *Acacia auriculiformis* that are perfectly adapted to local conditions. These two leguminous species also contribute to the restoration of agricultural soils whose fertility has been exhausted.

The objectives of this study are, firstly, to determine if the age of a tree and/or its agro-ecological source has an influence on the characteristics of the charcoal produced from it and, secondly, to compare the quality of charcoal produced from the above two species with that of charcoal sold commercially in the city.

The first stage of the study concerned the carbonization under laboratory conditions of woods from trees of the two Acacia species aged 7 to 15 years old. Pyrolysis was carried out in a 100 litre retort oven, heated with gas. The charcoals produced were analysed to determine moisture content, specific gravity, calorific value, volatile matter, ash content and fixed carbon content.

In the second stage, we studied the quality of charcoals from these two species of Acacia, carbonised in metal ovens (of Magnien type) of 4 m^3 capacity. These were compared with charcoals sold commercially in the city of Abidjan. The samples of commercial charcoal were collected according to a predetermined sampling program.

Pyrolysis tests showed no effect of tree age on the quality of the resulting charcoal.

The specific gravity of the commercial charcoal ranged from 0.34 to 0.73. (Specific gravity affects the rate of charcoal combustion and is a useful predictor of charcoal quality.) Of the two Acacia species carbonised in the experimental kilns, *Acacia mangium* produced a charcoal of specific gravity 0.30, comparable to that of the poorest commercial charcoals. *Acacia auriculiformis* gave denser, better quality charcoals. With regard to ash contents, those of the experimentally obtained Acacia charcoals were less than 2%, while those for the commercial charcoals were 2 to 6%.

The charcoal products from the two Australian species studied are of a quality that, in theory, should be acceptable to consumers in the city of Abidjan. These Acacias, in addition, improve the quality of soils. Encouraging their introduction in the agricultural areas in the south of the Ivory Coast would help supply the energy demands of Abidjan's households while regenerating the exhausted soils and also creating additional income for farmers.

Keywords: *Acacia mangium*, *Acacia auriculiformis*, carbonization, charcoal, energy supply, Abidjan, Ivory Coast.

Potential Application of Light Briquette Manufacture Method for Charcoal Production

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Recently we have developed new method of light briquette production from lignocellulosic waste materials of different origin, regardless of moisture content. Cohesiveness of the light briquette is achieved by the addition of recycled paper waste. Low-pressure application (3-5 bar) proved to be satisfactory for briquette formation. The light briquettes are characterized with high porosity and therefore low density. The light briquette structure does not decline upon moisture absorption or water suction, the problem commonly associated with the wood briquettes produced by conventional methods.

The two methods of enhancement of light briquettes heat characteristics are developed. The first series of enriched light briquettes are obtained by addition of pulp of recycled paper (as adhesive) in charcoal fines in course of the procedure of briquette formation. Our further investigations are directed to the carbonization of light briquettes, what is the second method suggested for heat characteristics enhancement. Preliminary experiments indicate that the briquettes maintain form and consistency upon carbonization, which could open new area of light briquette application.

Process of carbonization was carried on in the laboratory retort without air presence at 500 0C for three hours. Volatile content and charcoal were determined by JUS.B X8.317 method by annealing the briquette samples at the temperature of 900 C, during 7 minutes, without the presence of air. Ash content of investigated briquette samples was determined by the method TAPPI T 15 wd-80 by annealing the briquette samples at the temperature of 600-850°C during 1h. Higher heating values of investigated briquette samples were determined by standard method JUS.B X8.318 in the calorimetric bomb. Combustion characteristics of briquette samples were determined in the furnace of 3000W with maximum temperature up to 1000°C. The testing was carried out in the conditions of constant temperature in the furnace place repeated in the range between 425°C and 800°C, advancing at constant intervals.

The production of light briquettes characterized by different shapes and dimensions is provided during compression in mold. Charcoal produced from light briquettes and light briquettes produced from charcoal could be alternative to that produced by conventional method.

Briquettes made of charcoal fines and pulp could be used in households for cooking and for barbecues. This could be a way for better using of charcoal fines made during carbonization. Characteristics of briquette made from charcoal fines are presented in next table:

Density	Higher heating value	Volatiles	C-fix	Ash
kg/m^3	kJ/kg	%	%	%
450	28,000	21.4	62.8	5

Charcoal made by carbonizing of light-briquettes are made for production of activated charcoal and filters of all sizes and shapes. Characteristics of charcoal made from light briquettes are presented in next table:

Density	Yield	Volatiles	C-fix	Ash
kg/m3	%	%	%	%
104-143	28.2-37.8	17.8-18.0	72.38-74.78	7.25-9.78

C-fix content of charcoal produced by light briquette carbonization is lower than it is necessary for activation. By increasing temperature from 5000C to 6000C it is possible to increase C-fix content with simultaneous decrease of yield. Ash content is influenced by the way of waste gathering. The low density of charcoal is the consequences of high porosity of light briquettes. The dimensions of briquette samples were reduced significantly after carbonization (between 41 and 55%) but original shape was kept. The structure of carbonized light briquettes is gently and fragile what can be corrected by appropriate change of parameters of light briquette production process.

Novel Potentials of Chemical Activation and Carbonization of Biomass Components

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Pyrolysis is a widely accepted method for utilization of wastes obtained after mechanical and chemical biomass conversion. It is known that inorganic substances as catalysts regulate the thermal transformation and permit the creation of solid products with desired properties. The present paper concerns the production of highly effective carbon and ferromagnetic carbon-mineral sorbents. These sorbents, which are able to preserve human environment, have been prepared by pyrolysis of biomass wastes using alkali metals and ferric salts as catalysts. A complex of investigations has been performed to try sodium compounds (NaOH, Na_2SO_4, Na_2CO_3) as chemical activators in the pyrolysis of various types of lignin-containing raw materials. The investigations are aimed at the production of effective carbon sorbents simultaneously with regeneration of inorganic substances. The use of standard energetic equipment in the sulfate pulp mills for the pyrolysis is proposed. It has been shown that in the presence of sodium hydroxide or sodium sulfate or sodium carbonate the formation of perfect microporous structure occurs regardless of the raw material (saw dust, bark, hydrolysis lignin, sulfite and sulfate liquors) without usage of gaseous activating agents. The volume of micro- and mesopores in the sorbents obtained exceeds 1.5 cm^3/g. The specific surface (determined by the BET method) is more than 2500 m^2/g. A mechanism for the catalytic action of sodium compounds has been found. It has been demonstrated that it is possible to obtain more than 20 types of active carbons by varying the parameters of prepyrolysis and thermochemical activation, and the amount of catalysts. The sorbents are different concerning the volume of micro- and mesopores and the physical properties (e.g., dispersity, density). By regulation of the process the application range of the sorbents are amplified. They can be used for purification and recuperation of gases, selective removing of admixtures from liquid media, etc. Ferric salts, which are used as catalysts in the processes of thermal gasification of organic raw materials, change the mechanism of redox reactions during the pyrolysis of biomass and the structure of the carbonized products. The conditions of a catalyst introduction (impregnation with the solutions of salts at various pH, removing of anions of ferric salts) and nature of the organic matrix (wood, cellulose, lignins, sewage sludge) are the main factors influencing the activity of the ferric ions during pyrolysis. The impregnation mode influences the redox properties of the catalysts system and the redistribution of paramagnetic centres, which determine the subsequent process of thermal destruction. Introduction of ferric salts into the organic matrix through ion exchange increases the reduction rate of iron, inhibits the formation of large pores and promotes the formation of microporous structure. A mechanism for heterogeneous interaction of the ferric ions with cellulose and lignins has been proposed. It has been demonstrated that there are differences in their reducing properties during the pyrolysis. Unlike the cubic form of iron resulted from carbonization of the cellulose systems, in the case of lignins the reduced iron is an oversaturated alpha-iron-carbon solid solution in the tetragonal form. Carbonized products obtained are highly ferromagnetic and have a well developed porous structure. The maximum magnetizability is 60 $A*m^2/kg$, the sorption activity by iodine equals 1200 mg/g, and the clarification capacity in terms of methylene blue is more than 400 mg/g. The possibility to remove the ferromagnetic sorbents from solid and liquid media in the magnetic field can be considered as an advantage over the other approaches.

Production and Testing of Charcoal Briquettes from *Pinus radiata* Wood Residues

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Production of sawn timber from *Pinus radiata* is an important sector in Australia. These sawmills are typically large with log throughputs of over 300,000 m^3/yr. Residues in the form of sawdust, bark and dockings are often used as fuel for timber drying but these are far in surplus to the mill's energy requirements. A project was undertaken to carbonise sawdust residues in a fluid bed carbonisation unit and to produce charcoal briquettes for cooking purposes. A test cell was designed and built to evaluate and monitor burning properties of briquettes, ignition tests, cooking temperatures and cooking times. Ignition tests showed that the test briquettes were easier to ignite than commercial briquettes using brown coal based charcoal with ignition 2.7 times faster. Combustion time and cooking temperatures was adequate for a normal cooking session. The pine char briquettes burnt for 2.3 hours, approximately half the time of the commercial briquettes measured at 4.1 hours. Maximum cooking temperature was 180°C measured 25mm above the briquette compared with 195°C for the commercial product. Drop tests and compressive strength tests on the briquettes were also conducted which showed that they could withstand the rugged treatment that normal handling and storage conditions generally require. Drop test onto a steel plate from a height of 1.8 m showed no breakage after 20 drops for all briquettes. Ultimate compressive strength measurements showed a value of 0.28 MPa for the pine briquettes compared with 0.21 MPa for the commercial briquettes.

Production of Activated Carbon from Palm Kernel Shells by Steam Activation

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Palm kernel shells were carbonised in an indirect pyrolysis reactor to 750°C. The charcoal were then crushed, grind and sieved. Under intense heat and steam, the charcoal gradually turn into highly micro porous activated carbon. The granulated shell charcoal was then activated at 800°C in an atmosphere of superheated steam. It was found that good palm kernel shells activated carbon with an average CTC and 12 value of 50% and 900 were obtained respectively. The bulk density of the material was found to be 420-540 g/cc and its hardness index was found to be 95-98%.

A typical activated carbon plant will require a land space of not less than 0.6 ha with a built up area of the factory should be approximately 2050 m^3. Two reinforced concrete Rotary Kiln stand will have to be built with piling, to withstand 80 to 100 tonne weight each. The factory must have normal public water supply and electric supply requirement should be approximately 200A.

Based on a production capacity of 1250 tonne per annum and the current market price of raw material, direct labor cost, factory overhead, the net profit return of the plant was found to be 34.6%-

37.8%. The profitability of a typical company's operations can be summarised as follows.

	Year				
	1	2	3	4	5
Gross Profit Rate (%)	44.3	43.8	43.1	42.6	41.9
Net Profit Rate (%)	37.8	37.3	36.3	35.4	34.6
Return of Capital Employed (%)	34.8	35.7	34.7	33.9	33.1

Palm kernel shell activated carbon has been found to have very diverse usage, as it offers itself as a raw material that can be conditioned into myriad form of applications for purification of air, gas, liquids and in recovery of precious metals (i.e. gold) from ores. It has immense capacity for adsorption. The quality ranges from mainly iodine 900 to iodine 1300 with the price quoted as USD1000 to USD1500 per tonne respectively.

Keywords: activated carbon; charcoal; palm kernel shells; profitability; pyrolysis

Yield, Apparent Density, Volumetric Shrinkage and Quality of Charcoal as Affected by Raw Material and Charcoaling Properties

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The consumption of charcoal in Egypt increased in the last two decades as a cooking fuel and in industry. All charcoal used in Egypt are produced by earth pit method. The quality of produced charcoal did not meet the need of different uses. It is essential to study the different quality parameters from different local grown wood species under different charcoaling parameters.

Accordingly, this study was designed to evaluate the quality properties of charcoal produced from some local grown species as affected by carbonization conditions i.e., maximum final temperature, heating rate and residence time. Wood specimens representing four hardwood species, namely eucalyptus (*Eucalyptus camaldulensis*), casuarina (*Casuarina glauca*), tamarisk (*Tamarix aphylla*), and acacia (*Acacia saligna*) were charred in a flowing nitrogen atmosphere using tube furnace at maximum temperature of 450°C and 600°C, heating rate of 10 and 25o C/min. and residence times of 90 and 120 min. Yield, apparent density, volumetric shrinkage, gross heat of combustion, volatile matter, ash and fixed carbon contents of charcoal made the four wood species were evaluated according to ASTM Standards (D 1762-1984 and D 2015-85).

The charcoal yield differed significantly according to species and carbonization conditions. The yield from tamarisk and eucalyptus (33.45% and 32.86%, respectively) was higher than that from casuarina and acacia (27.62% and 27.58%, respectively). Increasing the maximum final temperature and heating rate decreased the yield significantly. However, the residence time had no effect on the yield.

Apparent density (AD) of charcoal was affected only by heating rate. It decreased as heating rate increased. The maximum final temperature and residence time did not affect significantly the AD of charcoal. There was no direct relationship between the AD of charcoal and specific gravity of the parent wood.

The volumetric shrinkage (VS) of charcoal is dependent on species and carbonization conditions. It affected by maximum final temperature, whereby it increased by increasing maximum final temperature and no effects were evident due to heating rate and residence time.

Species and carbonization conditions affect significantly the quality properties of charcoal. At lower maximum temperature (450°), the gross heat of combustion (GHC) and fixed carbon content (FC) were lower, and volatile matter content (VMC) was higher than that at maximum temperature of 600°C. However, ash content only in tamarisk charcoal was increased with increasing final temperature for all species heating rate and residence time did not affect or have a minor effect on the charcoal properties.

Charcoal produced from tamarisk was generally lower in its quality than other species at the same carbonization conditions. This is due to its higher contents of ash, volatile matter and fixed carbon as well as its lower gross heat of combustion. Acacia charcoal is generally of better quality compared to that of tamarisk but is lower in its quality due to higher ash content than charcoal obtained from casuarina and eucalyptus.

Keywords: Carbonization, charcoal, charcoal yield, properties, charcoal quality, processes.

Productivity of Pine Gum Producing Tree (*Pinus merkussi*) due to Stimulant Degree and Covering the Tapping Holes

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Pine resin obtained by tapping of living pine tree (*Pinus merkusii*). In Java there are three system of pine tapping, the leading one is by narrow face (U reverse side) system, the others in a limited area are "rill" (V) system and "drill" system. One another is with and without chemical stimulant.

The paper deals with pine gum productivity of narrow face tapping which was seriously affected by the stimulant degree as well as by covering the tapping holes. The stimulant degree, which is used as usual by the harvesters, is too high and have to be reduced. Covering on tapping holes increased either on the quantity or the quality of pine gum instead of the usual manner.

Manufacture of Active Carbons from Woody Waste Materials

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Keywords: Active carbon, Woody waste material, Wastepaper, Adsorption test

A lot of active carbons will be required in the future to remove many kinds of pollutants and clarify water and air. In the process of manufacturing active carbons it is interesting, that we can utilize the heat from the incineration of woody waste materials in the carbonation step and even more we can use the resultant gasses in the activation process, because the most powerful green house gasses, water vapour and carbon dioxide are often use as activation gasses. Furthermore we can also use the reaction product gasses that forms during the activation. The use of carbon dioxide and water vapour in the activation process forms carbon monoxide and hydrogen gasses which can be used as fuels for carbonization. Thus combustion gas can be recycled.

The present study was conducted to manufacture active carbons from woody waste materials such as plywood, fiberboard, particleboard and wastepaper with activation gas mixed carbon dioxide and water vapour.

Waste panel products were cut into cubic pieces before carbonization and activation. Wastepapers were defibrated and converted into paper pellets. The carbonization and activation were carried out in one step in one reactor. Each sample (c.a. 20g) was set into a net cage and inserted to a reactor made of stainless tube. Then the tube was heated under the flow of mixed gas of carbon dioxide and water vapour. Mixed gas was obtained by bubbling carbon dioxide into hot water. Activation time was estimated when the temperature of reactor reached 900 degrees centigrade.

After 1 hour activation process, the yield of active carbons from panel products became about 10% based on starting materials. On the other hand, in the case of wastepaper made of mainly cellulose, after 20 minutes activation, active carbon yield was about 6%. In the results of adsorption test of iodine(c.a.800-1000mg/g) and decolorization test of methylene blue(c.a. 150-200ml/g) by Japanese industrial standard, active carbons from woody waste materials showed almost the same values as commercially available active carbons. Although starting materials such as plywood, fiberboard and particleboard contained urea resin, plywood charcoal had no nitrogen. But fiberboard and particleboard contained a few percent nitrogen after carbonization.

Active carbons can be manufactured from various kinds of woody waste materials by using mixed gas of carbon dioxide and water vapour.

Preparation and Micropore Structure of Activated Carbon Moldings

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Acetic acid lignin (AL) was obtained by atmospheric acetic acid pulping that was developed to separate the wood components efficiently. AL had a unique thermal property, fusion property in addition to glass transition property, although technical lignins, such as lignosulfonate and kraft lignin, had only a glass transition property. Thereupon, AL was readily transformed into fibers and sheet by fusion spinning and thermal compression method, respectively.

These thermal moldings were converted to activated carbon (AC) moldings by carbonization followed by activation to produce the agents for environmental clarification. In the case of the AL fibers, they were carbonized at 1,000°C after thermostabilization in air atmosphere, which was performed to preserve fibrous shape. The resulting fibers were converted to activated carbon fibers (ACF) by steam activation. The ACF activated for 40 min had similar adsorption properties, such as specific surface area and iodine adsorption capacity, to commercial AC powder. The ACF activated for 80 min had very large surface area (ca 2,000 m^2/g) comparable to the commercially highest grade of ACF. Furthermore, such ACF had rapid adsorption rate to methylene blue. Thus, AL based ACF fulfills a prerequisite of ACF.

The adsorption mechanism of AL based ACF was investigated by determining its pore distribution (obtained from the nitrogen isotherm). The ACF was found to have only meso-, micro- and ultramicro-pores; it had no macro-pores. The adsorption mechanism of AC powder is proposed generally as follows. Adsorbates diffuse through macropores to meso and micro-pores as adsorption sites. The transport process is the limiting step, and therefore the adsorption takes a long period to reach equilibrium. By contrast, the adsorption of adsorbates to ACF occurs at the surface of the fibers without transport though micro-pores. This mechanism brings about rapid adsorption.

To develop new type of AC moldings, AL was transformed into AC sheet by thermal compression method. When the sheet was carbonized without thermostabilization, the sheet was deformed markedly probably due to the ejection of volatile material and softening of lignin. Thermostable cellulosic material was added to the sheet before carbonization to restrain the deformation. In the case of the sheet in the diameter of 5 cm, the deformation was restrained by the addition of 10% pulp. For the sheet in the diameter of 10cm, the complete restraint was attained by 20% addition. The AC sheet activated for 2 h had similar iodine and methylene blue adsorption capacities to commercial AC powder and granules, although the specific surface area of AC sheet was smaller than commercial ones. This adsorption property was suggested to result from large internal surface area that involved the adsorption directly. The AC sheet had more rapid adsorption rate to p-chlorophenol in addition to methylene blue than the AC granule. Moreover, it also had methane adsorption capacity three times as large as the AC powder. Thus, AL based AC sheet could be utilized as an agent for environmental clarification in not only liquid phase but also gas phase.

In conclusion, thermoplastic AL was readily converted into AC moldings by thermal forming method followed by carbonization and activation. In particular, AL could be transformed into ACF because of fusible property. The resulting moldings had excellent adsorption property superior to and/or comparable to commercial AC powder and granules. Therefore, AL is a promising source for the production of AC moldings.

Wood Carbonization Products as Accumulators for Carbon and Energy

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The accumulation of greenhouse gases, forest devastation and environment-unfavourable backward technologies are the main problems being faced not only the forest industry but also the entire mankind. The use of energy dense fuels and carbonaceous materials produced from lignocellulosic biomass may improve the environment situation, will solve problems of transportation and favour a sustainable forestry.

Charcoal-making industry could be termed environmentally friendly if it would be energetically self-sufficient, ensure a low emission level, be neutral to the carbon cycle and cause no deforestation. The latter can be achieved by making use of dispersed wood residues and alternative raw materials of charcoal production. Partial combustion equipment of charcoal production is not environmentally friendly. Afterburners of charcoal kilns improve, to a certain extent, the situation of noxious emissions, but worsen the joint energy efficiency. We suppose that a technology employing 4-6 medium-size indirect heating retorts and a joint furnace, developed by the Latvian State Institute of Wood Chemistry, is an environmentally friendly solution for lump charcoal production from logging and saw milling wastes. The installation is an energetically self-sufficient one and uses piroligneous vapours as a fuel for production of heat carrier.

The same principle of energy self-sufficiency is employed in a two-stage pyrolysis system for pyrolysis of dispersed wood wastes (sawdust, crumbled wood, chips), developed by us. The two-stage pyrolysis reduces the overall construction costs, improves the charcoal quality and yield. Sawdust pyrolysis eliminates the problem of the leakage of contaminants from the wastes storage in landfills. The charcoal yield is up to 25-26% on the oven dry wood basis, and high-quality briquettes can be produced.

Carbonization of other types of dispersed lignocellulosic biomass (sugar-cane bagasse, straw) is more complicated due to a low bulk weight as well as high ash and moisture contents. Nevertheless, the use of the two-stage pyrolysis concept and the proposed methods of fine biomass charcoal processing enable to produce a high-energy density fuel (briquettes) and carbonaceous materials. The development of new carbon materials for industry and building materials for long-term application will give a possibility to stabilize or decrease the global warming because no real decrease in the use of fossil fuel is expected in the nearest future. More intensive research activities should be directed not only to increasing the efficiency with which energy from biomass can be obtained, but also to develop new materials for long-term use.

5.08.00 Production and utilization of bamboo and related species. Challenges for the new millenium

Effect of compound fertilizer and soil mounding on natural stand bamboos of *Gigantochloa scortechinii* in Peninsular Malaysia

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Gigantochloa scortechinii is one of the most important commercial species available in Malaysia. It is found growing profusely in the forest immediately after logging has taken place. This species is widely distributed throughout Peninsular Malaysia and its culm is mostly used in producing such as chopsticks, skewers, joss-sticks, baskets, blinds and handicraft's item. The raw material has been extracted from the forest without prior systematic management by the locals and the resources tends to deplete. Due to this reason, it is timely to have e proper silvicultural management of the culms. In addition, future value-added products such as lamination panels tend to play an important role as a substitute for the local timber supply. Owing to its importance, a trial study has been dona by FRIM to see the effect of compound fertilizer and soil mounding experiment at Nami, Kedah in Peninsular Malaysia. The experiment involved 20 treatments and four-fold replications (four compact group of 20 clumps each as a replicate). Each one of the 20 clumps within the replicate received a different combination of mounding level and fertilizer application. Parameters of numbers of shoots, diameter- breast height (Dbh) and height were monitored twice in October 1991 and August 1992 and the observations took on year to complete. Treatments such as fertilizer with rates of 0, 2, 4, 6, 8 kg including soil mounding levels of 0, 10, 20, 30 and 40 cm above ground were done once a year. Significant effects only showed for the first 3 months period after the treatments in comparison for a duration of one year.

The Pandanus, Mengkuang and Ribu-Ribu Weaving Industries in Malaysia: The Role of the Malaysian Handicraft Development Corporation

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This paper aims to highlight the role of Malaysia Handicraft Development Corporation in the developmental works related to the vegetables fibres weaving especially those of the non-timber forest-based materials of Pandanus, Mengkuang and Ribu-ribu. This is important since the institute plays an important role in development of the industry with the emphasis on product development, skill training and marketing. Product development entails the product diversification, new designs, patterns and new functions. In order to ensure the survival of the industry and the use of proper production techniques, young apprentices are trained at Handicraft Training Centres as well as at their working places. The woven products need to be sold to ensure that the craftsmen can earn a living. Therefore efficient marketing agencies are needed to tailor this objective. The setting up of marketing companies and Craft Cultural Complexes under the auspices of Malaysia Handicraft Corporation is expected to relieve the craftspeople from the extra burden of marketing on their own.

Product Development From Laminated Bamboo (Lamboo)

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Keywords: laminated bamboo - Lamboo, bamboo furniture, new product development

Bamboo utilization are gradually progressing from a traditional entities into a more machine intensive products. Its usage are however confined to inferior house hold items and other low recovery products that prevent it to mark its presence dominantly comparative to rattan. This inherent problem is not only associated to non-profitable ventures or labour intensive, but also due to in-competency in product management and quality control. Lack of in-depth R&D and product development partially contributed to this pathetic scenario while the abundant raw material are left idle and non productive.

Globally, the bamboo based industry is estimated to worth about RM 15 billion a year. While Taiwan's bamboo industry contributed about RM 650 million a year, Malaysia exports a meagre RM 1 million (US$265,000 at RM3.80 per US$1.00) in 1997. There are 287,000 ha of natural stand bamboo available in Peninsular Malaysia capable of supplying about 250,000 tonnes of raw material annually.

The federal and state government gives full support in promoting bamboo industry by allocating sufficient funds and land area for plantation. Of late, with mechanization and proper industrialization, bamboo usage are slowly experiencing changes transforming into more elaborate and appealing products. Development in bamboo products in the form of laminated bamboo (Lamboo) into flooring, building panels and other house hold items has long been exploited locally and overseas. This paper aims to address the upper market such as furniture which would enable to provide higher return. It will address superficially on the production of Lamboo, from raw material preparation until laminating by jigging into laminated bamboo blocks.

The manufacturing of furniture from Lamboo provided new dimensions in product diversity and market potential. The production methodology is continuously being improve to increase its capacity and ensure continuous product quality. Already it has created interest from both local and international participants at the 1999 Malaysia International Furniture Fair when some prototypes was exhibited. Description on the various stages involved in the production will be illustrated and discussed in this paper. The problems encountered, its machining and lath properties, jointing and the finishing qualities will also be discussed.

Study on Establishment and Management Technology for Sympodial Bamboo Sub-branch Cuttings-Garden

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A trial has been laid out by using orthogonal design with 3 factors and 3 levels in three different locations in order to find out the proper establishment and management technologies in promoting sub-branches from adventitious buds and the best propagating materials in the field i.e. *Bambusa textilis* (Guangzhou city), *Dendrocalamopsis oldhami* (Nanping city) and (*B. multiplex*) in their cuttings-garden. The results indicated that the proper technology for establishing cuttings-garden could be achieved by 1). keeping the mother offset culm with 7 internodes, 2), damaging all buds on its culm base and, 3). applying MS nutrient solution with 6 BA+NAA of various concentrations for several times in accordance to the species, which can produce about 142500, 54000, 114000 sub-branches per ha each for *D. oldhami*, *B. textilis* and *B. multiplex* respectively. The sustainable management technology for *D. oldhami*, on the other hand could be done by 1). keeping 1 or 2 new culms during the latter-middle shooting stage, i.e. making the culm age structure of clump as 1-year old: 2-year old=2:1 or 1:1 and 2). chopping their top in next early spring and keeping the culms with 7-internodes height, which will give a sustainable amount of 120000 or 160500 sub-branches per ha in each year.

Processing and Utilization of Bamboo in Vietnam

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This paper basically highlights the scenario of bamboo processing and utilization activities in Vietnam, where bamboo grows widely, both in natural as well as in plantation forests and becomes an important alternative forest resource to timber. The total area covered by bamboo is about 1.5 million ha and extending to all over the provinces of Vietnam. The plant is valued for its versatility usage for the making of various products either targetted for domestic or export market. The

processing and utilization of this giant grass have been analysed mainly through application and technological aspects. The advantages and disadvantages of each technology were also assessed in order to facilitate future development of the processing and utilization sectors. The problems and constraints were also discussed. General concensus indicates that there is a need for the right orientation and clear yet synchronous plan by the government to foster development of this bamboo-based industries as well as to obtain the highest social, environmental and economical advantages to the communities.

Bamboo Composites - Material of the Future

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Bamboo is an important traditional resource on which around 2.5 billion people all over the world depend greatly for wide range of products and livelihood. Bamboos have more than 1000 documented uses. About one billion people live in bamboo houses. Bamboo, a tree like grass, represented by 1250 known species, is found in all regions of the world, tropical, sub-tropical and temperate except in Europe and West Africa. Bamboos account for approximately 25% and 20% of the total biomass respectively in the tropics and the sub-tropical areas. Bamboos have several unique advantages viz. (i) ability to rejuvenate degraded areas, (ii) grow well in plantation models in harmony with other species, and hence there is no need for monoculture, (iii) have short rotation cycle of 2-5 years, and (iv) as traditional resources bamboos are widely recognised by people and their products are easily and willingly accepted.

Panel composites made from bamboo have great potential as an alternate panel material with improved strength and other characteristics compared to other panel products made from some fast growing plantation timbers. Bamboo mat board (BMB) is important bamboo composite development at IPIRTI. Its use in place of plywood to the tune of about 25% in the country is expected to save about 8000 ha of natural forests while generating around 60 million workdays in mat making alone, in which economically weaker sections of the society are generally involved.

Additional positive aspects of bamboo based panel materials are: environmental friendly-reduction of pressure on forests through wood substitution; people friendly as uses traditional resources; enhances rural employment generation, participation of women and community development.

BMB technology development at IPIRTI has been found to be an exemplary demonstration of implementation of Agenda 21 by the International Selection Commission EXPO 2000 and has been recommended for registration at EXPO-2000 Hannover, Germany.

This paper discusses R&D work related to development of bamboo based composites being carried out at the Institute and its relevance for people oriented development programme.

Treatment of Round Bamboo

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In Malaysia, the use of round bamboo for high quality furniture production is increasing. The treatment of round bamboo using traditional techniques such as leaching in running water, smoking with fumes and dipping/soaking in chemical solution often do not offer the necessary long-term protection. This paper discusses the treatment of round bamboo using a specially designed machine based on the High Pressure Sap Displacement or "Boucherie" process. With the High Pressure Sap Displacement technique, preservative solution is forced under pressure through a "treatment cap" into one end of the freshly cut bamboo. The preservative solution displaces the sap from the bamboo and this is forced out from the open end at a rate dependent upon the applied pressure and length of bamboo. The treatment pressure can be set up to 4.2 kg cm^{-2} (60 psi). To ensure effective treatment of bamboo, it is important that the bamboo should be as fresh as possible. This is to minimize the blocking up of pit openings of the parenchyma cells as the sap being dried during the initial drying process and the possibility of air trapped in the vessels that inhibits the passage of the preservative solution during treatment. Results of CCA treatment on buluh minyak (*Bambusa vulgaris*) carried out using the machine indicated that a minimum penetration of 11.5 kg/m^3 could be achieved. This amount of preservative is sufficient to protect bamboo from either insect or fungal attacks, and provide an expected service life of more than 15 years.

Bamboo Industries in Malaysia: Challenges in The New Millenium

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The bamboo industry in Malaysia does not fall into the mainstream of prominent industries. However, its potential is tremendous. Worldwide, bamboo contributed USD 4 billion annually. The local market grossed a meager USD 3 -4 million per year and less than USD1 million is posted for export market. The bamboo in the wild survive without human management. The results are - dire shortage of supply of desired species, uneven aged material on harvest, all of which ultimately resulted in inferior use of materials and of final products quality. A managed bamboo plantation would spell a more systematic regimes for fertilization, thinning and harvesting. The bamboo industry models as a precursor to other innovations. As such, policy decisions should be taken to fulfill the required ends. The inventory work, growing efforts, and the industrial components - each has to be tackled with devote and vigor. The utilization of bamboo in various categories of uses are discussed. The categories include its use in construction, transport, medicine, arts and crafts, music and sports, tools and utensils, as decoration and for aid to fashion, protein and food resources, in religion and mystics. The challenges faced by the bamboo industries in Malaysia are also discussed. This paper also highlights some of the key strategies for future development of the said industries.

The Starch Content of two Malaysian Bamboos in Relation to Age, Culm Height, Site and Harvesting Month

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The variation in starch content of one-, two-, three- and four-year-old *Bambusa vulgaris* and Gigantochloa scortechinii collected from four experimental sites in Peninsular Malaysia at 12 consecutive harvesting months is reported. The starch content differs significantly with species, site, age, culm height and harvesting month. The starch content, regardless of site, harvesting month, age and height, varies from 2.9-7.4% and 0.35-10.1% in *G. scortechinii* and *B. vulgaris*, respectively. The highest and lowest starch content of the two bamboos occurred at the top than the basal portion, and in the older than the younger culm. With regards to seasonal changes, the starch content in each bamboo species tended to increase with decrease in monthly rainfall but increase with the increasing temperature at each site. The difference in starch content levels in both species between the driest and wettest month is relatively higher at the top than the basal portion, and in the older than the younger bamboo.

Soil Suitability for Bamboo Planting

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The growth and productivity of shoot and culm production of selected Malaysian bamboos in various experimental sites were carried out. From the experiment sites, it shows that sandy clay loam areas (Renggam series) is the best and followed by shallow laterіteic soil mixed with fine sandy clay (Jitra series) than those of the lateriteic soil (Terap series), bris soil (Jambu series) and tin tailings areas.

Propagation Study by Branch Cuttings of *Gigantochloa levis*

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Specific propagation study by branch cutting of *Gigantochloa levis* in the nursery showed that there is no different in percentage of survival either on nursery beds or polybags used. Cuttings prepared on nursery beds yielded better growth rate in term of root length, culm/shoot and rhizome production and leaves. The use of hormone IBA 2000 Powder was also observed to promote the growth of cuttings as compared to other IBA hormone treatments. The planting of *G. levis* in the field showed that the polybag branch cuttings gave the highest survival percentage (92.6%) than those of the bare root planting (50.9%) and the newly branch cutting planting (30.6%).

Comparative Efficacy of Bamboo Treated With Boron Compound By Dipping and High Pressure Sap-Displacement Processes

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A lot has been said about the effectiveness of high pressure sap-displacement technique in treating round green bamboo. This paper evaluated the effectiveness of this technique by comparing it to that of the dipping process. Evaluation through accelerated 8 weeks laboratory fungal tests shows that the dipping process gives better protection to the treated bamboo. The percentage of fungal attacked on the treated bamboo samples through the dipping were found to be far less when compare to those treated by the high pressure sap-displacement process. This was further supported by the under shed insect exposure study.

Study on Associated Nitrogen-Fixation of Bamboo Plants Rhizosphere

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It was proved that the Gramineae plants have the character of associated nitrogen fixation with some azotobacter. Bamboo plants belong to the Gramineae, which is important forest resource with numerous species in China even in the world. Their associated nitrogen fixation characteristics or any resemblance with other Graminae crops, however, have not been well reported. Some studies have been conducted by us on this field since 1994.

In this paper five bamboo species [*Phyllostachy hetercycla var. pubescens* (Mazel) Ohwi, *Phyllostachy meyeri* McClure, *Dendrocalamopsis latiflorus* Munro, *Dendrocalamopsis beecheyana* (Munro) keng f, *Bambusa textilis* McClure] have been investigated and determined at many sites with a number of samples on nitrogen fixing activity of roots by acetylene reduction method. It was shown that the acetylene reduction activities of bamboo plants, in general, are higher than other Gramineae crops. Meanwhile the sympodial bamboos' are higher than the monopodial bamboos'. The maximum nitrogen fixing activity of sympodial bamboo root can reach to 921.5 nmolC_2H_4.$h^{-1}g^{-1}$ of fresh root determined by enrichment culture method; 24.5 nmolC_2H_4.$h^{-1}g^{-1}$ of dry root determined by direct determination technique. Counting (MPN method--most probable number) and isolating to azotobacter from bamboo plants rhizosphere, it was found that there were a lot of azotobacteria in bamboo rhizosphere. Generally, the numbers of azotobacteria for the sympodial bamboos could be more than 108 cells g-1 of dry roots in root surface, over 108 cells g-1 of dry roots in root inner, over 109 cells g-1 of dry soil in rhizosphere soil. So far, 11 and 17 azotobacter strains have been isolated from the sympodial and the monopodial bamboo rhizosphere respectively. Identification of azotobacteria isolated from *P. pubescens* and *P. meyeri rhizosphere* has also been conducted. The results revealed that there are a lot of *bacillus azotobacteria* in *P. pubescens* rhizosphere, which mainly belong to *Bacillus polymyxa* and *B. licheniformis*. In *P. meyeri's* rhizosphere, the azotobacter was identified as *Klebsiella pneumoniae* (Schroeter) Trevisan. So far, eight strains with quite high nitrogen fixing activity have been sifted. Using those strains to inoculate moso (*P. Pubescens*) bamboo seedlings, it is shown that the seedlings' growth can be promoted. The effect of inoculating four strains (GW-2, GW-12, GW-14, G-7) was observed to reach the significant or the remarkable significant levels in seedling height, plant bio-mass and plant total nitrogen content than that of CK. The roots growth, the fresh root bio-mass per plant was also found to increased from 44.1% to 76.9%, because the lateral roots are increased significantly and the roots look stronger than CK group. Through this research it is verified that bamboo plants, being a big member of Gramineae have the character of associated nitrogen fixation like other Gramineae crops. This research brings us a hope to resolve bamboo’s nitrogen supply finally by biological nitrogen fixing and lays a foundation for further studies.

Structure of Bamboo-Based Reconstituted Panel Composite in View of the Characteristics and Properties of Raw Bamboo

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Based on the results from the studying of the biological characteristics and properties including the texture, main physical and mechanical properties and chemical composition of the four typical thick-growing woody bamboos (*Dendrocalamus giganteus*, *D. brandisii*, *D.*

membranaceus and *Bambusa lapidea*) in Yunnan of China, this paper suggested that both the proper structure and quality of the bamboo-based panel composites and the appropriate dimension, structure, and property of the unit to compose the panels, i.e. bamboo-based veneer, particle or fiber, should be designed and got, in view of the influence originating from the special characteristics and properties of the raw bamboo, such as the hollow structure of the culm with the knot, the green skin outside and the yellow covering inside but without any ray, the high content of extractives and the difference of the wall thickness, the texture and the physical and mechanical properties from the species and the position on the culm, to ensure the most reasonable cost and economic benefits for the industrial production of the panels. As structural panel materials for engineering, various bamboo-based laminated veneer plywoods possess the merits of very high strength and elasticity. However, the strict requiring of the wall thickness which limited from the species and the part of the bamboo culm, the low coverage of the raw bamboo and the uneven structure, surface and properties of the panels are their deficiencies. Compared with this, despite of lower strength and elasticity, bamboo-based particleboard and fiberboard own the advantages of accepting various species and almost all part of the culm, no matter how thin the wall is, the high coverage of the raw bamboo and the even structure, surface and properties of the panels. As compensation with each other, it is suggested that the best way to reduce the cost of raw bamboo to ensure the economic benefit is to combine the production of laminated veneer plywood with bamboo-based particleboard or fiberboard. Bamboo-based waferboard is an excellent reconstituted structural panel composite because of its reasonable structure, stable properties and low cost. It has got both high strength and elasticity like bamboo-based laminated veneer plywood and the wide acceptance of the species and the part of culm of bamboo as its raw material with a high coverage up to 92% like bamboo-based particleboard or fiberboard.

Keywords: bamboo, characteristics and properties, bamboo-based plywood, bamboo-based particleboard, bamboo-based fiberboard, bamboo-based waferboard

5.10.00 Forest products marketing

An investigation of the roles of household individuals on the furniture consumers behavior

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Keywords: furniture, consumer behavior, demographic group.

One of the most significant factors affecting the process of consumers' behavior for furniture purchasing is influence of the individuals of the household. The members of each household have important roles on the purchasing decision. In general furniture purchases can be termed as postponable compared to other higher priorities on expenditure for clothing, shelter and transportation. Therefore disposable personal income and, more importantly, discretionary purchasing power have a significant influence on the demand for furniture. The effect of family on the purchasing behavior can be analyzed based on several factors, namely the number of the family member, the level of income level, population characteristics, and living in a small town or metropolitan area.

In this study, furniture purchasing process from the producers and consumers viewpoint was analyzed within the scope of above factors. It was determined that producers that consider effect of members of household for the purchasing process were more successful and effective in their overall production management including advertising and budgeting. Study also evaluated various parameters including age and income level, related to consumers behavior which are responsible for furniture manufacture. A significant relationship was found between income level, demographic group and furniture purchasing decision based on the variance analysis at 95% confidence level. Consumers behavior as function of different age groups of household individuals were also analyzed and it was determined that persons in the 30-40 age group purchase more furniture than any other age category. However, the data showed that furniture demand is influenced as the age distribution changes over the time. Finally, suggestions related consumers behavior for the future market analysis and production management for the furniture industry.

A Marketing Approach Applied to the Wooded Sector of Rio Branco, State of Acre-Brazil, 1995

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Although the State of Acre (located in western Amazon-Brazil) has 93% of its area covered by original forest, its forest sector has faced a stagnation of even reduction in timber operations. It is also important to note that the studies on Amazonian forest sector, some approached the economy in this region, but did not detail the State of Acre, other researches analyzed the Acrean forest sector, however did not focus commercialization points of wooden products from Rio Branco City (Capital of State of Acre) or even just studied technically the local wooden industrialization. Thus, marketing proceedings adopted by the local timber sector was not studied yet. Due to these facts, this study will be important in order to give support to marketing strategies for commercialization of wooden products coming from this region. The study was carried out in 1995 with the objective of analyze marketing procedures adopted by the timber sector in this region.

The study covered 39 sawmills, 43 furniture manufacturers and 16 retails lumber yards located in the Rio Branco. The main aspects considered in the analysis were: (1) pricing strategies; (2) promotional mix and (3) target markets.

The main results obtained from this studies were: (1) wooden sector of Rio Branco, during 1995, consumed 143,262 m^3 of wood in log and the total retail segment, in turn, sold 4,800 m^3 of timber; (2) in 1995, about 89% of sawmills consumed cumaru ferro species, 67% used cerejeira species and 58% processed cedar species while among furniture manufacturers, cedar and cerejeira species were used in 83.7% and 97.7% of these industries, respectively; (3) for 41% of sawmills and 31% of the local retails, the market price of timber was priced in function of a price-list set by Timber Enterprises Syndicate of Rio Branco enterprises, while 27% of furniture manufacturers fixed their prices considering its production costs; (4) the local, national and international markets consumed, respectively, 46%, 29% and 25% of production from Rio Branco's sawmills in 1995; (5) the most of furniture manufacturers sold to Rio Branco market and. the retail, in turn, sold to small consumers as well as to building enterprises, both located in this city (it was small the sale to external consumer in this segment); (6) 53% of sawmills sold with a cash descont, 65% supplied freight of the product and 18% considered that such actions could arise a negative profit; (7) 18% of sawmills, 27% of furniture manufacturers and 38% of retails divulged their products by radio and television (such procedures could increase the sale to 10%, as these sale is compared to sale without such strategies); (8) 77% of the furniture manufacturers supplied a home delivery (this procedure include an assembling process supplied by the furniture industry), while 68%, depend on the sale value, sold a cash discount and 18% warranted the quality of its product or substitute it in case of defects.

Miombo Woodland Utilisation by Small-scale Farmers in Handeni / Tanzania: Strategies for Income Generation as an Incentive for Woodland Preservation

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(i) Problem addressed:
Within African dry lands the increasing displacement of Miombo woodlands is a special problem. The yield of traditional management of these ecosystems (frequent burning and shifting) is not longer sufficient to cover the needs for food supply and cash crop of the growing rural population.

(ii) Research question/hypothesis
The study is based on the controversial assumption that comprehensive woodland management with agroforestry systems, including timber as well as non timber products utilisation, will positively influence the economic and social situation of the population, and thereby contribute to a higher valuation of these resources by the inhabitants themselves. The know-how about the multiple use of Miombo woodlands is a basis for further development of properly resource utilisation systems. These systems should not only guarantee the capability of the woodlands to fulfil the subsistence needs of local household, but also an ability to generate income through marketing of products from the woodlands.

A consequently integrated management according to agroforestry systems while considering timber and non timber products of trees and shrubs should influence the economic and social situation of people in this area to more positive conditions. Non wood forest products (NWFP) which, on the one hand contribute to the subsistence of single families, on the other hand can be marketed and build up a source of income, should rise up the prestige of that forest type or at least for single tree species in the awareness of the users.

(iii) Objective of research
Based on these presumptions the main objective of a study in Handeni District, North Eastern Tanzania was to improve a better understanding about the situation of Miombo utilisation in the research area through descriptive analyses. Derived objective was to describe the potential development of the region in case of fulfilment the subsistence needs, income generating, and ergonomic aspects such as labour organisation and qualification.

The investigation was focused on the inhabitants of four villages from two different ecological zones of the Miombo woodlands. Information related to the utilisation of forest-resources, especially the potential use of NTFP, based on the knowledge and experiences of local people and the local experts, was collected through individual interviews and group discussions as well as field observations and key interviews within and outside the research area.

Most of the people in these villages belong to the Zigua- and Nguu-tribes. Both tribes basically depend on small scale agriculture. Moreover, Maasai – a semi-nomadic cattle rearing tribe -live in this area at times. They depend on milk and other cattle products. Because life style and diet of Zigua / Nguu are basically different from that of Maasai, different knowledge about useful NTFP on Miombo woodlands was to be expected.

(iv) Methodology and workplan
To get access to the traditional knowledge about woodland utilisation, tools of PRA were used to record the actually used NWFP and also the way of harvesting and use of these products, their contribution to subsistence and their economic means.

The following research steps lead to the main objective:
1. Assessment of the role of forest utilisation in general, and especially of the role of non wood products, for the predominantly agrarian subsistence livelihood.
2. Identification of the present role of selected non wood forest products (NTFP) of Miombo woodlands, taking into account ecological, economical and socio-cultural aspects of land use.
3. Description and evaluation of the possibilities and constraints of diversification of the product range, and an increase in the direct utilisation of trees and shrubs of Miombo woodlands for the people, based on the carrying capacity of the ecosystem.

(v) Results and conclusions and their relevance for development
All three tribes consider woodlands first of all as a resource for agriculture and cattle grazing. Honey, mushrooms, other wild foods and barks were identified as most promising NWFP in the region for subsistence households and income generation.

In the research area the marketing of woodland products, also of NWFP, fundamentally can be considered as an incentive for the conservation of the woodlands. But today the marketing of forest products is already problematic, expanding the markets would become even more risky because of uncertain conditions of delivery and purchasing.

The acceptance levels for accelerating propagation of utilisation and marketing of NWFP vary between and within communities. For subsistence economies a strengthened use of NWFP can be recommended in each case, except for bark splitting. On the contrary, strengthening commercialisation is only with caution recommended because of the high risks. An establishment of collaborative processing and marketing can favour the marketing possibilities of all product samples.

Key word: Miombo, NWFP/NTFP, Social Forestry; Zigua, Nguu, Maasai

Product Oriented Wood Research Improves Market Chances For Small Scots Pine Logs

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Keywords: western larch, *Larix occindentalis*, specific gravity, stand density, x-ray densitometry

Western larch (*Larix occindentalis* Nutt.) is one of three native Larix species in North America, besides subalpine larch (*Larix lyallii* Parl.) and tamarack (*Larix laricina*(Du Roi) K. Koch). Western Larch occurs mainly throughout the Upper Columbia River basin of southeastern British Columbia, northwestern Montana and northern Idaho. It easily reaches 50m in total height. High wood density and strength usually characterize its wood. Throughout most of western larch's natural range, existing stands originated from natural regeneration following wildfires, and are often overstocked. Therefore, early reductions of stand densities by precommercial thinning became an important management tool to establish stabilized stands and to concentrate stand growth potential on fewer vigorous, well-formed trees. This process of maximizing total stand value rather than maximizing yield can be completed by later commercial thinning and artificial pruning. The intent of this study, carried out by Forintek Canada Corp., was to provide basic information on the relationship between tree spacing and the two major wood quality parameters wood density and branch size to support stand management decisions. From young western larch experimental stands in northwest Montana, 618 sample trees were chosen representing different stocking levels ranging form 270 to 4300 trees/ha. From two pith-to-bark cores, taken at breast height for each tree, density profiles were obtained using Forintek's x-ray densitometer. We also measured the largest branch diameters below 4 m stem height. The sample trees showed a strong relationship between width of spacing and tree height and diameter breast height. As expected, trees in the widest spaced plots grew the fastest. Despite large differences in diameter growth, no significant differences in average wood density occurred between spacings. A second moderate thinning on the best sites clearly showed that enhancing the wood density of western larch is possible. For the most valuable part of the tree, the branch sizes do not exceed 20mm even when a wide spacing as 4.6 by 4.6 m is applied. High wood density levels and reasonable knot size confirm that western larch from sustained managed stands remains a valuable tree species in future markets.

5.11.00 Non- wood forest products

Germination Requirements of *Calamus subinermis*, an Important Rattan Species in Sabah, Malaysia

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Calamus subinermis (rotan batu), a rattan endemic to Sabah, Malaysia, is commonly used in the furniture industry. The species are commonly found along the coast of Sabah from Labuan up to Tawau. Seeds are procured for the germination study from Ulu Sugud in Sandakan and Luasong in Tawau, Sabah. The seeds are placed under different light intensity and watering regimes to look into the possibility to enhance the germination of the species. The species is known to have staggered germination ranging from three weeks to about one and half years. This paper highlights and discusses the results.

Improving The Strength and Stiffness Of Joints In Rattan Furniture-An Overview

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This paper gives an overview on the research and development aspects of improving rattan furniture jointing system to enhance the in-service performance of the joints. It describes some faults found in the current practices of jointing rattan furniture components that weaken the joints based on the author's observation and previous research results supported by mathematical models on the strength and stiffness characteristics of the joints. Using the knowledge, methods for improving the jointing system are suggested and some relevant works by the author are disclosed.

Utilisation of Eucalypt Oils for Sustainable Weed Management

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Trees - the dominant components of forest ecosystems are known for their longevity and can thus provide a number of goods and services to society. Rapid population growth coupled with the needs of changing society has further increased the dependence of man on non wood forest products like resins, cork, mushrooms, food and oils. The oils extracted from the forest trees like the *Eucalyptus* and *Pinus* species are mainly used in perfumery or medicinal purposes. However, in the present study, their exploitation for managing the noxious weeds was explored. Volatile oils comprising mainly of terpenes were extracted from leaves of eucalypt trees by steam distillation and purified. Of these, cineole and citronellol were used in the present study. The oils were demoistened before use. Under simulated conditions, different concentrations of these oil were vaporised in the environmental chambers. The seeds of noxious weeds like *Parthenium hysterophorus* and *Ageratum conyzoides* collected locally were subjected to germination in these chambers. A parallel control was also maintained in which the environmental chambers were without oil vapours. The study reveals that oils (both crude as well as purified forms) inhibited the germination, initial growth and subsequent development of the weeds. Further, in the fiels conditions, the effect of oils was also assessed on the growth of one month old plants of these weeds. The total chlorophyll content and cell survival values reflecting the respiratory metabolism were significantly less in treated plants compared to that of control. The treated plants also wilted after 20 days. However, the inhibitory effect was observed more on germination, which is a crucial factor in the proliferation of weeds and hence can be utilised to suppress the germination of weed seeds. Though in the present study the oils were used in vapour state but they can easily be mixed with water with the help of surfactants and can, thus, be applied in a simplified way. The present study is particularly important in the modern times when the efforts are being made world over to explore alternatives of synthetic herbicides which are posing a threat to mere existence of human beings by polluting the environment. The plant products on the other hand are not only bio-degradable but possess a number of other eco-friendly properties such as easy applicability, longer shelf life, cost effectiveness, easy storage methods etc. and can be safely used for the management of noxious weeds and pests.

A Method for Comparative Analysis of Non-Timber Forest Products Cases: A Test with Cases from Indonesia

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Non-timber forest products have been targeted as key entry points for both development and conservation initiatives. Significant investments have been made in a variety of project interventions, and new attention is being given to policy options to encourage NTFPs development. And yet, understanding of the true role and potential of NTFPs to contribute to development or conservation, based as it is on scattered and inconsistent case-based research, remains limited.

This work is part of an ongoing effort to develop and refine a methodology and to undertake comparative analyses of cases. The overall aim is to develop an analytical framework that will facilitate systematic NTFP policy and management decisions. This paper describes the rationale, the approach, and the results and conclusions of the first stages of the work.

The method was designed to help to find patterns among divergent cases, to develop classes of cases, to identify those variables that are most useful for classification, and to analyze the relationships between different classes of case and observed development outcomes. In this study a set of 12 studies of NTFP cases from Indonesia was organized, with each case described using a standard set of descriptors. The products included benzoin resin, gaharu (incense wood), damar (resin), bamboo, tengkawang (nuts), wild gathered and cultivated rattan, wild honey collecting, butterfly ranching and farming, palm sugar, and sandalwood (fragrant wood). The cases were selected to represent a range of kinds of products (animals, plants, plant products), of production systems (from pure extractive to cultivated) and market systems (from local markets to export markets). The variables were organized into several categories, describing different aspects of the production-to-consumption system, including:

- Geographic setting
- Production system and ecological implications
- Socio-economic characteristics
- Policy aspects
- Institutional aspects
- Characteristics of the processing industry
- Characteristics of the trade and marketing system
- Type and focus of external interventions

Expert judgement was used to assign ranks to each case, on a variable-by-variable basis. Cases were compared using these data in: 1) non-linear principal components analysis to identify key variables that account for dissimilarity between cases; and 2) cluster analysis, to classify and group similar cases.

Several interesting classes of case were identified, based on characteristics such as remoteness, management intensity, the role of the product in livelihood strategies, level and kind of state intervention, degree and kind of processing required, characteristics of trade and marketing, and degree of external intervention

This trial confirmed the feasibility and the utility of the method, and helped to identify areas for improvement. Some problems were encountered with the definition of variables. Important limitations were experienced due to use of mainly qualitative data and rank-ordering. Personal knowledge and expertise about the case by collaborators was found to be very important, at least during the methodology development phase. Work is still needed to facilitate linking development and conservation outcomes with case characteristics. These lessons have been taken into account in the design of a new international comparative analysis.

Growth, Money Flows and Income Distribution of the Brazil Nut Industry in the Bolivian Amazon

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This poster analysis the money circulation in the Brazil nut economy in northern Bolivia. It first analysis the functioning of the entire harvesting production selling cycle. Supply of raw material stems from concessions or barracas and from independent communities. Brazil nuts are processed in factories or beneficiadoras. Additionally these have their own commercialisation and marketing channels. In this entire industry there are a number of quite different actors, including collectors, intermediary contract holders, concession owners, independent communities, factory owners, Brazil nut crackers, deposit owners and transporting agents. Each has a different role, set of activities. In addition there are non-direct stakeholders like the suppliers of equipment and other input, the state, brokers and consumers.

This poster will indicate the detailed cash flow between stakeholders. How much money is transferred, and where does it go. What are the expenditures of the stakeholders. Importantly linkages will be established between several industry and non-industry agents like food stores, banks, money lenders, transportation agents, and inputs suppliers. This analysis allows to calculate the share that different actors capture, as well as to calculate the accumulation along the chain, capital formation, savings and reinvestments.

The Importance of Forest Product Commercialisation to Rural Households: The Case of Craft Markets in Chivi Communal Area, Zimbabwe

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Since Zimbabwe's independence in 1980 the tourism sector has evolved into one of the most important sectors of the national economy. Along with the rise of tourism, an increase of craft markets offering forest based products as curios was observed. At the end of the eighties not more than twenty craft markets existed along the major roads of the country, compared to over two hundred in 1998. The markets are mainly located in the communal lands. Decline in the productive capacity of agriculture, the rising number of unemployed people in communal areas and the expansion of the tourist industry, are factors likely to attract even more people into the craft industry. Previous studies on the craft industry revealed the dominance of wooden items. The rapid growth of the craft industry and the discriminate use of local trees has raised concern on environmental degradation from governmental institutions and environmental groups. At present the existing legislation regulating the use of natural resources in communal areas prohibits the harvesting of tree species used by the craft industry, but no serious action has been taken to either prohibit or promote the growing sector. A general hesitation whether to advance or hinder the craft industry is prevailing.

The uncontrolled growth of the craft industry in Zimbabwe and the discriminate use of natural resources for material supply needs organisation. Decisions on how to go about with growing social and environmental problems are necessary, if the craft industry in Zimbabwe is to grow sustainable. Government institutions, policy makers, craft traders, researchers and development workers are equally concerned about the future of the trade. However, significant data is missing for further elaboration of possible guidelines or recommendations. The number of people involved in the craft industry is unknown. There is no data on the economic importance of the craft trade at village and ward level and no information to what extent the craft industry contributes to household income. Whether the income is beneficial to the poor and thus could signify a potential sector where development efforts could assist in alleviating economic hardships, needs identification. Of primary importance is also the lack of information on environmental impacts.

Social and environmental impacts originating from an expanding craft industry has raised attention in many sectors of society in Zimbabwe. Though general concern has been expressed, significant data for further elaboration of possible guidelines or recommendations on the future of the craft industry is lacking. The data underlying this investigation were collected during 1997 and 1998. Participatory rural appraisal (PRA) tools were used in group meetings, formal household questionnaires were administered, and semi-structured and open-ended interviews took place with groups and individuals. Emphasis was laid on participatory and direct observation at craft markets and in households. This poster examines the value of the craft industry for rural livelihoods in southern Zimbabwe. Households involved in the production of craft items are compared with households that are not, and cash income earned from the sale of craft items is set into context with cash income earned from non-craft based activities (other forest based products, farm produce, labour and remittances). This, in order to identify socio-economic differences and the proportion the craft trade contributes to household income. The paper also establishes whether the distance from the craft market location and the actual homestead has influence on participants level of income and whether the number of households participating in the craft industry diminishes with distance away from the vending locations.

Identification of Morphological Parameters for Catechin Content in *Acacia Catechu* Willd

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Key Words: *Acacia catechu*, Catechin, Morphical traits, Chi- square and Selection index

Acacia catechu is one of the commercial timber of India and Myanmar. It is mainly used for Katha (Catechin) and cutch extraction and is subsidiary source of income for rural poor, vital for quality of life. The economic importance of catechin is digestive, abortive, expectorant, aphrodiastic and cooling agent. It increases milk secretion in the cattle, useful in cough, diarrhoea dysentery, and sore throat and externally in the preparation of ointment for local application. There is great variation for catechin content among trees in the same stand and, therefore, needs some physical parameters for its identification.

The present study was conducted to determine correlation between morphological traits and catechin content and to develop a selection index to identify main traits responsible for higher catechin production, which may help in selecting the superior trees for raising improved plantations.

Three sites in two forest divisions in the state of HP were selected for the study and named as S1 (Jandhuta), S2(Subathu) andS3(Nauni). In each site four different plots of 30x30m were laid out and numbered as P1,P2, P3and P4.Within each plot 20% of the trees were randomly selected and marked asT1,T2, T3---Tn with yellow paint at dbh for identification and recording of data. Tree characters viz; tree height, dbh, crown width, no.of primary branches, stem pattern (straight, crooked, forked and lean), fruiting status (heavy, medium and poor) , leaf area, pod size, no. of seeds per pod, 100-seed weight and specific gravity were recorded and analysed. Soil chemical analysis was done for pH, EC, avalable N, P and K. Approximately 200-250 g of heart wood chips were collected from the standing trees at a height of 30 cm above ground level of the bole by making an opening of 5x5cm. Catechin was extracted from each sample as suggested by Rao and Mishra (1983). Carl Pearson's correlation and chi-square test were performed to find out the existence of association between morphological traits and catechin content, stem pattern (straight, crooked, forked and lean) and catechin content (high or low) and between fruiting status (poor, medium and heavy)and catechin content. Subsequently, selection index was developed based on Fisher (1936).

The study revealed that S2 (Subathu) possessed high catechin producing trees and S3 (Nauni) the lowest. Southern and western aspect yielded more catechin as compared to northern and eastern. Significant variation was observed for all morphological and reproductive traits at three sites. Height, dbh, crown width, pod width, leaf area and specific gravity gave positive and significant association with catechin content but non-significant association with distance from adjacent trees, no. of aborted seeds/pod and 100-seed weight. Catechin content revealed positive but non significant correlation with soil pH, EC, P and K; negative and non significant with N.

Chi- square analysis revealed that leaned and forked trees produced maximum catechin content.

In general, high catechin producing trees were found poor in fruiting quality. Height, dbh, crown width, leaf area, pod width and specific gravity of a tree showed positive and significant correlation with high catechin content. Selection index gave information on proportionate weightage of dbh, number of primary branches, pod width and specific gravity for high catechin content possessing *Acacia catechu* trees.

The Sustainable Utilization of Insect Resources

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Insect is an important component in forest ecological system. In forest ecological system, many insects feed on plants and affect growth and development of plants. Meanwhile, insects can be used as edible insects, medical insects, natural enemy and pollination medium. So insect is a kind of valuable resources. Insect and insect products are very important resources for chemical and other industry materials, protein, natural medicine and others.

Insect usually is prevented and eliminated as pest. In fact, the resource value of many insects is much higher than the damage of insect. Some insects can be used as natural enemy and control other pest population. Some insects can be cultured and utilized, such as lac insect, white wax scale, kermes insect, Chinese gallnut insect, silkworm, bee and others. The utilization for these insects can develop to a new kind of industry. In utilization of forest resources, people mainly use wood and ignore other resources, especially insect resources.

The cultivation and utilization of insect resources have close relation with forestry. The core of insect industry is that insects grow and develop in coordination with host plants. In order to develop insect resources industry, the first thing to do is to culture host plant and afforest. Afforestation can promote to green barren hill and have good ecological benefit. Meanwhile, on the foundation of ensuring normal growth and development of host plants, the obtainment of insect products will produce economical benefit. In this paper, from point of insect resources development and utilization, it is discussed that relationship of insect industry and sustainable development of forestry, combining with forestry, agro-forestry, economic development of mountain areas and environment protection.

Keywords: utilization of insect resources, eco-forest construction, agro-forestry, sustainable development

Consumption and Marketing of Wild Vegetables

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Wild vegetables and flavours from the forest are of major importance to local communities in Borneo as supplier of food and cash income. This study is based on 1) ethnobotanical collection and identification of wild vegetables in an Iban and a Kelabit community of Sarawak, Malaysia; 2) food diaries by eight households in the same communities keeping a daily record of all ingredients in their food during one year; and 3) weekly market surveys of vegetable prices and quantities during one year in five urban centres of Sarawak.

In both communities, a total of 218 wild vegetables are used compared to 87 cultivated species. Wild vegetables are as frequently consumed as cultivated species, notably various ferns and palm shoots which represent about 10% of all vegetable intake. The main reason for this given by the communities is the high labour requirements for vegetable cultivation. The frequently consumed wild vegetables are often common in secondary forest, but a number of minor species are only found in old secondary forest and climax forest. These are likely to disappear if their habitats are degraded, and domestication or habitat protection may therefore be necessary if consumption is to be maintained.

Wild vegetables are very popular in urban markets and prices are comparable to cultivated products. The interest is partly sparked by concern over high pesticide residues in cultivated vegetables, but taste, flavour and tradition also play a significant role. Some of the most popular products are fern fronds, palm shoots, various products of Zingiberaceaes, and leaves of Gnetum gnemon which all fetch good prices. A large number of vegetable species consumed in the villages are not marketed, but may potentially be valuable cash crops if introduced to urban populations. An overall seasonal variation in supply is not seen for most products but periods of heavy rain appear to reduce harvest intensity and marketing. Further research on nutritional composition and domestication of wild vegetables is strongly recommended, both regarding popular species that

are already consumed and marketed extensively and minor species that are likely to disappear.

Domestication and Improvement of Jujube tree *(Zizyphus mauritiana*) - State of Art in Senegal

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Forests have always been instrumental in guaranteeing the dietary security of African populations. Exploitation of forest fruit-trees has traditionally been based on the gathering of wild fruit. In the long run, this has led to the erosion of genetic resources, worsened by the recurring periods of drought that affect the Sahelian zone, hence the need to protect, safeguard and increase the worth of these species. That is the reason why the CIRAD and the ISRA started a program of improvement and domestication of the most important species, with the threefold view of taking part in the dietary security of populations, increasing their yields and protecting the genetic resources that are sometimes endangered because of overexploitation. Research focused most particularly on *Zizyphus mauritania* Lam., the jujube tree, which is one of the most widespread forest fruit-trees in dry areas.

The general problematic that was developed in Senegal follows two complementary routes. The first one consists in setting up a program of selection and improvement of the local jujube based on fruit characteristics (fruit size, sugar content, taste, earliness). The second option aims at transferring and adapting the improved varieties that have been produced and spread in India. This paper reviews the work currently going on in Senegal. It describes the knowledge gained, the experiments under way and the perspectives of research and development constituting the items of a technological package that will, in fine, make it possible to turn the jujube from a wild tree into an orchard tree.

In order to reach this goal, several lines of research are at present developed in Senegal.

- The improvement of local jujube trees started with individual selections that were made in different natural or artificial plantings in Senegal between 1988 and 1997. Thirty progenies were singled out and submitted to comparative testing in the Bandia station in 1996. Most trees bore fruit right from the first year plantation. The assessment under way will lead to the selection of the best plants that will make up the basis of a new cycle of recurrent selection.

- Tests on the introduction of Asian jujube trees have been carried out over the last three years. These tests focus on the India-originating Gola variety whose fruit volume is multiplied more than 20 times in comparison with the local jujube. The plants that were introduced (grafted onto a rootstock belonging to an Indian species, *Z. rotundifolia*) appear to have adapted well to the edapho-climatic conditions of Senegal.

- -Studies of horticultural and *in vitro* vegetative multiplication methods have been made. The jujube can be propagated through grafting, but the Indian method is not readily usable in Senegal and adaptations are required (these are the object of current work). Research on the micrografting of *Z. mauritania* has enabled us to develop an original and efficient technique for the micropropagation of selected adult trees.

- Studies of floral biology have enabled us to define a methodology for the controlled cross-breeding of jujube trees, which is an important tool within the framework of the improvement programme.

- Individual management of trees, in particular the development of pruning systems (date, intensity) enabling better fruit yield, has been given full consideration. The first assessments of pruning tests based on the Indian model are currently being made. Manuring and irrigation tests are scheduled to take place in 1999.

- Inoculation of mycorhizal fungi (such as *Glomus aggregatum*) which allow natural phosphates to act more efficiently, has shown that mycorhized jujube trees make better use of the phosphorus lying in the ground than non-mycorhized jujube trees. The impact on fruit yield is being appraised.

Methods to fight pests, such as the setting of traps aimed at mature pests, the use of food lures or repellents made from the essential oils of plants will be developed in 1999. Special attention will be paid to fruit flies (the determination of these insects is under way) as these pests put a curb on the development of improved species because of the important damage they are responsible for.

Beyond technical and scientific aspects, however, the fundamental issue to be addressed is whether these new products are likely to be accepted by the population. Will local jujube trees, even after they have been selected and improved, be attractive enough for farmers to regard them as orchard trees? Will Indian jujubes meet the tastes of African populations? Although the initial response seems to be positive, many points will have to be ascertained before it is possible to consider the jujube as a domestic species in Africa.

Improvement in Tapping of Philippine Canarium Trees for *Manila Elemi*

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Trees of the genus *Canarium* growing naturally in the Philippines were experimentally tapped for resin. Four tapping lengths (10, 15, 25 and 35 cm) and four levels of aqueous sulfuric acid treatment (0, 15, 30 and 45%) were teased of effects on resin yield of 32 trees. The influence of rainfall on resin yield was studied over a 12-month tapping period. Resin yields differed among the tapping length within six months, the 15-cm length gave the highest yield. No significant difference in resin yield was noted among the acid concentrations. The interaction between tapping length and acid concentration was not statistically trees. A workable method of tapping *Canarium* species was developed.

Plant Gums and Resins: An Alternative Potential Source of Income for the Pastoralist Communities of the Dryland Kenya

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Drylands account for about 80% of Kenya's land surface. The people living in the drylands are mainly nomadic pastoralists, deriving their livelihood from keeping livestock, and practicing a form of land use that involves seasonal movement of both people and animals in search of pasture and water.

Increasing human and livestock population coupled with annual fires and droughts has resulted in degradation of the vegetation in the drylands. This has greatly affected the pastoralist's socio-economy with serious loss of animals. With fewer or no other options of alternative resources for supporting livelihood of the local communities, drylands have become famine-prone and aid dependency zones.

However livestock production is only but one source of livelihood that drylands of Kenya can support. Most plants hold known or potential promise as resources of economically viable products whose possible wild exploitation could offer considerable benefits in improved rural livelihood by providing food security, gainful occupation, cash income and contribute to foreign exchange earnings.

Plant gums and resins are such products that could be sustainable exploited for profit and still conserve most of the biological diversity and ecosystem functions of the dryland forests. Gum Arabic from *Acacia Senegal*, frankincense from *Boswellia neglecta* and myrrh from *Commiphora* spp. are abundant in the drylands of Kenya. They represent a group of non-wood forest products with opportunities in income and employment generation thereby uplifting the socio-economic status for the local pastoralist communities.

The paper gives a general background on the potential of exploiting gums and resins and indigenous knowledge systems for the economic development of the pastoralist communities of the dryland Kenya.

Domestication of Indigenous Forest Products

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The Faculty of Forestry of the University of Stellenbosch, South Africa, is currently conducting research into the sustainable utilisation of forest and woodland products, with special emphasis on the domestication of indigenous fruit trees. The long-term goal of this program is twofold: (i) to develop indigenous products that can be used on a sustainable basis for economic development in rural areas, where it is desperately needed, and (ii) the conservation of natural forest and woodland resources by maintaining the balance between biotic diversity and the utilisation of natural products.

For this program a four-phase model is used. The program has started with the identification of forest products on a regional level through community surveys. Products were rated according to popularity and level of utilisation amongst local inhabitants. To compliment this phase a national data base on available forest product information is being maintained.

The second phase of this program is the selection of popular and highly utilised indigenous products and the screening of suitable provenances within the distribution ranges for domestication studies. Different methods of testing for genetic variation, like electrophoresis, chromosome counts and electron microscope studies, are being used to study biotic diversity and to select provenances with the highest potential for domestication.

From the second phase study, provenances of the selected indigenous trees are selected for cultivation studies. Cultivation through seed and cuttings forms the cornerstone of this process. This can be a long process as a couple of growing seasons is required for the development for the best cultivation techniques and the raising of trees for orchard development. While the cultivation studies is in progress, the potential for sustainable utilisation of the in situ forest products is also investigated as well as the development of potential markets for the products. The sustainable utilisation of in situ forest products is an interim measure as the demand for forest products can reach a higher level than the sustainable supply level. The balance between supply and demand may then be maintained through supplemental cultivation of products. Ecological and biological studies is also incorporated in this phase to investigate the impact of utilisation on the forest and woodland ecosystems.

The fourth phase of this program is the development of enterprises based on the sustainable utilisation of forest products. The focus of this phase is on entrepreneurs in rural areas. The aim is to create employment and improve the quality of life in the areas of South Africa where it is needed most.

The four phases of this program are ongoing. Different products will be produced at different phases throughout the programme. The aim of this project is incremental economic empowerment in rural areas with minimisation of environmental impacts.

Molecular Biology of Natural Rubber Biosynthesis in *Hevea Brasiliensis*

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Rubber (cis-1,4-polyisoprene) is an important raw material for many industrial uses. The diminishing acreage of rubber plantation and life-threatening latex allergy to Hevea rubber, coupled with increasing demand, have prompted research interests in the study of rubber biosynthesis and development of an alternative rubber source.

Rubber biosynthesis takes place on the surface of rubber particles suspended in the latex. Rubber particle-associated proteins have been speculated to play an important role in rubber biosynthesis. We isolated and characterized a novel cDNA clone encoding the small rubber particle protein (SRPP). SRPP is one of the two major rubber particle-associated proteins, along with rubber elongation factor (REF). Sequence analysis revealed that this protein is highly homologous to the REF and the *Phaseolus vulgaris* stress-related protein. SRPP gene is expressed abundantly in latex and plays a positive role in *in vitro* rubber synthesis. We suggest that SRPP is a part of the rubber biosynthesis machinery, if not the rubber polymerase.

As rubber is synthesized in latex, the genes uniquely or preferentially expressed in the latex may be important for rubber biosynthesis. To study the gene expression profile in latex, we constructed and analyzed two cDNA libraries (complete and subtractive) from the latex of *H. brasiliensis*. Single-run partial sequencing of the cDNA clones identified a total of 245 expressed sequence tags.

As expected the most abundant transcripts were rubber biosynthesis-related genes. Detailed gene expression profile in the rubber-producing tissue will be presented.

Computation of Annual Forecasts of Non-wood Forest Products

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Keywords: Forecast, theme map, kriging, permanent plot, wild berries, commercial mushrooms, non-wood products, Finland.

The Joensuu Research Station of the Finnish Forest Research Institute started a project in 1997 concerning with the yield of wild berries and edible mushrooms that are of considerable economic and commercial importance in Finland where 2.1 million people pick wild berries and edible mushrooms every year. One of the main purposes of the project is to inform Finns about the season and abundance of the wild berry and mushroom yields and on what kind of sites the main yield occur. The flowering season of berries, the harvesting seasons of berries and mushrooms, the abundance of the yield and the factors affecting the yield are forecast and reported on TV, on local radio stations and in newspapers during the growing season. Most of the information is delivered in the form of theme maps.

The forecasts are based on a national observation network, which consists of 440 forests and peatlands (2200 permanent experimental plots). The number of flowers, unripe berries and ripe berries of bilberry (*Vaccinium myrtillus*), cowberry (*Vaccinium vitis-idaea*) and cloudberry (*Rubus chamaemorus*) are counted three times during the growing season. Edible commercial mushrooms are identified and the number of fruit bodies are calculated at least three times during the mushroom season. The most common and the most popular edible mushrooms are ceps (*Boletus, Suillus* and *Leccinum* species), milk caps (edible *Lactarius* species), mild *Russula* species, and some other good mushrooms, e.g., *Cantharellus cibarius*, *Rozites caperatus*, and *Craterellus cornucopioides*.

A new, more precise method of computing the theme maps was developed in 1999. The method applies universal kriging predictors and takes advantage of the permanent sample plots of the national forest inventory (3009 plots). Variables assessed in the national forest inventory in 1985-1986 included the percentage coverage and the height of the swarf-shrub of cowberry and bilberry and the productivity class of each sample plot. Productivity was assessed on the basis of the number of flowers and unripe and ripe berries. The predictors use these variables together with the site index, temperature and rain fall variables, tree species composition, the basal area of the trees, the development class of the trees and the geographic location and altitude of the site.

Potency and Taxonomy of Endemic Rattan Species (*Calamus Occidentalis* J.R. Witono & J. Dransfield) in Ujung Kulon National Park, West Java

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Among the 25 species of rattan in Java, about two are endemic. One of them is in West Java: *Calamus occidentalis*. Since research in a distinctive botanical region is natural the potential value in exploration should be the subject of inquiry. Studies concerning the potential and taxonomy of endemic rattan species has been carried out in Ujung Kulon National Park. The inventory rattan endemic in the south part of Ujong Kulon National Park is predicted has a potential source of good shape. Methods use in conducting the field research consisted of measuring the density and frequency of rattan endemic using formula developed by Cutis (in Muller and Dumbois and Ellenberg, 1974). Data were collected from July 1997. Illustrations of rattan endemic species found in the area were described and analyzed both in Forest Botany Herbarium in Forest and Nature Conservation Research and Development Center in Bogor and in Herbarium Bogorience, LIPI. It is expected that availability of these data could be given away in this conservation area and also other resources as well.

Non-Timber Forest Products Research: Challenges for the Future

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Keywords: non-timber forest product, certification, people, sustainable forest management

Mid 1980's optimistic views emerged about the potential of commercial extraction of NTFP to contribute to forest conservation as well as improved livelihoods. Research strategies aimed at identifying requirements for ecological sustainable, economic feasible and social acceptable commercial extraction were launched. The goal is that NTFP extraction is recognised as a potential land use option in natural resource management (Ros-Tonen et al, 1995). Three central issues can be distinguished in NTFP related research: product, source and people.

Product

A particular feature related to NTFP is their great number and versatility (Lintu, 1996). Within NTFP a floristic and faunal origin can be distinguished, but other classifications could be made just as easily (harvesting method, processing, end product, market, etc.). A well defined classification is the cornerstone for the efficient collection of data and information. A number of organisations, such as the International Organisation for Standardisation (ISO), have established specification and testing conditions for various NTFP at the national and international level, but a general agreed upon classification system of NTFP is lacking.

Source

In natural resource management it is important to distinct human altered systems from natural forests. Both systems are important sources of NTFP, but require different management strategies. For NTFP form natural forests the Forest Stewardship Council (FSC) (Pierce, 1998) Working Group and the Rainforest Alliance (1998) and Smartwood (Shanley, 1998) have prepared specific sets for management. However a sound scientific basis for many of the criteria is still lacking, such as allowable harvesting levels and other management practices.

People

A range of people, from gathers, through processor and trader, till customer, can be distinguished. A good interaction between the different actors in NTFP management is essential for effective management. The Fair Trade Labelling Organisation (FLO) coordinates 17 national fairtrade systems, focussed on socio-economic criteria and principles, such as an equitable sharing of the benefits. While FLO is mainly concentrated on international trade, NTFP markets tend to range from local subsistence to international commercial markets. Each market has its specific requirements (quantity, quality), and therefore different management implications, which need to be incorporated in a participatory manner. Research on all items mentioned above is essential to evolve into a natural resource management practice in which NTFP is seen as a viable and compatible land use option and practice. NTFP extraction is being applied on a daily basis by millions of people now, and research is essential to sustain it for the future.

The relevance of local controls for the management of woodland resources: the case of Zimbabwe

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There has been much interest in the last decade in local knowledge and its validity for the management of natural resources. This interest has fed into the debate on Common Property Management, where rules, rule adherence, rule enforcement and the recognition of resource boundaries are considered to utmost importance. A case study in Zimbabwe was conducted, using sociological and ecological methods, to investigate the impact of local controls on the ecological state of the woodlands.

The work shows the richness of the local controls (including codified rules, taboos, and regulatory norms and emotions) for the management of woodlands and trees. The domains of human habitation (home bases and home fields) were found to be the spaces where the greatest number of local controls applied; the least controls were evident for the woodland commons. However, work on rule adherence and rule enforcement showed that there was much contestation, negotiation and breaching of local controls, with very low levels of enforcement of the controls. Greater respect for local controls was evident in the areas of human habitation. The resource use boundaries differed for each of the resources collected from the commons, and showed no relationship to local traditional boundaries (where they existed) or to any of the local administrative boundaries. The traditional boundaries between villages can be regarded as soft boundaries, with reciprocity amongst villages widespread. Elites within the villages are able to manipulate situations and local controls to their benefit. Thus, for instance, `sacredness' can be re-negotiated, where necessary. The result of the `control framework' for areas around human habitation showed a consistent enrichment of the tree component, through conservation and planting. In the commons, the `control framework' made little impact, except that some sacred areas still were being strongly protected.

The possibilities for common property management based on local controls are regarded as being rather limited. The study concludes with an analysis of how systems of local control can, or cannot be, incorporated within the on-going exercise to devolve power to local authorities (Rural District Councils). National legislation needs to be reformed so as to provide a framework for Councils to have the tools to support local controls, in the form of, for example, by-laws and locally-relevant enforcement mechanisms.

NTFP Management and Participatory Process of Forest Conservation

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Joint Forest Management (JFM) is considered as a watershed in the history of Forest Management in India as it seeks to develop partnerships between local institutions and Forest Departments for sustainable management of forest areas on the basis of trust and mutually defined rights and responsibilities of both parties. Managing forests for multiple products including NTFP at local level is a challenge facing India where JFM is being implemented widely. This paper attempts to discuss the existing hurdles to this shift and also highlight the importance of NTFP and the need to focus on its management for sustenance of the current management system. It also attempts to suggest ways and means of involving local communities in management of forests.

The current policy framework, lack of value addition methods, gender and equity imbalance and existing silvicultural practices are some of the hurdles to a shift from timber oriented system to an NTFP oriented system. It has been proved time and again by several studies that communities value more, regular flow of NTFPs and other benefits from the forests rather than a one-time share of the harvested timber. This is because the local communities are unable to wait for 8 to 10 years to get a share from the timber revenue as the opportunity cost borne by them becomes too high. This pressure on the locals could possibly lead to a collapse of the protection system itself. In order to avoid such a situation, it is very essential to make arrangements, for accrue of increased benefits to the communities. The fist step towards realization of this goal of real participation is "Informed Decision making".

Communities need to be involved in decision making apart from being involved in protection and management operations. Some work done in Africa has proved that local communities will manage a forest if they have:

- Adequate rights and access to resources
- A sense of belonging to the forest and
- Have the desire as well as incentives to manage it

This interest of communities in sustained yield of forest products will ensure that the process of forest conservation is successful and there will be hope for the future. This mode of forest protection and management will not only fulfil the needs and aspirations of forest dependent communities but will also aid in realizing the long-term goal of forest conservation for sustainable forest management.

Extractivism and Socio-Cultural Dynamics for the Development of Rattan and Almaciga Resin Resources: A Case Study in Palawan, the Philippines

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The investigation was conducted in the island province of Palawan, home of the unique tribal communities, to assess, from multidisciplinary perspective, the conditions of existence, the potentials and limitations of extractivism as an alternative strategy for the development of rattan and almaciga resin in the context of sustainable development of forest land. It also aims to assess the indigenous knowledge and the influence of socio-cultural forces related to extraction. Data derived from vegetation survey and micro-climate measurements were analyzed using two complementary methods, namely: Two-Way Indicator Species Analysis (TWINSPAN) and Canonical Correspondence Analysis (CCA). On the other hand, socio-economic/cultural data were assessed and subjected to descriptive and non-parametric analyses.

Data gathered shows that rattan grows at a wide range of elevation though the concentration of the species, particularly the commercial ones, is at higher elevation and on less accessible areas interspersed in the natural dipterocarp forest. This is due to the fact that the species are gathered and used for livelihood by the tribal community and other individuals that frequently traverse the area for the same reason. Meantime, almaciga (*Agathis philippinensis*) trees are observed to thrive mostly along ridges and side slopes to the gullies from 340-740 meters above sea level (masl). The tapped trees are large but the incisions for the resin to exude out appear to be too many and oftentimes larger and deeper than the prescribed limits set by the Philippine government. In addition to the problem on unregulated tapping methods is the lack of reproductions and lower diameter almaciga trees that would ensure continued production of the resin.

Socio-cultural information revealed that extraction of rattan and almaciga resin is an ancient practice among Bataks. Nowadays, it has become the major source of income of these indigenous peoples (IPs) including other rural folks. Rattan is a raw materials used for manufacturing furnitures and handicrafts while almaciga resin is utilized for production of paints, varnish, adhesives, among others. Due to this, rattan and almaciga resin are highly in demand both in local and international market. The economic popularities of these non-timber forest products (NTFPs) eventuate to encroachment of outsiders in the gathering areas of the (IPs) bringing with them conflicts because of competitions and destructive extraction methods which later was learned and adopted also by the IPs. Likewise, their constant business transactions with traders influenced not only their lifestyles but also their cultural practices.

As the global economic crisis, particularly in regional level was being felt, the demands for these NTFPs began to decline which consequently affected the traders and gatherers. Much more for the case of IPs who are more vulnerable and prone to exploitation and have no livelihood alternatives. The limited livelihood opportunities for these upland gatherers make them heavily dependent on rattan and almaciga extraction. This is compounded by the local policy that prohibits kaingin (swidden agriculture) in the uplands. Without alternative sources of income, incessant extraction of materials proceeded throughout the year even under inclement weather conditions.

Usos económicos y etnobotánica de las cercas vivas en Cuba.

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Se realizó una amplia revisión bibliográfica, consultas a especialistas y entrevistas a campesinos para conocer las especies utilizadas en Cuba como cercas vivas, así como sus usos. La información fue introducida en una base de datos automatizada, que incluye nombre científico, sinonimias, familia, nombres comunes en Cuba, hábito, forma preferente de reproducción, observaciones, entre otros aspectos. Se describen 88 especies pertenecientes a 55 géneros de 27 familias; las familias mejor representadas fueron *Cactaceae* (13 especies), *Agavaceae* (9), *Euphorbiaceae* (8), *Fabaceae* (8) y *Mimosaceae* (7). Se reportan 45 empleos posibles. Los usos más frecuentes fueron ornamental (53 especies), medicinal (43), melífera (35), comestible por el hombre (30), comestible por animales (15) y maderable (14). Se reportan además 4 especies endémicas y 14 tóxicas. Se destacan aspectos vinculados a la creencia de la población pero aún sin comprobar.

Palabras Claves: cercas vivas, usos, etnobotánica, Cuba.

Management System for Non-Timber Forest Products in Three Community-Based Forest Management Projects in Quezon Province, Philippines

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The study assessed the management practices adopted by the communities and the factors affecting the management system for non-timber forest products (NTFPs). The study described the problems and possibilities of developing a management system for NTFPs. Policy recommendations were made. Three community-based forest management projects were selected for this study in Quezon Province.

Data were gathered from 84 households in the project areas and from eight project technicians as key informants. Secondary data were collected from PENR Office and DENR Offices. Descriptive and simple statistical tools such as frequency counts, percentage, range, means were employed in data analysis.

The study showed that the biophysical environment, socio-economic and psychological characteristics of the people influence the management system for NTFPs. Most of the respondents engaged actively in forestry activities were middle aged. They all have obtained formal education. They practice agroforestry system for their livelihood. The respondents were highly aware of the utilization of non-timber forest products mostly for their subsistence use. They have skills and knowledge of management and utilization of NTFPs. They have positive attitude towards the management for NTFPs. There exists a good potential sustainable NTFPs in these project sites. However, these potentials are not fully tapped. High participation in management of NTFPs is not observed due to low market price, poor market access, lack of information on new technologies and low external support for NTFPs.

The results of this study showed that the practical and best way to manage and utilize NTFPs in the CBFM projects is to tap the knowledge of the local people. External support such as financial, technical and material subsidies are needed to

encourage and promote the existing knowledge and practice of the participants of the projects. Resource inventory, assessment of existing utilization system and technology, adoption of silvicultural practices, training, infrastructure development, market assessment, promotion of processing and small scale enterprises are important for the management of non-timber forest resources.

Based on the actual analysis of the gathered data and field observation, it was found that three basic inputs namely more financial, material and technical supports are needed for the sustainable management of NTFPs.

Usos no madereros de las especies forestales en Cuba

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Alternatives of use of wooden trees growing up in Cuba are described; reported by literature; experts (interviews), and specialist (consults); with the objective of promoting an organized profit of woods, contributing to a supportable manage of forest and a rational reforest. An automatized database was made, which contains scientific name, synonyms, common names, fitogeografical, and kind of vegetation where it is present, among other elements. 229 infragenus taxa of 157 genus and 55 families are described. It was tested that almost every Cuban wooden species has, at least, and alternative for being used, which could perfectly be used and taken advantage of, before or after being cut, getting sustentation in such way. The commonest usages were medical (150 species); useful for bees (145 species), ornamental (77 species) and eatable for men (53 species). 45 ways for being used are mentioned.

Cultivation of Two Medicinal Plants *Andrographis paniculata* and *Rauvolfia serpentina* in the Floor of *Acacia auriculiformis* Stands

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Andrographis paniculata is a medicinal herb. Andrographolide is the main active bitter principle of *A. paniculata*. It is used as stomachic tonic and anthelmintic. It protects alcohol induced toxic effect on liver tissues and accelerates intestinal digestion and absorption of carbohydrate. In Bangladesh and India the plant is extensively used in traditional and Ayurvedic medicine. *Rauvolfia serpentina* is a perennial herb. Its roots are extensively used as medicament. The importance of the root drug and the alkaloids obtained from it has been recogniged in the allopathic system of treatment of hypertension. In the present investigation, seeds of Andrographis paniculata were sown by broadcasting method, in the floor of three plantation regions (plot-1, 2,3) of 5-year-old *Acacia auriculiformis* vegetation, for exploiting the intercropping method of cultivation of these two species under agroforestry system. Each plot consited of 400 sqm area of land and 100 plants of *A. auriculiformis*. One plot (plot 4) was prepared in the open field for direct sunlight. The whole aerial parts of the plants were harvested at the phase of appearing inflorescence branches. Plants (*A. paniculata*) were raised in two consecutive years. After harvesting they were dried in the sun and weight of the dried plants were taken.

In the present investigaion it was also undertaken to study the commercial feasibility of cultivation of Rauvolfia serpentina, in the floor of *Acacia auriculiformis* vegetation, for its undergraound biomass production. 10-15 cm long plantlets of *R. serpentina* were planted at the espacement of 50x50 cm in the floor of two different plots (plot-1 & 2) of 5-year-old established *A. auriculiformis* vegetation. The plantations of *A. auriculiformis* were at 2mx2m espacements and each plot consisted of 400 sqm of land and 100 trees. One plot (plot-3) was prepared in the open field, for direct sun light, in an area of 100 sqm. The number of *R. serpentina* plants in each plantation plot under *A. auriculiformis* were 1581 and in the open plot were 441. The roots were harvested and dried in the sun and whole weight of roots grown in a particular plot was weighted.

The results show that both the species of *A. paniculata* and *R. serpentina* could be cultivated in the forest floor as the total weight of the dry matters obtained from vegetation floor and open plots were significantly parallel. The study has amply shown that the intercropping of medicinal plants with nitrogen fixing *A. auriculiformis* is quite feasible. It is also revealed that through this system of cultivation, the endangered medicinal berbs or undershrubs could be saved from extincition and a yearly recurring income is possible for rural livelihood as well.

Diversity of medicinal plants in Bangladesh and their conservation needs

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The medicinal plants played very important role from times immemmorial among the illiterates and the highly civilized persons in the folklores connecting with healing of diseases which are still practised by men and women of the east and the west, not to speak of tribals. In Egypt, India and China good informations of medicinal plants are available in the old literature, folklores, mythological stories etc. The Rig-veda, an old repository of human knowledge (4,500-1,600 B.C.) mentioned the medicinal uses of plants. The Ayurveda, evolved much later, compiled the properties of drugs and their uses.

Bangladesh has a rich heritage of medicinal plants. Geographically, the location of Bangladesh is very unique. It is a short stretch of land between the Himalayan mountains and the Bay of Bengal. It is a fertile deltaic region criss-crossed by the Ganges, the Brahmaputra, the Meghna and their network of tributaries. Naturally, Bangladesh has a rich forest resources having diversified ecosystems, such as in mangrove forest, hill forests, plainland forests, unclassed state forests, village groves etc.

There are no less than ten tribal races in Bangladesh and the country is rich in sources of ethnobotanical information. An ethnomedicinal survey was conducted in different forest regions of Bangladesh among the tribal people to record their knowledge about the use of plants for the cure of different diseases. More than 200 plants growing in the forests are found to have medicinal values. We also visitied different Ayurvedic and Unani manufacturing firms in Bangladesh and enlisted the names of plants being used as raw materials. 110 plants are extensively used by these manufacturing firms to produce crude drugs.

There is a growing interest in medicinal plants and traditional medicine within the last decade. With the increasing use of medicinal plants in many countries, and with the accelerating destruction of natural resources in the tropics, it has become clear that the exploitation of medicinal plants must be accompanied by conservation measures. Otherwise these plants become depleted as resources or may even face extinction.

At present, there are more than 300 Ayurvedic and Unani manufacturing firms in Bangladesh, of these, nine are quite big and supplying the major bulk of the traditional medicines in the market. These manufacturing firms exploit the nature by collecting the medicinal plants indiscriminately for their raw materials. So the conservation of these plants is needed for their sustainable use.

Influence of Silviculture Measures on Preservation and Productivity of Wild Berry Plantaions

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Keywords: non-wood forest resources, wild berry plants, productivity, sylviculture measures, cutting.

Wild berry plants are of great importance as kind of non-wood forest resources. Measures to assist the natural regeneration of wild berry plants after cutting are developed insufficiently now. At the same time they are needed on the areas with irregular distribution of berry plants and on cutovers.

The present studies were conducted to determine the influence of different types of cutting, sowing of seeds, planting and rejuvenation of wild berry plants on conservation, restoration and raising productivity of bilberry (*Vaccinium myrtillus*), bog whortleberry (*Vaccinium uliginosum*), cowberry (*Vaccinium vitis-idaea*) and cranberry (*Oxycoccus palustris*).

We studied the influence of cuts on preservation and restoration of wild berry plants. Thinning cuts were carried out in myrtillosum and vaccinosum forest types. They increased projective covering of berry plants in some times and subsequently increased productivity of latter. Non-clear cuts (sheltewood and selective) damaged berry plants much less, than clear-cuts do. Clear-cuts were carried out as a rule in areas where bilberry, cowberry and sometimes bog whortleberry grow.

Good fruiting and phytomass growth of cowberry are noted on clear-cut areas and in *Pinetum vaccinosum* types when canopy density is 0.5. Thinning of stand canopy on cranberry bog (sphagnosum type) from 0.4-0.6 up to 0,1 results in increase of a crop of berries as much as 25-50%.

By regulating of light availability and canopy density using different types of thinning high productivity of berry plants can be obtained. All types of cuts and thinning should be carried out in winter time when timber is transported using machines and in any time in case of hand transporting. The minimal damages of berry plantations are noted after selective thinning. For instance, the most productive cranberry plantations growth at canopy density of 0,1-0,4 when yield reaches 1000-1200 kg/ha. Cowberry prefers premature pine stands with canopy density about 0,4-0,5.

When projective cover of berry plants is about 35% (on clear-cut areas and in disturbed stands), the sowing and planting bilberry, cowberry and bog whortleberry are used. To increase density of cranberry and bog whortleberry plantations, an assistance to regeneration by seeds are recommended. To do that the seeds and berry wastes from processing are sowed in microraises of bogs.

Rejuvenation of bilberry, cowberry and bog whortleberry by removing old plants and cutting of sprouts are used for increasing their productivity. Mechanical method and using managed fire are developed for rejuvenation as well. Growth activity is increased at 5-10 times after this rejuvenation, which results in raising productivity.

Thus, in taiga zone of European Russia the complex of measures is used to restore and increase a productivity of wild plantations. This complex consist of following measures: thinning of forest canopy, assistance to a natural regeneration, cutting of berry plants, sowing the seeds, planting the perspective forms of berry plants.

Apical Role of NTFPs in Sustainable Forest Management & Research

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While defining Non Timber Forest Products (NTFP), Non Wood Forest Products (NWFP) or Minor Forest Products (MFP) and classifying NTFP in twenty six categories, pivotal role of NTFP species has been emphasised for various forestry programmes of Management and Research in the posters. Mechanism to overcome problems on the subject has also been conveyed. Future action plan required for conducting Research, Documentation of information in files and MFP Database and NTFP based enterprise development for community forest management have also been addressed in the posters.

Definition of NTFP:

Forest usufructs or utility products from forests except timber are termed as minor forest products (MFP) or non – wood forest products (NWFP) or non-timber forest products (NTFP). Viz. Edible plant products; spices and condiments; medicinal; aromatic; fatty oil; gum and resin; tans and dyes; fiber&flosses yielding plants; bamboo's; canes; fodder; leaves for bidis, platter, soapnuts etc., of plant origin. Honey, lac, silk etc., of animal origin.

FAO defines NWFP/NTFP/MFP as all goods for commercial/industrial or subsistence use derived from forests and their biomass, sustainably extracted from a forest eco-system in quantities and ways that do not downgrade the plant communities basic reproductive functions.

Suggested solution to problems on the subject

1. Pivotal role of NTFP species with Multi disciplinary integrated holistic approach needed to meet the challenge of Management and Research.
2. Strengthen IUFRO as a nodal agency for global guidance, through Centre of MFP, Dehra Dun (India).
3. Shift fom Timber - dominated to NTFP-oriented Need Based Sustainable Forest Management.
4. Understand the diversity of NTFPs (Not only restrict to Medicinal Plants).
5. Make choice of right species of the trees/ shrubs/herbs according to the edapho-climatic situation for raising plantations for replenishment of depleting stock and man made forests for NTFP-based enterprises (for sustainable forest management and biodiversity conservation).
6. Create awareness on NTFP and collect primary and secondary data in about 54 parameters on plant species, their distribution; their uses; climate; soil type; silvicultural requirements/characters; propagation; harvesting techniques; grading, processing and storage; value addition; production; marketing, trade and revenue earnings; employment generation; short and long terms gains; recommendations/future vision.
7. Document and strengthen information to create awareness and generate training material.
8. Extension of MFP/NTFP database of Centre of MFP, Indirapuram, Dehra Dun (programme on T.V. Van Darshan and other media).
9. Conduct NTFP- related enterprise development.
10. Create awareness through training programmes and revise school/college syllabi.
11. Re-orient working plans for choice of NTFP species for different forest programmes viz., JFM, JRD, Watershed Management, Global Warming, Biodiversity and Environmental Conservation.
12. Recast legal issues for people's participation and equitable distribution of profits.

FUTURE ACTION PLAN
Research
* To increase production of NTFP species for maintenance of biodiversity.
* Identify appropriate choice of species according to edapho-climatic factors.
* Ensure increased productivity:
- Standardize methods of propagation and models for raising mixed crops.
- Standardize harvesting techniques.
* Marketing research for:
- Equitable distribution of profits.
- Upliftment of disadvantaged groups of people.
- Study marketing channels and price regime.
- Assessment and regulation of demand and supply of NTFP enterprises and trends.
Documentation
* To upgrade documentation and MFP Database according to parameters for every species with primary and secondary data.
NTFP based enterprise development for community forest management
* Training programmes to all user groups through education programmes.
* Offering expertise to NTFP based enterprises.
* Augment plantations to ensure healthy and rich biodiversity/environment and socio-economic development.
ACTION TAKEN
By Team members of Centre of Minor Forest Products
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(The only Centre in India and abroad specifcally and exclusively working on NTFPs)
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ACTION TAKEN AND CONTINUING BY COMFORPTS:
* COLLECTION OF PRIMARY AND SECONDARY DATA FROM INDIA'S MEGA DIVERSITY.
* DOCUMENTATION ACCORDING TO THE STANDARD NTFP CLASSIFICATION AND DOCUMENTATION MANUAL BY DR. SHIVA AND MATHUR.
* STORED 3000-4000 SPECIES IN MFP DATABASE COMPATIBLE WITH THE ABOVE MANUAL AND PUBLISHED A BOOK ON INVENTORY OF FOREST RESOURCES WITH 2204 SPECIES.
* DISSEMINATION OF NTFP RELATED INFORMATION.
* COMMUNITY DEVELOPMENT THROUGH NTFP SPECIES.
RESEARCH ON VARIOUS ASPECTS: RAISING MIXED CROPS OF MULTI-PURPOSE TREE SPECIES YIELDING BOTH WOOD & NTFPs & SHRUB & HERB SPECIES OF NTFP IMPORTANCE.

Sundarbans, Role of NWFPS in National Economy and Management Practices.

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The Sundarbans is the largest single tract mangrove forest in the world. It is famous for its Biodiversity and economic potentialities of Non Wood Forest Products. The Sundarbans mangrove forest is enriched with its natural regeneration of multipurpose species. The Non Wood Forest Products of the Sundarbans is traditionally used as food, firewood, tannin, medicine, thatching materials, housing, fencing post, roof trusses, woven utensils, cheap furniture, handicraft etc. The NWFPs also play a vital role to the environmental enrichment. The different component of the forest area and parts of plants and animals are used for different purposes in various ways by people. Especially medicinal plants may be used and popularized in commerce and trade by dint of scientists and naturalists for conservation of the forest and to use the resources properly, because medicinal plants are still unknown and not yet been popularized. The Sundarbans is a unique natural resources not only Bangladesh but also universal worth. Considering its economic importance UNESCO declared Sundarbans as "World Heritage" and the Honorable Prime Minister of Bangladesh inaugurated Sundarbans formally "World Heritage" last 4 February, 1999. In the Sundarbans Sundri (*Heritiera fomes*), Gewa (*Excoecaria agallocha*) is the predominant plant species and Royal Bengal Tiger (*Panthera tigris tigris*) and deer (*Axis axis*) is important and most common fauna. The NWFPs are goran (*Ceriops decandra*), golpata (*Nypa fruticans*), singra (*Cynometra ramiflora*), hogla (*Typha elephantina*), hantal (*Phoenix palludosa*), cane, grasses, shells and different types of fishes such as shrimps, king crab, dry fish etc. Honey and wax and all other NWFPs are extracted from the forest annually and managed by the Sundarbans Forest Division for sustainable development. From these resources the Government earns a lot of revenue, which influence our national economy and improve socio-economic development.

Ecological Effects Associated with Rattan (*Calamus zollingeri*) Harvesting in Sulawesi, Indonesia

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The sustainable harvest of non-timber forest products (NTFP) has been advocated as a means to simultaneously encourage economic development and the conservation of biological diversity, and now forms the basis of many tropical forest conservation efforts. Some ecologists argue that the sustainable harvesting of NTFP resources is flawed, that conservation and development are incompatible, and that there are few, if any, documented examples of sustainable extraction that consider ecosystem-wide effects over ecologically significant periods of time.

This study documents ecological impacts associated with the extraction of the most important NTFP from Southeast Asia, rattan, based on four years of field work (1995-99) in two village areas in Central Sulawesi, Indonesia. Specifically, I quantify and evaluate: 1) effects of cane harvesting on the abundance and growth of the premier commercial rattan, *Calamus zollingeri*, through monitoring of 175 randomly selected plants for three years; 2) nutrient losses associated with *C. zollingeri* extraction through leaf and cane tissue analysis; and 3) forest-related impacts associated with gathering and transporting cane by monitoring five permanent 10 x 1000 m transects for three years and the extent and volume of tree cutting to float cane to market.

Evidence of rattan harvesting is widespread in the study areas and marketable supplies of cane (i.e., > 10m in length) have become increasingly scarce. Permanently marked *C. zollingeri* plants experienced no direct mortality from cane harvesting despite repeated removal of mature canes. However, production of new ramets and ramet growth were lower where harvesting pressures were intense which suggests that vegetative reproduction and cane growth may be adversely affected by cane harvesting.

Significantly greater amounts of nutrients (i.e., total N, P, K, Ca and Mg) were found in the leaves than in the stems of *C. zollingeri*. Since all foliage is left on site when canes are harvested, only nutrients stored in canes are removed. On-going work will ascertain the dry weight equivalencies of these losses on a per ha basis, but nutrient removals appear to be less than natural inputs through weathering, atmospheric deposition, and N-fixation.

Rattan harvesting involves cutting canes at their base and pulling them down from supporting vegetation. Cane harvesting did not affect supporting trees or understory vegetation in this study (i.e., no damage was observed to other vegetation immediately after harvesting or one or two years later). However, in some cases trees may be cut if rattan cannot be pulled down. Natural tree fall gaps comprised 16% of the transect areas and their number and size were unaffected by pulling cane. In 1996, there was no evidence of tree felling to gather rattan, but in 1997 an average of 0.3-3.0 trees/ha had been to felled gather rattan. Tree felling is increasing due to the scarcity of easily extractable, large-diameter cane and now exceeds natural tree fall rates in intensively harvested areas.

Tree falls, both natural and to extract cane, can affect the growth and survival of rattan. Natural tree falls crushed 6.6% and killed 2.8% of marked rattans over a 20 month period where cane was not intensively harvested. Where cane extraction was intense, three times as many rattan were crushed by cut trees than natural tree falls and rattan mortality increased 2.5 fold.

The transport of rattan to market entails floating cane down river to road transport points and the use of floater logs to prevent cane sinkage. Eight tree species are regularly utilized as floater logs and all are light-weight, fast-growing, early-successional species. Floater trees are harvested primarily from fallowed shifting cultivation fields and regularly disturbed riparian zones.

Between October 1996 and September 1997, 135 and 100 tons of cane were extracted from the two study areas requiring 2350 and 1667 floater logs (averaging 25 cm diameter and 3 m length), respectively.

Harvesting floater logs appears to have little effect on biodiversity conservation. Floater trees are harvested in early successional, disturbance-associated forests and farms, thus their removal does not affect primary forests, some species coppice when cut, and the leaves, twigs, and bark are left on site so nutrient losses are not appreciable.

The collection of rattan cane is economically important at the household, village and provincial levels in Central Sulawesi. Fifteen years of *C. zollingeri* harvesting has reduced the supply of mature canes and, where intense, may have reduced ramet production and growth. There is no evidence that cane harvesting affects the survival of *C. zollingeri* plants or ecosystem nutrient stores, or that the cutting of small trees to float cane is a major environmental problem. On the other hand, tree felling to extract cane has significantly increased the number of canopy gaps, which may alter future forest species composition and successional patterns.

Margins Approach to the Performance of Non-Timber Forest Product Markets: A Study of the Woodcarving Markets in Southern Zimbabwe

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The commercial trading of wooden carvings is a recent phenomenon in Zimbabwe. Most markets have been sited along 'tourist routes' usually in areas designated for smallholder agriculture (it is in these communal areas where poor people are concentrated). The carvings are largely sold to foreign tourists and the carving industry probably plays an important role in sustaining the livelihood of poor people. The increase in the number of markets that trade in carvings has been attributed to macro-economic policies, recurrent droughts and the growth of the tourism industry.

The markets where wooden carvings are sold perform a number of essential functions that facilitate the trading of such artifacts, namely the exchange function (buying and selling), physical function (storage and processing) and facilitating function (risk bearing and market intelligence). For wooden carvings, a diverse number of market chains exist. Within these chains, distinct functional levels are evident. The first level is the acquisition of woodland-based raw materials and their transportation to the market, while the second level involves the carving of the product. The third level is the finishing (sand-papering and polishing) of the product. The final level is the trading of the product to consumers.

This poster presents data on the market performance of the wood carving industry in Zimbabwe. This assessment is done using data from three case study markets from Chivi district. From this data gross market margins and net market margins will be used to assess the returns to factors of production at various levels of the market chain including the cost of performing each function and the rules and regulations governing each level.

Using a gross margin approach to the analysis of woodcraft production and trade, the overall cost of processing and marketing of traded NTFPs was less than the selling price. Although some functions in the marketing chain were loss-making, most participants had countered this by integrated such functions with profit making ones. Carvers also trade to capture the high net margins associated with this function. The distribution of costs along the market chain are not uniform. As such, the paper acknowledges the disparities in incomes accruing to different functions in the market chain. These also vary with product type and the tree species.

The margins approach as applied to this paper depict the trading of woodcarvings in Chivi District as an economically profitable enterprise. Total net margins, are all positive, ranging from US$23 to US$565. A decontsruction of these total net margin shows that most of these accrue to the traders in the market chain. The widely accepted thesis has been that the woodcarving markets in Zimbabwe are inefficient. This poster demonstrates how this notion is a fallacy, exposing that participants in woodcarving markets are rationale given their socio-economic environment.

Extractivism, Peasantry and Wage Labour in an Amazonian Context: Shifts in Rural Livelihood Strategies of Northern Bolivia

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In the late 19th and early 20th century, rural livelihoods in the northern Bolivian Amazon were largely based on the commercial exploitation of rubber. Extraction was organised in a highly oppressive debt peonage system leaving most of the rubber tappers in permanent indebtedness to their patrons. But the slump in rubber prices following World War I called for adaptations of the organisational mode underlying forest product extraction. Rural livelihood systems changed accordingly, as rubber tapping became supplemented with subsistence agriculture and Brazil nut collection. This agro-extractive mode of making one's living was prevalent until the mid 1980s. In 1986, the withdrawal of Brazilian rubber subsidies, which had been granted to Bolivian rubber, too, brought about the collapse of rubber trade in Bolivia. The renewed rubber crisis was overcome through the expansion of the Brazil nut, palm heart and timber industries which nowadays provide employment to thousands of unskilled labourers in towns and income to the vast majority of about 7,000 rural households.

This poster presents results of the dynamics in rural livelihood strategies against the backdrop of the rubber demise. Household economies in northern Bolivia reveal various trade-offs between agriculture, extractivism and wage labour. Notwithstanding the loss of rubber-based incomes, virtually all rural households continue to depend on earnings derived from the sale of non-timber forest products. This is especially true for remote settlements where Brazil nuts and palm hearts combined provide up to 90 percent of a family's cash income. Even in settlements closer to one of the towns, where ease of access to agricultural markets provides further income opportunities, extraction-based incomes do play a significant role. Varying dependencies on NTFP-based income are analysed through a typology of rural households. Key factors for their distinction are access to land and markets, economic life histories, and labour division within a given settlement. Based on the typology conclusions are drawn for tailor-made extension programmes taking into account the individual history and present specialisation of rural households.

Some of the main conclusions of this study are that the commercialisation of forest products has long been part of rural livelihood strategies in which agriculture and extractive activities were embedded. Partly new is wage labour as additional source of income. The underlying reasons of the resulting intra-community differentiation are analysed to better predict future trends in off-farm income. There is high variation both within and across the communities as regards trade-offs between agriculture, extractivism and wage labour. As there is no such thing as a uniform rural household and, moreover, intra-community specialisation increases, extension programmes need to be adjusted to meet the demand of a fairly heterogeneous group of forest dwellers. The Brazil nut and palm heart industries are indispensable sources of cash income. But along with a slump in Brazil nut and palm heart prices, as well as the ongoing depletion of natural stands of *E. precatoria*, rural dwellers (will) face increasing difficulties to gain sufficient monetary income. In the light of lacking economic alternatives expansion of agriculture and increased rural-urban migration are likely to be adaptive responses

Impact of Logging on Species Diversity of Palms in the Lowland Forest of Pasoh

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We compared the species diversity of palm community, including rattans in the unlogged and logged forests of Pasoh in Negri Sembilan, Peninsular Malaysia. The latter was logged in 1955. Both forests are on soil developed on shale parent materials and characterized by the presence of band of laterites. Four 0.12 ha plots in the unlogged forest, and nine in the logged forest were established and assessed for all palm species at four growth stages: seedling, juvenile, intermediate and mature stage.

Logging reduces the species richness of palms. The number of palm species for the unlogged and logged forests were 27 species (6 genera) in 0.48 ha and 18 species (5 genera) in 1.08 ha, respectively. Eight out of eleven commercial rattan species recorded in Pasoh are found in the logged forest. Most species occurring in small numbers in the unlogged forest were absent in logged forest. Variation of species richness between plots exist but not crucial. The impact of logging increased the variability in the number of species per unit area across all growth stages. However, it appears that the element of chance plays a greater role in determining species richness as there is no clear indicator for lack of species in some plots. A larger sampling area for the logged forest is required for better and precise estimation of palm species richness.

The most prominent effect of logging, even after forty-two years is the low density of palms. There were only 1008 individuals per ha as opposed to 8691 individuals per ha in the unlogged forest. Most number of species and individuals are those in seedlings and juvenile growth stages. One of the main factor for low palm density is the damage caused along trails made by log-hauling tractors. Only a few palm seedlings were observed to be growing on old logging trails which soils are compacted and sparsely covered. No information on the logging intensity was available for comments. Other factors observed to contribute to the low density of palms are the past distribution of palm species present prior to logging, growth characteristics of the species and topography.

Palm densities were also observed to be influenced by light gaps, the damage to the undergrowth or forest floor, fruiting frequency and seed dispersal and recruitment of seedlings from outside the plots. These influencing factors were also observed in unlogged forest.

Ecological status of non-wood forest produce extraction in the tropical forests of W.Ghats of Tamil Nadu, South India

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Non-wood forest product utilization in the tropical forests in Veerapuli and Kalamalai Reserve Forest in the Western Ghats of Tamil Nadu, South India. Kani's the local tribal people in this region largely depend up on the collection of non-wood forest produce for domestic and other uses. The non-wood produce of 12 plant species were extensively extracted and sold to local traders for commercial exploitation. Unwise and over exploitation of this produce might cause a potential threat to the survival of the plant species such as *Cinnamomum, Cycas, Canarium, Bambusa, Calamus* and *Emblica.* In addition to that the activity of non-wood products collection in these forest ecosystems has resulted in alteration of population dynamics of certain size classes of tree species such as *Cinnamomum malabathrum, Canarium strictum* and *Caryota urens*. The present study suggested that the unscientific exploitation of non-wood products and associated anthropogenic perturbation in tropical forests may result in the decline or may even gradual extinction of certain species. In addition to that this anthropogenic perturbation occasionally result in forest fragmentation, which in turn may lead to loss of local biodiversity.

Biodiversity of Rattan Species in Mount Halimun National Park District, West Java

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For a management of a forest, it is believed that much basic knowledge about the nature of the forest is needed. One of them is to develop the forest a resource of cane industry in sustainable way. For these purpose the composition, distribution and density of rattan species in Gunung Halimun National Park (TNGH) were studied as a model. Data were collected from December 1994 until May 1995. For species composition on rattan in TNGH, three areas were observed namely in Gunung Kencana, *G. Pameugpeuk*, and *G. Pangkulahan* using a continues square transact method, from elevation 800-1,400 m asl. From three areas in TNGH, it was found that three are 13 species of rattan in the region. In terms of species richness and densities, *G. Pameunpeuk* comes first, follows by *G. Pangkulahan* and *G. kencana*. *Calamus heteroideus*, *C. javenals*, *Daemonorops melanochaetes*, and *Plectocomla elongata* are dominant both in seedling and nature forms, The rattans are relatively abundant in areas less than 1000 m asl. and decrease in number of species as well as the minimal population in the higher altitude.

Production and Research of Gum Oleoresin in China

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Keywords: gum oleoresin, chemical utilization, *Pinus*

The pine species, about 22 species and 10 varieties, is widely distributes in China, amounts to 16 million ha. Main pine species valuable for oleoresin production include *P.massoniana, P.yunnanensis, P.langbianensis* and *P.latteri*. Rosin and turpentine can be produced from oleoresin.

For more than 1700 years ago, pine oleoresin had been used as medicine described in a Chinese ancient medical book "Shen Nong Code of Medical Herbs". In mountainous area oleoresin as a byproduct provides considerable benefit to the local people. Approximately 200,000-250,000 farmers are engaged for part time in gum oleoresin tapping in China per year. The total income of tapping workers amounts to nearly 100 million U.S. Dollars. Now oleoresin output in China is around 500,000 tons yearly, increasing 20 times in the recent 50 years. It takes the first place in the world. The quality of gum rosin has been upgrade. The export quantity of rosin is about 200,000 T/Y, occupying 40-50% of the world trade exported to more than 50 countries and districts al over the world.

Since 1966, many chemical modified products of rosin can be already researched and produced in China such as polymerized rosin, disproportionated rosin, hydrogenated rosin, maleated rosin, rosin amine and serial esters of these modified rosins and so on. Now the total producing capability of these modified products is more than 60,000 T/Y. Pine oil, terpineol, synthetic camphor, borneol and polyterpene resins are main modified products of turpentine in China. The perfumes from turpentine have been developing rapidly. Now China can produce all main modified products of rosin and turpentine abroad. Their qualities can be satisfied with that of the same products in abroad basically. Some modified products have been exported.

At present, developing fine chemicals from renew resource, instead of less and less petroleum resource has been paid more and more attention in world. Since 1990, we begin to prepare many new fine chemicals products, which have not been mentioned in literature and patents at home and abroad. New plasticizer for PVC, high electric insulating rosin, rosin type heat resistant polyamideimide, modified rosins used in soldering flux, rosin type of surfactants, synergist for insecticides and so on can be produced. We have prepared colorless rosin used in electronic and adhesive industry instead of colorless hydropetroleum resin. These above fine chemicals will compete with some petro-chemical products and extend the uses of oleoresin products, thus bring more and more economical benefits to China.

5.11.02 Medicinal and aromatic plants

Anti-inflammatory Activities of *Tabebuia chrysantha* (Jacq). Nichols

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Anti-inflammatory activities of *Tabebuia chrysantha* were evaluated using the *in vitro* (soya 5-lipoxygenase) and *in vivo*) 12-0-tetradecanoylphorbol- 13-acetate (TPA)-induced mouse ear oedema and carrageenan-induced rat paw oedema) methods. Lipoxygenase activity is associated with the antiiinflammatory response and thus inhibitors of this series of enzymes may provide compounds of interest. It was found that the dichloromethane extract of *T. chrysantha* (stem) showed strong inhibitory activity on soya 5-lipoxygenase. Bioassay- guided chromatographic fractionation led to the isolation of a naphthoquinone, lapachol. The inhibitory activity of lapachol from *T. chrysantha* against soya 5-lipoxygenase (IC500.76 µg/ml) was equivalent to that of the positive control fisetin (IC500.97µg/ml). TPA-induced ear oedema in mice and carrageenan-induced paw oedema in rat are the model for detecting the topical and oral antiinflammatory agents respectively. A dichloromethane extract of *T. chrysantha* (stem) was found to inhibit oedema in both tests. Topical application of *T. chrysantha* inhibit the oedema by 77% at a dose of 0.5 mg/ear in the TPA-induced mouse oedema. The dose-response relationship of the extract showed that the maximum effect (100%) was given at a dose 1 mg/ear. The extract administered orally (1g/kg) significantly reduced the oedema by 33% and 28%, 2 and 3 hr respectively after carrageenan injection. These results may imply that *T. chrysantha* is topically and orally effective and have the potential to be used as an anti-inflammatory agent.

Investigation into the Induction of Gaharu in Standing Karas (*Aquilaria malaccensis*) Trees

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Gaharu or agar wood is a resin-infused wood produced under certain conditions in the karas (*Aquilaria malaccensis*) trees. The fragrance produced on burning the wood is greatly valued. Gaharu is collected from the forests and despite the wide distribution of karas in Malaysia, the supply is diminishing. Gaharu is a valuable NTFP (Non-Timber Forest Product) and contributes towards the national income revenue as a minor export. By identifying the inducer(s) for gaharu formation, a more sustainable or plantation type approach to manage this resource should be possible.

Previous research had shown that wounding and microbial infection could stimulate gaharu formation. In this study we investigated the combined effect of wounding and microbial infection in gaharu formation in standing karas trees.

Bacteria and fungi were isolated from fresh samples of naturally formed gaharu. Seven isolates were selected based on their ability to infect willow wood under laboratory conditions. Fungal isolates were grown on MEA (Malt Extract Agar) and bacterial isolates on NA (Nutrient Agar). The inocula were prepared by macerating ten stock plates each of the selected isolates in a Waring blender and made up to 500 ml with sterile water. A volume of 40 ml of each inoculum was pumped into the drilled hole under pressure (200 psi) using a patented Hort+Research pressure injector.

Treatments were placed 10 cm apart in a spiral with 30 cm between spirals to minimise the influence of one treatment upon another. A total of eight treatments were set up on three mature karas trees in two localities. The treated trees were left for 10 months. Samples from the treated areas were collected for examination of the extent of infection, presence of gaharu and chemical analysis by GC and GC/MS. In view of the commercial potential, karas wildings were planted to observe their growth performance under plantation conditions.

Our preliminary results were encouraging. By burning the wood samples collected from the treated regions, majority gave off the gaharu scent. Transmission and scanning electron micrographs clearly showed the deposition of resin in channels in the intercellular spaces. Profiles of oils obtained by hydro-distillation of the treated wood samples when compared with oils from natural gaharu indicated similar major constituents but in different proportions. The major constituents were basically sesquiterpenes and oxygenated sesquiterpenes. The presence of two major compounds, jinkohol and jinkohol II, was observed in some of the treated samples as well as a commercial gaharu oil. These results strongly indicated the presence of gaharu after treatment. Continued monitoring of the planted wildings showed that this species could tolerate shade and relatively high acidity in the soil. They grew well under established trees and also did not suffer under exposed conditions.

We conclude that gaharu can be induced successfully by artificial means. However, more research is needed to focus on the selection of treatments for effective induction on a large scale, and more trees are needed for further induction trials. After selection and verification of selected treatments, the quality of gaharu produced will need to be determined.

The Utilization of *Eurycoma longifolia* Jack (Tongkat Ali) in Peninsular Malaysia

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Medicinal plants are known to be used by various ethnic population around the world since early time. As important ingredients, the practice and knowledge of the traditional medicine are still persisted passed on though many generations. Malaysia is richly endowed with a diverse flora with e great potential to develop into various useful natural products. Ethnobotanical/ethnomedical study suggests that at least about 20% of the estimated total of higher plant flora of 15,000 species comprise plants, which have been reported to possess medicinal and other therapeutic properties. One of the famous medicinal plants being utilized in Malaysia *is Eurycoma longifolia* Jack (Tongkat Ali). This plant has been widely used in the Malay traditional medicine for many years. With its special aphrodisiac properties, which are much touted about, *E.longifolia* had stimulated public awareness on its use. Its parts (roots and stems) have been a primary source of traditional medicine products for the pharmaceutical industry, especially the Malay traditional medicine manufactures. This paper discusses the utilization of *E. longifolia* Jack by Malay practitioners, which focussed on the process of harvesting by collectors as well as the production process of *E. longifolia* Jack roots and stems by industries including *E. longifolia* Jack are also being highlighted.

Soil Fertility Improvement Following Application of Mulch Mat from Oil Palm Empty Fruit Bunches

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Through a collaborative research with a private company, FRIM scientists have successfully development a product called "mulch mat". This product is made from the palm oil mill residue that is rich in plant nutrients particularly potassium. Technically, the process of making mulch mat is simple The oil palm residue, in this case empty fruit bunches (EFB) are shredded, mixed with biodegradable binder and pressed to form a mat. With this simple technique, however, problems associated with handling of EFB are minimised. For example, unlike EFB which contains high moisture, these mulch mats are dry and light thus allow for storage and cheaper transportation cost. Mulch mats are flat of standard with size, no spikes and minimal oil content thus handling in the field is easier.

Field trials carried out at two different locations showed that the many mats is capable of soaking rainwater and remained moist underneath even though the surface layer was very dry. The studies also revealed important increase in soil pH of acid soil and improvement in soil nutrient content particularly potassium. Conspicuous changes were observed in the first 15-cm soil layers where the feeder roots are most concentrated. For example, exchangeable K increased from 0.6 $cmol_c$ kg^{-1} to 3.8 $cmol_c$ kg^{-1} in a trial in Perak and from 0.08 $cmol_c$ kg^{-1} in a trial in Kedah in the first 5 cm soil layer after one month of mat application. Similar trends were also observed for other soil parameters such as pH, available phosphorus and organic carbon. The only parameter analysed that did not exhibit any important increase was total nitrogen. This is due to the initially low nitrogen content of oil palm empty fruit bunches.

Utilization and Cultivation on Selected Medicinal Plants in Malaysia

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Many of the Malaysian medicinal plants have long been used as medicines, health foods, flavours or fragrances and cosmetics. They are either used directly for preparation of dishes or as aqueous or oil extracts prepared in a crude traditional manner. Medicinal plants, which are commonly used by the locals for preparation of traditional medicines, are *Centella asiatica* (pegaga), *Cinnamomum zeylanicum* (kayu manis), *Curcuma domestice* (kunyit), *Eurycoma longfolia* (tongkat ali), *Kaempferia galanga* (cekur), *Languas galanga* (lengkuas) and *Zingiber officinale* (halia). These plant materials are mainly imported from abroad or collected from the wild, with some of them being grown by households in small garden plots to flavour dishes, or grown by vegetable farmers as minor cash crops. Although the Malaysian environmental conditions are suitable for large-scale cultivation of medicinal plants, the commercial potential of these plants has yet to be explored. With the view of developing a Malaysian medical plant industry, the Forest Research Institute Malaysia (FRIM) has initiated several programs to document, domesticate and commercially cultivate selected economic medical pants in the country.

Prospecting For Anti-Methicillin Resistant *Staphylococcus Aureus* (Mrsa) Plants At Pos Lanai

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Methicillin Resistant *Staphylococcus aureus* or MRSA, first detected in the UK in the early 1960's, has recently hit the headlines as the 'hospital superbug'. It has become endemic in many countries and is a significant cause of nosocomial infections in large hospitals worldwide. Approximately 100 patients a year die from infection with MRSA, and the bacterium is acquiring greater resistance to antibiotics almost by the day. Treatment of MRSA infections often require multiple drug therapy using available antibiotics. However, scientists are now concerned that MRSA may even become resistant to the last known conventional treatment, as some strains are now resistant to all antibiotics except vancomycin, a powerful drug with toxic side effects. Hence the threat to patient care posed by such organisms has stimulated continuing efforts to search for potent anti-MRSA agents and one such source of alternatives are phytochemicals.

Phytochemicals form the basis of many drugs currently in use and is forseen to continue to be so in the future. Accounting for about half of the world's flowering plant species, the megadiversity of the tropical rainforest represents a natural target for the discovery of phytochemicals as potential therapeutic agents. Although a large number of new phytochemicals are being discovered, as reported in many natural products publications, not many of these discoveries come from the Malaysian rainforest which houses about 12,000 species. This indicates that there would be many more potential drug candidates yet to be discovered from our diverse flora, including new antibacterials to combat MRSA.

Based on this scenario, during an ethnobotanical survey carried out on medicinal plants of two Orang Asli villages *viz*. Perkampungan Orang Asli Pantos and Perkampungan Orang Asli Suar, at Pos Lanai, Lipis in the state of Pahang, the opportunity was also taken for a short survey on anti-MRSA plants. A total of 20 medicinal plants from 14 genera were analysed for anti-MRSA activities towards a panel of 15 clinical isolates of MRSA. The MRSA isolates were taken from blood, throat, puss and the environment. Assaying method employed was the paper disc diffusion technique, the strength of activity denoted by size of inhibition zones around each plant extract impregnated discs. Out of the total number of plants tested, nine were found to inhibit the growth of ≥10 of the MRSA isolates. The active plants included species from the plant families Opiliacea, Moraceae, Sapindaceae, Piperaceae, Gesneriaceae, Lauraceae and Myrsinaceae.

Evaluation of Medicinal Flora in Western Ghat Forests of Karnatka State: Plants Used in Dental Care

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The studies on the medicinal flora with particular reference to the plants used in dental care of Western Ghat forests of Karnataka state, India, was undertaken during 1996-1998. The tropical forests of Western Ghats of Karnataka widely acknoledged as one of the most species rich terrestrial ecosystems in the world. The Phytogeographical zone of Western Ghat forests stretching from Belgaum to Mysore in Karnataka with total area of 6191187 ha. The medicinal plants are very important components of tropical forests. Traditional medicine has been used since the existance of homosepians, and its importance is still in practice even today. During the present investigation, the comprehensive data on the plants used by the indigenous people and local health practitioners for various dental problems were recorded. The study revealed that 75 species of 43 plant families are most important and widely used for curing dental disorders. Some of the plant species used in dental care are: *Azadirchta indica*, *Acacia sp.*, *Artocarpus heterophyllus*, *Syzygium aromaticum*, *Emblica officinalis*, *Glycyrrihiza glabra*, *Pongamia pinnata*, *Pterocarpus marsuopium*, *Datura metel*, *Barleria prionitis*, *Mangifera indica*, *Semecarpus anacardium*, *Elephantopus scaber*, *Terminalia arjuna* etc.

The present study highlights the conservation status of the plants used in dental care and draws attention to more intensive and integrated efforts to protect, conserve, investigate and utilize the valuable natural plant resources for human needs.

5.11.03 Edible products from the forest

Tree Borne Oil Seeds as a Source for Subsistence to the People and Raw Materials for Industries

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Oil and fats are not only an essential part of human and animal diets but are also an indispensable ingredient in numerous industries such as, Paints and varnishes, soaps, cosmetics, hardened fats, textiles, leather. pharmaceuticals, lubricants etc. Satpura Plateau of Madhya Pradesh (India) has been bestowed with vast forest areas which contain a very rich flora, tree borne oil seeds being a part of it. Tree borne oil seeds have tremendous potential and if it is harnessed in full it will lead to the productivity of forests. This will help to improve hte socio-economic conditions of the tribals and rural folks. It will also generate huge employment opportunities to the rural poors. The demand of fatty oils are also increasing world wide and this is likely to increase with the rapidaly increasing population. Hence there is need to identify more and improved sources of the fatty oils and to prescribe scientific methods of collection, preservation, processing and extraction practices for maximization of economic production/growth.

5.12.00 Sustainable wood industry

Procedure for Evaluating and Monitoring the Sustainability of a Lumber Production Forest

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Keywords: sustainable forestry, *Eucalyptus grandis*, plantation, wood products

A reliable estimate of the standing volume of sawn wood enables a strategy to be formulated for the sustainable management of production forests. This study proposes a method for estimating the sawn-wood volume stocked in any standing plantations. Only a few variables are required to make such prediction and each of them is very easy to be obtained for a particular forest, either planted or natural one. The accuracy of that proposed theory was verified in an *Eucalyptus grandis* experimental plantation which was being grown and managed according to the Correlated Curve Trend (CCT) method. The paper shows that stem shape and round wood volume can be predicted very well by a studied function, which is based on the DBH and the height of the tree only. This function permits to obtain the diameters of all logs that are intended to be obtained from that stem. Another function was obtained from logs processing in an industrial sawmill for predicting the recovery rate, which is expressed by the relationship between sawn wood volume and its early round wood volume. This function is based on the smaller diameter of the log only. The combination of those functions permits to obtain the sawn wood volume stocked in each DBH class of a standing population. Also provides a good estimate of the total round wood volume and sawn wood volume available in the entire forest. It was important to note that round and sawn wood prediction curves get closer each other as DBH becomes larger. This means that at some extent smaller trees do not contribute effectively with an optimized lumber production. In the case of natural forest, smaller trees can be saved for contributing with the regeneration process, without introducing great impact on lumber productivity of the whole forest. It is important for the sustainable management of forests that companies obtain an accurate assessment of end-product volume. They must know how large their forests have to be in order not to have either problems concerning to raw material supply or to explore above of the forest capacity. It is possible from this study to calculate either the exact area needed to supply a specific sawmill or the exact size of a sawmill that will operate, at optimum, based on a specific forest area. The proposed methodology estimates the potential of a forest lumber production and arrives to an indicator that brings together all people who work consciously exploring and protecting the environment. It may be considered as an interesting tool, which increases the capability for monitoring the maintenance of the lumber productivity.

Made to Compete: A Hybrid Product for Forest Products Industry

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Keywords: engineered wood products, composite products

Wood has long been considered as an engineering material. Recent survey showed that many builders do not consider wood as a suitable material for construction use. They see wood as the least durable material. In order to improve wood's competitive position, forest products industry is facing many challenges. One of the attractive and practical approaches is to produce a hybrid product from wood and plastic materials. The potential of producing a high wood fiber, low plastic characteristic wood fiber-thermoplastic composite is discussed. Current upward trend in cooperation between the forest products and plastics industries is exhilarating.

Implementation of Sustainable Forest Management: Application of Criteria and Indicators in Korea

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Since the UNCED in 1992, sustainable forest management has been the major theme of conservation, management, and development of forest resources around the world. While addressing the promotion of efficient utilization and assessment to recover the full valuation of the goods and services provided by forests, forest lands and woodlands at UNCED, governments agreed to pursue, in cooperation with special interest groups and international organizations, the formulation of scientifically sound criteria and guidelines for the management, conservation and sustainable development of all types of forests (Chapter 11 of Agenda 21, Programme Area C, Section 11.23[b]). Also governments recognized that sustainable management and use should be carried out in accordance with national development policies and priorities and on the basis of environmentally sound management guidelines; and that, in the formulation of such guidelines, account should be taken, as appropriate and if applicable, of relevant internationally agreed methodologies and criteria(paragraph 8(d) of the Forest Principles). To promote sustainable forest management in Korea, many actions have been taken in close cooperation with international and regional initiatives about forest resources. In particular, Korea has actively participated in the Montreal Process and others including Intergovernmental Panel on Forests under the UNCSD. Based on the major criteria and indicators for sustainable forest management, the current forest management conditions were evaluated in Korea. The average applicability of criteria and indicators for sustainable forest management in Korea was estimated at about 70% among major criteria, except for legal, economic, and institutional framework. In each criterion, the current status were discussed and future activities were suggested to achieve the sustainable forest management in Korea. In particular, the general conditions of forest management based on criteria in Korea was briefly described and major programmes towards sustainable forest management were explained in context with the long-term Forest Plan, started in 1998.

Sustainable Development of Rubberwood in China

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Keywords: sustainable forestry, plantation, China, preservative treatment, marketing, value-added products

As the 4th largest rubberwood resource in the world, Chinese rubberwood plantations occupy 618,500 ha of which 374,000 ha are on Hainan Island, 156,500 ha are in Yannan Province and 88,000 ha are in Guangdong Province. The rubberwood industry on Hainan Island is more developed than in other areas of of China. Between 1988 and 1997 the production from the General Bureau of Hainan State Farms (GBHSF), which owns 66.5% of rubberwood plantations on Hainan Island was approximately 350,000 m^3 annually from a growing stock of 13.5 million m^3. The demand for rubberwood is expected to increase in the near future because at the end of 1998 China adopted a policy to protect natural forests that will reduce wood supply for quite long time. An annual harvesting of 3% of the standing volume of rubber trees is planned in Hainan State Farms sector. This will yield an annual supply of rubberwood of 418,000 m^3 of logs and 188,000 m^3 of branches. The industrial use of rubberwood began at 1985-1987. The annual production capacity was 400,000 m^3 of sawn timber, 20,000 m^3 of plywood, and 39,000 m^3 of MDF at 1998. The average annual output of rubberwood products from 1991 to 1996 was 60,000 m^3 of sawn timber, 15,000 m^3 of plywood, 25,000 m^3 of particleboard and 779,000 sets/pieces of furniture. Other rubberwood products were flooring, blockboard, moulding board, laminate, and handicrafts.

China has had an active rubberwood research program since the 1980s when the rubberwood industry was established. Research has included sawing, prevention of attack by mold and blue stain fungi or insects, preservative treatment, drying etc., but the main focus is on primary processing. This research provided the basic technical information needed by the rubberwood industry at that time. With the emergence of environmental protection as a critical issue in industrial development, and the consideration of sustainable management of forests in national development, many new problems have arisen in the rubberwood industry. Sodium pentachlorophenol, which is highly toxic to both humans and the environment, is still used as preservative. There are no clear specifications for processing control. And the conversion efficiency during manufacture of rubberwood products is relatively low, which results in waste of drying energy and preservative chemicals.

In order for the conservation of natural forest and the sustainable management of plantation forest, appropriate fast growing tree species should be selected that thrive under the climatic and growing conditions in China while still producing timber with satisfactory characteristics. Rubberwood is such a species. It fits the sub-tropical climate region of China and has acceptable wood properties. Research and development work on rubberwood products, should emphasize improvements in efficiency and competitiveness of the Chinese rubberwood industry. Some important topics to address in this R & D effort include:
1. Identification of clones that can provide high wood volume with good quality;
2. Replacement of sodium pentachlorophenol (NaPCP) with environmental friendly alternatives;
3. Formulation of specifications for raw materials, each stage of production, end-products, and end-uses;
4. Assessment of the end-use performance of manufactured rubberwood items;
5. Manufacture of value added products;
6. Market study and marketing of rubberwood products.

Pelleted Municipal Sludge - A Key Element in Future Resource Cycling and Sustainable Forest Management?

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Keywords: municipal sludge, fertilization, shrubs

Field experiments have been established in northern and southern Sweden on the basis of the vision that forests may become important links in the cycling of waste by-products, such as e.g. municipal sludge and wood ash, and that cycling of environmentally safe sludge pellets could be an important element in sustainable forest management.

New technology, including spraying of newly formed sludge pellets with lime or wood ash, which prevents pellets from sticking together, allows for producing dry and hygienic (non-infectious) pellets that are easily stored and transported. This method eliminates severe problems that are associated with the handling of wet or moist sludge, i.e. high water content, pathogenic bacteria and bad smell. Partly due to these problems and credibility gaps between the general public and public agencies regarding the fate of waste water products, amendments of municipal sludge to agricultural or forest soils have not been generally accepted and become common practise - in spite of the fact that the quality of sludge has constantly improved with respect to e.g. the content of toxic trace metals. Our study was restricted to:

- testing a method of spreading sludge pellets in forest stands
- the pellet fertilization effects on the rate of nitrification and nitrogen turnover
- the heavy metal content in berries, mushrooms and field vegetation in fertilized and unfertilized plots, and
- number of mushroom species and changes in their relative abundance following various amounts of pellet amendments.

In order to test the value of a forest application program with respect to environmental and ecological effects, including single tree and stand growth, dried and hygienic sludge pellets were amended in doses of 0, 4, 8, and 16 tonnes ha^{-1} in Scots pine and Norway spruce dominated forest stands. The pellets contained approximately 32% C, 2.9% N, 1.8% P, 0.2% K, 0.3% Mg, 7.2% Ca and 0.4% S. Each treatment was replicated three times. Nitrate reductase activity (NRA) in vegetation was measured according to Högberg et al. (1986).

The results show that:

(i) an ordinary farm tractor equipped with the most common type of centrifugal spreader designed for commercial fertilizers, can be used for spreading sludge pellets as well. These were evenly distributed after spreading in perpendicular direction from strip roads 10-12 m apart.

(ii) the nitrate reductase (NR) activity in leaves of *Deschampsia flexuosa* (L.) Trin. was moderately (but statistically significant) increased 6-8 weeks after pellet amendments of 4-16 tonnes ha^{-1} (fig. 1). In another set of experimental plots NR activity was still somewhat raised two years after application of 4 tonnes ha-1.

(iii) two years after treatment, the heavy metal concentrations in edible lingonberries (*Vaccinium vitis idaea* L.), blueberries (*Vaccinium myrtillus* L.) and fruitbodies of mycorrhizal fungi, did not differ between untreated control plots and plots recieving 4 tonnes ha^{-1} (Table 1). (iv) inventories of fungal fruitbodies 6-8 weeks after pellet amendments of 4-16 tonnes ha^{-1}, showed that the number of species remained unchanged, while species composition changed significantly. The very large and important genus of Cortinarius decreased in relation to other groups.

Despite constantly improved quality of municipal sludge in Sweden since the 1970´s, pellet concentrations of most heavy metals are higher than in the organic matter of surface soils in the Swedish forests. Possible biological enrichment in microbes, plants and further up in food chains have to be checked. In this investigation no such enrichments were indicated. The results encourage further efforts to find out whether or not cycling of pellets from municipal sludge into silvicultural systems for intensive and extensive production rates can be justified. Provided environmentally sound, relatively large amendments of pellets could be made in areas selected for intensive forest production (pulpwood, fuel) whereas smaller pellet doses could favour timber assortments in forest stands which are reaching the end of the rotation period.

Alternatives to Clearcutting in the Old-growth Forests of Southeast Alaska

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Keywords: sustainable forestry, clearcut, landscape ecology

Clearcut logging of old-growth temperate rain forests is one of the most visible and contentious forest management issues in southeast Alaska. This issue touches the cornerstones of southeast Alaska's economic and social well being: the timber industry, fisheries, tourism, and subsistence. Broader concerns for biological diversity, threatened or endangered species, and the value of wild and remote places have focused national attention on this issue. Observations suggest that southeast Alaskan forests and the associated animal taxa are well adapted to the widespread small-to-medium-sized disturbances caused by wind, disease, and landslides. The use of silvicultural systems other than even-aged management with clearcutting could take advantage of this adaptation to provide a sustainable supply of timber-along with a host of other important values.

The alternatives to clearcutting (ATC) study uses experimental and retrospective approaches to evaluate several silvicultural systems for managing old-growth western hemlock-Sitka spruce (*Tsuga heterophylla-Picea sitchensis*) forests-including even and uneven-aged management-and their biological, physical, and socioeconomic effects. The ATC study integrates research on stand dynamics, forest health, understory plant communities, wildlife habitat, stream ecology, slope stability, hydrology, economics, visual quality, and social acceptability.

Three factors and their interactions are tested in the experimental study: the stand density retained after timber harvest, the spatial pattern of the retained trees (uniform vs. patchy), and the size of patches (gaps or uncut reserve areas). The matrix-patch design includes both 'hard' and 'soft' edges. Post-treatment stand densities range from 0 to 100% of the initial stand basal area (clearcut and uncut control, respectively), with three intermediate densities. Nine treatments are replicated in three blocks located across the Tongass National Forest, and each experimental unit is 18 ha, on average.

The purchase of two major ATC timber sales and the successful harvest of one demonstrated that ATC systems are viable in the current timber marketplace and that the treatments are feasible from technical and safety points of view. In general, residual trees at the first harvested block showed higher levels of harvest related damage in 25% retention prescriptions (top breakage in 5.2-10.2%, bole wounds in 4.0-26.8%) than in 75% retention prescriptions (top breakage in 3.4-4.5%, bole wounds in 3.4-6.4%). Group selection employing gaps with diameters of 200-300 feet was operationally efficient, but 100-foot gaps created severe difficulties during falling and yarding operations.

Second-Growth Western Hemlock Product Yields and Attributes Related to Stand Density

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Keywords: western hemlock, *Tsuga heterphyla*, young-stand management, mechanical properties, pulp

The effect of stand density on 90-year old western hemlock tree and wood characteristics was determined to assist foresters with stand density management. Trees were selected from three Vancouver Island stands. Stand densities were 580 and 930 stems/ha (sph) at two northern locations, and 930 sph at a stand 500 km south. Mean breast-height wood densities were .42, .45 and .47 respectively. The 580 sph stand trees had fastest early growth rate, were taller, larger in diameter, had largest branches, and highest taper. The southern 930 sph stand had the slowest early rate-of growth. Tested in bending, lumber mean modulus-of-elasticity (MOE) and mean modulus-of-rupture (MOR) differed significantly by stand density, and average early growth rate. The 580 sph stand had the lowest proportions of high grade structural lumber and the lowest MOE and MOR values. Structural properties of veneer, LVL, and small clears were consistent by stand with those of lumber. Lumber machined as well, and treated more easily than old growth hemlock. Kraft and TMP pulp properties did not differ significantly by stand. Kraft pulp yields were 1 to 3 percent higher than those published for western hemlock.

Saving the Wooden Rhino in Kenya through Responsible Sourcing and Sustainable Use

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Keywords: Kenya, Wood Carving, 'Responsible sourcing', Sustainable use, *Azadirachta indica*

Wood carving industry in Kenya is a significant source of income for more than 50,000 families and generates about US$ 20 million annually. Like any other wood based industry in Kenya, it relies on raw materials from fast diminishing forests and woodlands. Currently there is widespread awareness and concern amongst wood carvers, conservation organisations and some wood carving exporters that the two major sources of wood, *Dalbergia melanoxylon* (Mpingo) and *Brachylaena huillensis* (Muhugu), have been overexploited. Large trees of the other two popular species, *Olea europaea* subspecies *africana* (Mutamaiyu) and *Combretum schumannii* (Mugurure), are also increasingly difficult to obtain. The preferential demand for these few popular species, a high rate of expansion in wood carving industry, declining forestland, low regeneration capacities and slow growth rates of these species has resulted in acute scarcity of wood carving materials. The carvers have resorted to immature wood from these species or substitutes. Among the alternative species *Azadirachta indica* (Neem) is the most viable substitute.

This paper compares *Azadirachta indica* with the four popular wood carving species in terms of wood properties, quality and cost of products and recommends strategies for substituting these species with it.

The four species have very high density ranging from 0.93 g/cm^3 to 1.23 g/cm^3, very high Janka hardness from 10 KN to 19.7 KN and are very durable. *Azadirachta indica* has a moderately high density of 0.70 g/cm^3, moderate Janka hardness (6.2 KN) and is moderately durable. Its macroscopic and microscopic features are similar to those of the four species except for the interlocked grains, coarser (medium) wood texture, predominantly heterogeneous and multiseriate rays and thinner fibre walls. In terms of costs, wood carvers are currently paying as much (and sometimes a higher price) for Neem (3800-5800 Ksh./m^3) as compared to Muhugu (4600-7700 Ksh./m^3), producing carvings indistinguishable to tourists.

It is concluded that, *Azadirachta indica* has properties that can make it a good substitute for the traditionally used wood carving species. Its use will enable the recovery of wild stocks of the overexploited indigenous species, leading to environmental conservation. To ensure a sustainable supply of wood, it is recommended that wood carvers and farmers plant *Azadirachta indica* as an investment to diversify farm incomes using seeds, wildlings and cuttings. Resource assessment surveys to determine the current stock levels, natural regeneration potential and growth dynamics of Neem have been proposed. Product labelling and certification are recommended.

Jacaratia spinosa: An alternative in the Multiple Use of the Forest

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Keywords: food, chemical modification of wood, *Jacarati spinosa*, plantations

The objectives of this technology development project were: a) to evaluate the possibilities of converting the wood of the tree *Jacarati spinosa*, into a raw material for the production of foods for human consumption, b) to study the conditions necessary for the reproduction, cultivation and growth of this species. After evaluating the chemical components of the wood and its extractives a process was developed to alter their characteristics. This method consisted of hot water extraction to remove compounds that impart an unpleasant flavor followed by hydrolysis with weak acids of natural origin, to modify the wood structure. The second step softens the wood to allow it to be chewed and swallowed. Adding color, flavoring, sweeteners, and perfume then gelling the resulting material completes the process. The final product maintains the aesthetic characteristics of the wood and has an excellent taste. This is not conventional food but the result is an original and novel product that can command a premium price, which in turn leads to acceptable profitability of the process. Information was also gained on the cultivation and tending of this species.

Jacarati spinosa can reproduce without difficulty if it is protected from extreme high and low temperatures are during first years of its development. The best method is to grow young trees under cover. Development of this unique product and evaluation of cultivation techniques has allowed us to improve the value to a species that until now was not commercially important. Commercial recognition promotes its cultivation and provides a non-traditional forest product.

Biodiversity Conservation, Non-Timber Forest Products Management, Rural Livelihoods and Sustainable Forest Management Linkages - Insights from Western Ghats, India

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With the shrinkage of forest resources, the issues of sustainable management of forests (SFM) and conservation of bio-diversity are gaining importance. The likely positive impact of managing the forests for non-timber benefits on sustainable management of forests, is receiving increasing attention. However there is need for greater clarity on the linkages between bio-diversity conservation, NTFP management and rural livelihoods with the sustainable forest management, to develop appropriate policy initiatives for better management of forests. The western Ghats forestry project has attempted to address the issue of SFM of the mega-bio-diversity area of Western ghats through approaches combining conservation and collaborative forest management. The present study specifically explores the linkages between the forest management, use and the livelihoods in western ghats. Through a survey of the forest use by the communities in the Western Ghats the study maps the dependencies of communities on NTFPs for their livelihoods. These studies are inter linked with the studies on the bio-diversity status of the forests to provide insights into bio-diversity conservation, livelihoods and SFM linkages.

Keywords: Biodiversity, Western Ghats, Livelihoods, Sustainable Forest Management, India.

Thinning Western Larch Stands Improves Sustainability of a Valuable Resource

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Keywords: western larch, *Larix occindentalis*, specific gravity, stand density, x-ray densitometry

Western larch (*Larix occindentalis* Nutt.) is one of three native Larix species in North America, besides subalpine larch (*Larix lyallii* Parl.) and tamarack (*Larix laricina*(Du Roi) K. Koch). Western Larch occurs mainly throughout the Upper Columbia River basin of southeastern British Columbia, northwestern Montana and northern Idaho. It easily reaches 50 m in total height. High wood density and strength usually characterize its wood. Throughout most of western larch's natural range, existing stands originated from natural regeneration following wildfires, and are often overstocked. Therefore, early reductions of stand densities by precommercial thinning became an important management tool to establish stabilized stands and to concentrate stand growth potential on fewer vigorous, well-formed trees. This process of maximizing total stand value rather than maximizing yield can be completed by later commercial thinning and artificial pruning. The intent of this study, carried out by Forintek Canada Corp., was to provide basic information on the relationship between tree spacing and the two major wood quality parameters wood density and branch size to support stand management decisions. From young western larch experimental stands in northwest Montana, 618 sample trees were chosen representing different stocking levels ranging form 270 to 4300/ha. From two pith-to-bark cores, taken at breast height for each tree, density profiles were obtained using Forintek's x-ray densitometer. We also measured the largest branch diameters below 4 m stem height. The sample trees showed a strong relationship between width of spacing and tree height and diameter breast height. As expected, trees in the widest spaced plots grew the fastest. Despite large differences in diameter growth, no significant differences in average wood density occurred between spacings. A second moderate thinning on the best sites clearly showed that enhancing the wood density of western larch is possible. For the most valuable part of the tree, the branch sizes do not exceed 20mm even when a wide spacing as 4.6 by 4.6 m is applied. High wood density levels and reasonable knot size confirm that western larch from sustained managed stands remains a valuable tree species in future markets.

Ecosystem Management of Forests In Russia: Place of The Forest Certification

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Forest certification in Russia developed as an obligatory system according to the Article 71 of the Forest Code of the Russian Federation (1997) and the Ordinance of the Government of the Russian Federation from February 2, 1998, 1131 "On obligatory certification of wood stumpage sale and of secondary forest resources" (further referred as FC). Promotion of this system is assigned to the Federal Forest Service of Russia, which will carry out necessary organisational measures according to norms of the Russian Federation Law "On the certification of products, goods and services".

The FC system was developed by a team of specialists, the core of which was the staff of the All-Russian Research and Information Centre for Forest Resources (ARICFR) and Federal Forest Service of Russia, with participation of the experts from many scientific institutions of different Russian ministries and agencies, ecological NGOs (WWF, IUCN, Greenpeace) and other interested federal executive authorities. The team, guided by rules and procedures issued in 1994, with the subsequent agenda and corrigenda, has worked out "Rules of obligatory certification of wood stumpage sale and of secondary forest resources in the forests of the Russian Federation". The FC system is entered into action since July 1, 1999 in several members of the Federation for approbation.

When working out the FC system, the available international experience was taken into account, in particular, principles of the sustainable forest management agreed by the FSC (Forest Stewardship Council) and ISO Standard 14001 "System of environment management. General requirements and management guidelines establishing requirements to the system of environmental management" In the mentioned international systems of certification the assessment of activities on conformity to the normative documents is not stipulated, and instead of the standards of running forest management and use, only requirements of submitting applications are prescribed. The procedure of FC developed in Russia, as well as the systems of voluntary FC working at the moment, are based on assessments of provenance of wood and secondary forest resources, i.e. assessments of forest sites. But in contradistinction to international systems, the Russian FC system provides for an obligatory certification of wood stumpage sale and of secondary forest resources on conformity to the existing Forest legislation, the executive acts of which, with their ecological requirements, have been widely discussed and are agreed with the Russian Ministry of natural resources and the State Committee on environmental protection.

The FC system includes a Central board of forest certification (CBFC) and accredited FC centres. A Council of the System and a Committee of Appeal are being created as bodies of the CBFC. The Council of the System will draw experts of forest management timber industry, representatives of scientific centres dealing with problems of environmental protection and representatives of ecological NGOs. Such centres would organisations independent from forest management units, forest users and consumers and possessing experience in the running of forest management and use (scientific and inventory and planning establishments). Thus, the created FC system allows of the legal acts, and thus to provide the local level of forest management with an effective tool of ecosystem-minded forest management.

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Developing Criteria and Indicators for Sustainable Forest Management at the Forest Management Unit Level in China

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Keywords: criteria and indicators, sustainable forestry, wood

Criteria and indicators (C&I) for sustainable forest management have emerged as a central element of international and domestic forest policy discussion. They also have been described by some as the most important innovation of the decade in the field of forestry. To implement C&I requires the collective commitment of stakeholders, including forest managers and the scientific community, which is particularly true for the development from national-level down to the forest management unit (FMU) level. Based on the framework of C&I for sustainable forest management at the national level, a case study for the further development of the C&I at the FMU level is introduced. The requirements for forest products and services are different at the national, provincial, and FMU levels because the natural, social and economic conditions, and the forests status should be considered during the development of C&I. The forest managers, technicians, research scientists, and national and international consultants jointly identified the appropriate indicators and this process is described. The methodologies and procedures for testing and reporting the identified indicators are also described in this paper.

Division 6
Social, Economic, Information, and Policy Sciences

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6.00.00 Division 6 Meetings

Forest-Socioeconomic Framework for Time Series Analysis of Global, Regional and Country-wise Forest Resources and their Utilization

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Forests have always played important roles for human welfare by providing material and economic benefits to the society in terms of forest products and amenities. The magnitude and sustainability of these contributions through time are linked to the manner in which these forests are utilized and exploited by those countries under whose stewardship these resources fall, often as influenced by global forest resource interdependence. In this work, an analytical framework was developed for studying global, regional and country-wise patterns of forest resource changes vis-…-vis temporal patterns in some socioeconomic indicators such as GNP/capita within the three decades from 1960 to 1980. Using this framework, time series statistics on population, land-use, forest products and trade of FAO from 1961-1991 as well as annual data on GNP from 1970-1989 were analyzed. The work progressed from a macro global view to micro country-wise case studies. As a baseline, countries of the world were first classified into six groups differing in economic status and forest resource basis. In general terms, the classification allowed a broader perspective of the present global status in forest endowment and income levels, which in some ways are indicative of economic development or industrialization. Further analysis identified countries with significant changes in forest resources basis within the last three decades. Almost 60% of those were industrializing countries in South America and Southeast Asia. On a phase plane of income versus forest resource basis, the global trend showed decreasing forest resources vis-…-vis increasing income. However, country-wise patterns included periods of decreasing forest resources along with declining income or slowed economic growth. Countries of Southeast Asia, whose economies greatly benefited and is still benefiting from forest resources, particularly exhibited this pattern. Forest products production and trade patterns in Indonesia, Malaysia, the Philippines and Thailand, who altogether accounted for 13% of the 380 M ha global decrease in forest and woodland cover from 1961-1991, were analyzed as case studies. This was to further understand how these countries used their forest resources for material gains and the sustainability of these benefits. For these countries, primary forest products significantly contributed to their economies but this contribution was either not sustained with the forest resources being depleted, as illustrated by the Philippine case, or remained significant, as in the case of Indonesia. The patterns of utilization shown by these countries revealed that the rate, timing, and scale of transition of forest product production and export from raw to processed forms relative to changes in forest resource basis, could be a major contributor to the success or the decline of forest-based industrialization and the resultant state of forest resources. Indonesia who phased out the export of industrial roundwood within a short period in the 1980s while at the same time expanded their wood-based panel industry exemplified this pattern. The transition was drastic and large-scale and occurred when the forest resource base was still high. Despite temporary reduction in the early 1980s, processed forest product exports steadily rose to account for more than 10% of the country's total merchandize exports in 1991. For the Philippine case, forest products exports (mostly in raw form), which accounted for 22% of total merchandize exports in 1961, peaked in the late 1960s and dropped to only 0.96% in 1992. The forest resource base was already on the decline when exports of processed products were increased. With much reduced domestic raw material sources and undeveloped industry, such expansion was not sustained and the Philippines became a net importer of forest products by 1990 with forest per capita at 0.15 ha.

Total Valuation of Environmental Services of the Tropical Rain Forest: Policy Implications

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One major limitation to integrated the forest and society needs has been the fact that when in the past we have look at the forest we think only of one product timber resulting such a consideration in one major shortcoming that when policies to deal with the forest and its problems are design what the thinking is only in terms of the consideration related to timber production.

The paper will report the individual of the past 4 years at the Tropical Agriculture Research and higher Education Center (CATIE) were we have conducted a series of research studies on the valuation of Environmental Services in order to attempt to do two things a) test some possible methods and b) tog et a feel for the possible values of the different environmental services other than timber. The goods and services that we have developed preliminary values are: carbon sequestration for, water production under different uses, ecotourism, biodiversity for pharmaceutical purposes and non-timber forest products.

The major problem that we have observed when dealing with environmental services is that fact that the money that can be estimated to be attributed to such services are imputed social values and it has been very difficult to developed mechanism for collection and allocation of a part of such values to the owners of the forest which the persons in the final analysis responsible for the safe keeping of the forest this problem does not happen with timber that can be appropriated and sold by individuals with the logical benefits deriving from such actions it is felt that unless such mechanism are developed to make the transfer payments environmental services will only be of academic interest.

Other problems that have been identify for such environmental services have been: lack of credit mechanism to promote them, markets, adequate balance between production and conservation practices and reliable technical and inventory data to permit relevant physical quantification elements that united to the transfer payment problems cited above make policy recommendations and decisions associated with them very complex.

Social and Economic Problems of Society and their Influence on Mountainous Forests of Tajikistan

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Tajikistan is the mountainous country, which situated in the Central Asia. After destruction of the USSR, acquirement of independence and the civil war this republic collided with many social and economic problems which hadn't be seen at the past. These were the such problems like lack of the fuel and food which directly influenced on mountainous forests. The total area of forests in Tajikistan is the 3% from whole country's area. Most of them are situated in mountain region of republic. In the valley zone there is some areas of jungle which situated by small fields in the hood-lands of big rivers. But in the last time the areas of tugai forests are abrupt decreased. In the Soviet Union period the biggest part of tugai forests was cut and made for the cotton. At the moment the only in "Tigrovaya balka" preservation there is strong tugai forests grow. But now there also started to cut them down.

Pistachio, hawthorn and another small leaved forests are situated in the front and low mountain zones. Small leaved, wide leaved and juniper forests are grow in the middle mountain zone of republic. Juniper forests are situated in the high mountain zone. All forests of Tajikistan have nature protective and soil protection meaning for country.

Forests play the huge role in the mountainous landscape's preservation and restoration. The inconsiderable violation of mountainous ecosystem by society may lead to destruction of whole mountainous landscape. The influence of society on landscape happens by the scheme of social and economical problems. At the beginning of this scheme the cutting of forests takes place and then destroying of vegetation and developing of the steep slopes. In the center of this scheme the society with its problems takes place. This society can render the double influence on forest formation. They are negative and positive influences.

The negative influence can lead to decreasing of natural forest's areas. It may intensify the erosion processes. Degradation or desertification are strongly influence on social and economical problems of society. The soiling of the water, the decreasing of agricultural productivity, the destroying of productive soils etc. are negatively influence on society's life.

The various strata of society in the upper watershed zone of the mountainous rivers are destroying walnut, juniper etc. forests and shrubbery which grew several centuries. That is the reason of the floods formation in the cold period. They flood and destroy the populated territories, irrigated lands and economic objects.

The main aim of the society at the moment is the providing people by the products of nourishment and widening of the cotton fields. So at the south of republic the several thousands ha of forests was cut down. These forests reliably fixed the soil from wind erosion. Now these erosion become strength and many barkhans which slowly move to the populated points and destroy the agricultural areas. It is known that the cutting of tugai forests in the long period is increased the area of desertification in the south side of republic and it is became the reason of population migration. These forests protected this territory of Tajikistan from the strong afghan winds in the past. In north of Tajikistan the tugai forests also was destroyed. The goal of this destroying was the increasing areas of cotton fields but it leaded to intensify of desertification.

Now in all high geomorphologic zones of the Pamirs-Alai mountain system the biggest negative load of society on forest territory can be observed. It is the using the forests as fuel, the extension of slope developed lands at the expense of pasture's and forest's lands which used for cereal cultivation and biggest load on the pasture forest lands. These and many another anthropological factors often lead to formation of soil degradation, landslides and sliding of upper layer of productive land.

The integration of Urban Forestry and Soft Landscape Plantings: The Case Study of the City of Kuala Lumpur

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This paper presents the history and the development of trees and shrubs planting in the city of Kuala Lumpur, Malaysia. Beginning with its founding at the confluence of two rivers, Kuala Lumpur during the colonial era has seen the introduction of a combination of exotic and local tree species by the British that were based on the needs for shade and beauty amidst the humidity of the tropical climate. The lack of seasonality in this city of humid tropic affects the vegetation profoundly. Since growth takes place throughout the year the vegetation has somewhat come in conflict with the pace of the development of the city. Some of the trees have been downsized, pruned or even cut down to make way for urbanisation. This is more apparent after Kuala Lumpur was declared a territory of the federal government in 1974.

The administration of the city was under the jurisdiction of the Kuala Lumpur City Hall (Dewan Bandaraya Kuala Lumpur or affectionately known by its acronym as DBKL) which undertook a majestic task of transforming it into a tropical garden city. Rows and rows of trees were planted along the streets, housing areas, office buildings and commercial centres. Millions of dollars were allocated yearly for the purpose of urban plantings, maintenance, and tree preservations. Many new species of trees were introduced and planted alongside low and medium sized shrubs for functional and aesthetic purposes. The lists of some of these species most used in urban plantings, their families and botanical names are mentioned in this paper. Such an immense effort by DBKL has produced result that transformed Kuala Lumpur into a garden city where people can live and work in a balanced and healthy environment. However, such transformation is not without problems but nevertheless DBKL has managed to solve them with high imagination and perseverance. These challenges are in many ways similar to other cities throughout the world, so the lessons learnt in Kuala Lumpur may be applicable to others.

Insertion Potentialities of the Uruguayan Forest Research in the South Cone Region (Cono Sur)

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Keywords: Forest research; policy; Latin America; South Cone Region; Uruguay.

The objective of this poster is to present a synthesis of the current state of the Uruguayan forest research and a study of his insertion potentialities in the South Cone Region (Cono Sur) of Latin America.

Uruguay has traditionally been a livestock producing country and, comparatively, forestry may be assimilated to a new alternative economic activity. In the eighties and nineties decades, a highly structured forestry policy with an exceptional package of incentives, was developed by the government, bringing on sound changes at institutional levels. In this context, the state of the forest research will be presented through a description and an analysis of the institutional policies as applied nowadays in the country, as well as the trends and scopes of the prospection and generation of technology. The role of the private sector will be also assessed and networking and international co-operation highlighted, taking into account the present and potential actions of international organizations such as FAO (Food an Agriculture Organization of the United Nations), IBD (Inter-American Bank of Development), IIAC (Inter-American Institute of Agricultural Co-operation), IUFRO (International Union of Forestry Research Organizations) etc. The role of the National Agriculture Research Institute (INIA) and his National Forestry Program will be specially emphasized.

The insertion potentialities of the Uruguayan forest research in the South Cone Region (Cono Sur) will be evaluated by the mean of a comparative study of the research systems of the main neighbouring countries (Brazil, Argentina, Chile essentially) and the weighing of the strengths and debilities of the Uruguayan system. The short and long terms goals to be reached for the concretion of this potential regional insertion and the actions for achieving it will be exposed.

A multiple-objective Forest Estate Planning Model Based on the Montreal Process Criteria: A Case Study for a Beech Forest in Chile

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A multiple-objective planning model for the management of forest estates based on the Montreal Process criteria is proposed. Economic, social and environmental objectives were clearly identified as well as restrictions on non-decreasing yield for economic, social and environmental value (our "weak" attempt to achieve the condition of sustainability). We explored the influence of the profile of distinct decisions makers over the policy of management of a forest estate.

A case study was developed regarding a forest estate (15.000 ha) made up by three croptypes of three native beech species located in the Comuna of Panguipulli, Province of Valdivia in Chile. The management regimes were a combination of silvicultural methods (clearfelling or shelterwood system) and size of the maximum area harvested (<25ha, 25-50 ha, >50ha). The model was run for a planning horizon of hundred years, and time was aggregated in periods of ten years. Seven scenarios were analysed considering the profile of different decisions makers. The profile was defined by the relative weight each decisions maker assigned to the economic, social and environmental objective. These objectives were set up as a combination of different indicators of the first six criteria of the Montreal Process. Preliminary results, showed that for those decision makers that weight the economic objective ten times over the social and environmental ones (achievement of 87%, 38% and 46% respectively), the decision of harvesting was mainly on clearfelling in large areas (>50 ha), replacing gradually by the end of the planning horizon for the shelterwood system in small areas (<25 ha).

Prediction of bioprospecting policy implementation in the Philippines

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In response to the Convention on Biodiversity, the Philippine government promulgated the Executive Order 247 together with the Department Administrative Order 96-20 (DAO 96-20) in 1995-1996 to regulate access to biological and genetic resources in the country. Prospecting of flora and faunal resources, including microorganisms for commercial, industrial and agricultural applications is covered by academic and commercial research agreements (ARA, CRA) with concerned departments such as Department of Agriculture (DA), Department of Environment and Natural Resources (DENR), Department of Science and Technology (DOST) and Department of Health (DOH). Applications for bioprospecting agreements are processed through the Technical Secretariat at the DENR and at the Interagency Committee on Biological and Genetic Resource (IACBGR). The latter recommends specific actions to the concerned Department, depending on the kind and species of materials to be collected and researched on.

One salient requirement for the research agreement is the prior informed consent (PIC) obtained from stakeholders where the resources are located such Protected Area Management Board (PAMB) for national parks, reserves and refuges, Local Government Unit (LGU) for those in public domains and private land owners in titled lands. The PIC process which involves public notification and hearings, sectoral consultations, community assemblies, posters and billboards whereby the research undertaking are presented in a language/dialect understood by the concerned stakeholders and local people. It should include purpose/s, methodologies, species/ specimen and quantity to be collected and equitable sharing of benefits.

With the executive order being in effect for two (2) years now and in the light of the provisions involving civil society, local government units and indigenous people, the paper will present the status of implementation with the use of the Situation-Structure-Performance (S-S-P) paradigm of Schimdt (1981) in the analysis. Prediction of whether the policy process is effective or efficient and compared with the realities encountered in the implementation will be made. Reasons behind the scenario and recommendations will be discussed for possible amendments or revision of the policy statutes. In the S-S-P paradigm, situation refers to the attributes of the resources covered by the policy, structure refers to the institutions and mechanisms operating in the process of implementation while performance results from the interaction of S-S to determine result of implementation.

Land Use Management For Sloppy Areas Using Four Appropriate Schemes in the Philippines

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In the Philippines, interest on agroforestry as a land-use management particularly in sloppy areas was intensified over the last decade because of some factors: there is tremendous migration of population in sloppy areas and the increased cultivation activities in sloppy areas resulted in tremendous soil erosion which consequently adversely affected agricultural and marine production. The objective of the study were to design and test various appropriate land.use management schemes in the Philippines; and to evaluate each scheme according to the following: soil erosion control, soil fertility changes, crop production, farmers acceptability and financial costbenefit analysis.

Result indicated that, multi-storey Cropping Scheme had the least soil erosion. The average soil erosion was 2.88 cm during the two years of observation. Alley Cropping Scheme had the highest soil erosion of 3.91 cm during the two years of obversation. Soil fertility changes differed variably with each soil parameters measured in four appropriate land-use management schemes. Yield of annual and horticultural crops grown in Sloping Agricultural Land Technology (SALT) Scheme was highest. The lowest was observed in multi-storey Cropping Scheme. Farmers preference to the appropriate land-use management schemes introduced were SALT Scheme and Alley Cropping Scheme as first choice. In terms of financial analysis using net present value and benefitcost ratio, SALT Scheme ranked first.

Employment and the Social Sustainability of Forest Sector

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Wood resourses are considered to be the most important of the economic resources supplied by the forest, and roundwood is considered to be the main product of the forestry. Especially in Finland, wood is the only domestic and renewable natural resource which can be sustainably utilised. The exploitation of wood recources also creates the main source of forest-based employment. Consequenly, the employment effect of the wood consumption is specifically emphasised in the discussion concerning the socio-economic effects of forest protection. The employment level achieved by utilising wood resources is one of the criteria of the social sustainability framework of the forestry sector. The aim of this paper is to discuss how employment can be measured and in which way it should be considered in order to achieve a functioning indicator of social sustainability in the forest sector. When using absolute values of the employment, persons or man-years, it is not possible to compare areas or countries of different sizes. If forestry employment is compared to the total employment, the relative significance of the forestry sector as employer is achieved. The social sustainability embodied in this figure is not necessarily indicated, because the employment shares ashieved do not contain the information as to how the renewable natural resource is utilised. If the frame of the sustainable utilisation of the renawable natural resource is to be included in the employment indicator, then the employment achieved must be compared to the quantity of roundwood used. This is defined as the labour input intensity coefficient, LIIC=1 man year/1000 m^3 roundwood. The LIIC is defined as the labour input, which is contained in the unit volume of roundwood leaving forest and its manufacture into forest industry products in a given country or region. Labour input is contained in wood raw material in three stages, in the forestry stage, in the primary manufacturing stage and in the secondary manufacturing stage. The end product of forestry is roundwood, to which end all extension-, improvement-, silvicultural-, harvesting- and transporting work is aimed. Primary wood manufacturing includes sawmilling and the plywood-, board-, pulp- and paper and peperboard industries. Secondary wood manufacturing includes carpentry, furniture, paper- and peperboard products, as well as the printing industry. The LIIC depends on the value-added- and on the productivity of the forest sector-production. In the empirical part of this paper is comparisons made by regions, by country and by industry. For example, the employment of forest sector in Finland in year 1997 was 140 000 man years and the consumption of roundwood in the same year was 70 million cubic meters solid volume. Thus the labour input intensity coefficient for the Finnish forest sector in the whole in year 1997 was 140000/70000=2. LIIC= 2 man years/1000 cubic meters round wood.

Bamboo as a Source of Livelihood in Philippine Rural Areas

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Bamboos, the tallest grass, have a long history as an exceptionally versatile and widely-used resource that provide sustenance, shelter and income especially to the rural poor. The uses of bamboo vary from place to place depending upon the choice of the local people as well as on the priority export products identified by the Department of Trade and Industry and the Department of Science and Technology. The industry receives full assistance and support under the Medium Term Research and Development Plan.

One strategy by which to increase productivity among makers of bamboo products, provide equitable benefits and assure quality of life to the farmers and weavers, is to form/organize a cooperative among themselves to minimize layers of middlemen and maximize the profit. The cooperative would supervise a trading center that will showcase the finished bamboo products as well as the marketing of the goods for local and foreign markets, with support and proper linkages with government an non-government organizations, other agencies and private companies.

Traditional systems as models for agroforestry development in Europe

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Agroforestry was a common practice all over Europe until about two centuries ago, when industrialisation made labour more expensive, and agronomic progress allowed the maintenance of soil fertility without recourse to reforestation. Nevertheless, a wide range of land-uses remain which integrate trees with animals and crops. Two of the most successful traditional systems are 'streuobst' in temperate Europe (namely Germany and neighbouring countries), where fruit trees are grown on agricultural land undersown with crops or grassland, and the Iberian Peninsula 'dehesa/montado' system, where wide-spaced evergreen oaks are grown in pastures grazed by pigs, sheep and cattle.

Recent decades in temperate Europe have brought an intensification and specialisation of land use, leading to overproduction of agricultural commodities and environmental damage in many regions. Intensification has also occurred in Mediterranean Europe, but it has been accompanied by extensification and abandonment of marginal agricultural areas. Traditional forms of agroforestry such streuobst and dehesa/montado systems have been diminished by both processes of intensification and extensification. However, streuobst still has a considerable im-pact on the European fruit market, and covers 1 Mha in temperate Europe. The evergreen oak dehesa/montado system covers more than 4 Mha in southern and southwest Spain and 0.6 Mha in Portugal. Total silvopastoral land-cover in the Iberian Peninsula, including more general forest grazing, extends to over 9 Mha. Some of these systems are now protected by law, and grants are becoming available for their re-establishment. This trend has been triggered by a combination of pressure from farmers and environmental NGOs, and has apparently stopped and reversed the loss of agroforestry in Europe.

The history and present status of traditional agroforestry systems in Europe holds lessons for the policy makers which will be examined in the particular context of streuobst and dehesa/montado systems:

1. Agroforestry provides environmental and socio-cultural services like biodiver-sity enhancement,

water quality protection, erosion control, fire limitation, landscape aesthetics, recreation and cultural functions;

2. The economics of agroforestry needs to be compared with forestry and farming on a 'level playing field', without considering distortions caused by competing grants, in order for traditional systems to be preserved, and for the advantages of novel systems to be recognised;

3. Farmers' attitudes to agroforestry depend on its place in local tradition, and, in those areas where it is no longer a traditional practice, whether it can be re-introduced using modern and cost-effective techniques;

4. Public support, based on the recognition of environmental and socio-cultural benefits, is a key to the preservation of existing agroforestry as well as to the spread of modern systems. Agroforestry needs both marketing opportunities and a favourable legal framework.

Policy-makers attitudes towards agroforestry (e.g. in the interpretation of EU Regulation 2080/92) varies considerably between countries and regions, and is given particular consideration in this paper. The reform guidelines for the Common Agricultural Policy ('Agenda 2000'), which aim to change the emphasis from agricultural price guarantees to farmer income support, will be examined with respect to the scope for traditional agroforestry systems to contribute to a 'European Model of Sustainable Agriculture and Forestry'.

Identification of technological demands: a methodological proposal

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The characterization of any agricultural or forestry business requires a knowlege which is not only technical

The characterization of the agribusiness demands knowledge that transcends the tchnical disciplinary area and is based in three theoretical vertices: 1) systemic approach 2) marketing studies and segmentation and 3) prospective vision.

A thorough market analysis is fundamental to the definition of a technology generation strategy and latter transference. It is widely known that technologies that do not meet society requirements tend to fail.

The main problem of research and development institutes is finding the answer to the following questions: 1) what should be researched? and 2) how human and financial resourses should be distributed among different proposed projects.

This paper aims at describing a methodology which leds to the identification of factors affecting sustainability and competitivity of agroforestry businesses, potencial markets fror their products and propose actions to local forest development and to the definition of research opportunities and requirements.

The methodology proposed includes the identification of agroforestry business elements based on the concept of demand prospection, systemic approach and market segmentation.

Forest Certification - Some Principle Issues Related to Economics and Policy

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Certification and labelling of forest products are being proposed by several interest groups to promote sustainable forestry. This paper aims at analysing more principally various economic and policy aspects related to forest certification often overlooked in the general debate. The following questions are emphasised in the paper:

- Do various certification systems create particular problems in the forest sector?
- What are the actual costs of certification - for the various stakeholders and society at large?
- What are the benefits? Under which conditions is certification a good investment for the forest owners?
- What are the likely distributional impacts between stakeholders and regions of various certification schemes?

Can we get differentiated markets-one market for certified forest products and another for non-certified ones - and what are the consequences?

The Globalisation and Europeanisation of Forest Politics: Impacts on National Actor Constellations

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Keywords: forest policy, multi-level governance, EU forest politics, Austria

The interest intermediation system has always attracted the attention of forest policy scientists. However, research on this subject has focused on the national level, despite the fact that forest issues are increasingly prominent on international and European agendas. Accordingly, the peculiarities of multi-level policy processes have not been sufficiently taken into account. The poster aims at representing how interna-tional forest politics and the integration of na-tional actors in the EU system of joint decision-making affect national actor constellations. To this end, it primarily draws on hypotheses of multi-level governance scholars as well as on my own empirical results regarding the mechanisms inherent to multi-level policy-making that affect the na-tional ac-tors' perspectives and influence.

In some European countries (Austria, e.g.) rather closed forest policy networks have emerged in the past. This actor networks are firmly rooted in legal and adminis-trative in-stitutions and characterised by a limited number of participants, a high degree of consis-tency in membership and out-comes on the long term, and a rather broad consen-sus on policy core beliefs and preferences. However, the secto-ral networks have come increasingly under pressure in recent years. On the one hand, pressure stems from in-creasing public awareness about forests and the subsequent develop-ment of in-terna-tional re-gimes. On the other hand, domestic ac-tors from EU-countries are increasingly in-volved in intergovernmental as well as supranational forest policy-making.

The European states and the EU itself were strongly involved in interna-tional initiatives on forestry in the wake of increasing public awareness of forest issues in the 1980s. The definite break-through of the 'forest issue' onto the international agenda came through the 1992 Rio Earth Summit (UNCED) and the commitments that were made there. Since then, the interna-tional dialogue on forests has continued at the UN and the pan-European levels. Furthermore, one has to take into account the ini-tiatives on forest certification that took place in recent years on international, regional as well as national levels.

Besides intergovernmental dialogues on forests EU policy-making is also quite significant with regard to national forest policy networks: The EU level provides a political arena for co-ordinating national policies and positions in the context of international processes; there is a large body of EU policies that affects the national forest sector either directly or indirectly; and - last but not least - the evolution of a multi-level system of joint decision-making has brought about sub-stantial changes in the logic of influence for domestic actors. It com-prises new actors and institutionalised arenas, and provides additional points of access. Since there is an additional supranational dimension, the EU typifies a political system quite dif-ferent from the inter-govern-mental arenas men-tioned above. One of the main aims of the poster is provide a comprehensive explanatory framework for analysing different mechanisms of the "Europeanisation" of forest policy-making and their domestic impacts.

Summarising, I offer some hy-potheses and indications suggesting that national forest policy net-works are subject to significant change. For the time be-ing, the external demands for policy change have manifested primarily in institu-tional changes at all levels. From an actor-centred perspective it is shown that forestry interest groups still tend to favour national strategies, as well as national channels of interest interme-diation, whereas other groups that do not en-joy privileged access at the national level are more likely to attempt to shift forest issues to the EU/international agenda. Perhaps most interestingly, I argue that the Globalisation and Europeanisation of for-est policy entail some mechanisms that provide public actors with additional opportunities to mitigate the influence of private in-terest groups. Public actors may gain additional lee-way to pur-sue their own strategies; the loss of autonomy that they have to suffer because of EU inte-gra-tion can be compensated by gains in autonomy vis-…-vis other national actors. Political scientists call this phenomenon the 'paradox of weakness'.

A Rural Promotion Plan in Sub-Mountainous Area

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Agriculture had no competitive productivity compared to another industry in Japan. However, they still have more efficiency on environmental conservation. When developing a rural area, the most important matter is to harmony development with nature and human life. Especially in agricultural region, the total assessment method for ecosystem and nature should be done to evaluate the watershed conditions before and after development. In these, ecosystem map was evaluated by the natural condition scores of Vegetation and animals. Landslide risk map was calculated by the Quantification analysis method I. Flood risk map and water resource map were simulated by the synthetic unit-graph method respectively. Successively, the agricultural promotion plans were suggested by considering the charaeteristics of rural site conditions. These plans are summarized as follows:

1. Promotion of a side business farmer is the actual sustainable agriculture because of the economical condition in a small field.

2. Modernized house construction is useful for the young generation because of the difference of life styles between new and old generations.

3. New producing system with the co-operative working groups is necessary for them efficiently to maintain a small and separate fields.

4. New crops with a high additional value are the most suitable ones in a submountainous field.

5. Synthetic use of rural resources, hot-spring and landscape etc., is the foundation of a new industry (welfare facilities) for the coming of aged society in Japan.

6. To support these plans, the transportation net work system should be constructed to link the rural to a large city at first.

The Coordination between Government and Non-government Organisation (NGOs) for Agroforestry Systems Implementation in Nepal

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Agroforestry in the hills of Nepal is an indigenous system where agricultural crops and trees are grown together for the sustenance of farming systems. Currently, the government and Non-government Organisations (NGOs) are involved in the promotion of agroforestry activities on private land, community land, degraded forest and community forest in order to increase the forest products needed for the protection and management of national forests, community forests and fragile mountain environments. The process of agroforestry systems implementation and the role of the Department of Forest (DOF) and the NGOs differ according to the area in which agroforestry systems are practiced. DOF has a significant role in the implementation of agroforestry activities in community forest and degraded forest land, whereas NGOs are playing vital role in private land and community land. However, NGOs are also encouraged for the support of community forest user group for agroforestry systems extension in some hill districts. The process which they have used for the implementation of agroforestry activities by involving local community in coordination with the government staff in various areas is supportive to the government and people for forestry development in Nepal.

Forest in Discussion in Austrian Printmedia with Special Consideration on Forest Restoration

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Due to the continuous successful research of the scientists the knowledge about the forest restoration increases. However this knowlegde may have an impact on the forest state of health if it is furthermore part of the political discussion. Regard to this subject the media is of essential importance to enter the scientific knowledge in the political process. Communication through the mass media is a central part of political life. In the role of the mass media as a multiplicator they make contributions to determine the agenda setting and to inspire confidence and acceptance in the population. Therefore communicators of different groups compete for their position in the media, forestry as well, both from the scientific and practical side.

The interaction of the media with the respective participants leads to some sort of topic-career, passing certain phases of media reporting (RUSS-MOHL 1981). Many themes, however, particulary of the forestry sector, do not exceed the preliminary phase as they cannot pass the threshold of attention.

One of only a few themes that captures great public attention is the phenomenon forest die-back. In the initial phase some "damage to forest" became the topic "Waldsterben" in the media. A report in the magazin SPIEGEL in the year 1981 can be considered the effecting event. During the following upswing-phase this topic was quite often used in the media and was reflected in a spectacular way.

It pushes other forest topics absolutely away from the media. The reversal phase is characterized by objective description which overweighs the spectacular reporting. According to RUSS-MOHL the regressive and the termination phases constitute the final of the topic-career.

Following these phases of media reporting, the topic forest die-back which has passed the upswing-phases already long ago (1984/85 and 1987) must have already disappeared from the media's visual angle. Publications of GLÜCK 1986, KRÄMER/SUDA 1987 and KROTT 1987 already presumed the approaching end of the career of the dying of the forests. Recent publications regarding the topic dying of the forest in the media clearly show that the dying of the forest only - at least only - has the status of an average daily incident and it can be rewrite stereotyply and it can be conjure up everytime (ZIERHOFER 1998 and HOLZBERGER 1995).

The analysis of 564 articles of Austrian newspapers (Der Standard, Die Presse, Die Neue Kronen Zeitung, Der Kurier) from 1994 to 1998 support this hypothesis. The main topic forest has a large variety of subtopics such as timber production, spare time, finances, restoration of barrier woodland etc. Yet, in 20% of the articles places special emphasis on the topic dying of the forests and the moderate form of damage the forests. Half of all articles on the dying of the forest also contain the topic forest restoration. The description of these restoration measures varies a lot.

The result in front underlines that the forest die-back and the connected forest restoration measures are still published as problems in the media. It follows from this the second main hypothesis of this paper. The policy analysis says that problems can never be objective. According to WINDHOFF-HERETIER (1987) are the definition of problems the result of political demands of different social groups. Different groups, like environmental groups, foresters, scientists and politicians, compete for the definition of the problem of forest die-back and forest restoration measures. This leads to the following hypothesis: The scientific description and knowledge and the powerful interest reporting of forest die-back and forest restoration of the media are far apart from each other.

The content analysis of the articles of the four Austrian newspapers shows that scientists - in spite of their knowledge - don't dominate the discussion about forest die-back and forest restoration measures. Of those who thanks to the dying of the forest gained a place in the media, it is above all the political actors who are in the best position. Especially the Austrian minister of forestry Molterer is repeatedly mentioned. By way of comparison the scientists and the foresters are fare less mentioned in the newspapers. A second important result of this analysis is that in the discussion about dying of the forest in the media environmental groups are of no importance.

It follows from that the question why the politicians and not the scientists dominate the definition of the problem of forest die-back and forest restoration measures in the media. A possible answer on this question could be the analysis of KEPPLINGER (1998). According to the most recent research report of KEPPLINGER the events with regard to their causes can divide into the following three classes: Genuine events are independent from the reporting of the media. An example for this are the forest cut, forest restoration measures like seed collection or debates about the state of the forest report. Media events are occurences which would happen presumable without the expected reporting of the media but which get with regard to them a specific media character. Example is the tree of the year. Produced events are only arranged for the reporting and therefore not happen without the expected publicity. Examples are most demonstrations, press conferences and meetings at special, spectacular locations (Dead spruce in the Harz). KEPPLINGER supposes that the politicians adapt to the media and produce more and more events for the media. Following this analysis results the third hypothesis of this paper: The reasons of the published events with the topic forest die-back and forest restoration measures are most of all produced for the media. This means that not scientific results enter the media but produced events. This will be checked by an empirical analysis. If this become true the scientific state of art of forest restoration is not reported to the stakeholders but a very different picture drawn by the media.

Keywords: policy science, forest restoration, media, Austria

Active perception of forestry in the media

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Similar to the discourse in specific literature, the way in which the subject of "forest restoration" is presented and framed in the media differs considerably from the scientific way to describe the problem. Communication theory indicates that the picture of forests in the media is created by single messages which are often repeated in articles (such as dying forests, forests as an important economic factor, forests as symbols for unspoiled nature). In the (over)simplifying logic of the media, forest-related messages are often attributable to either of two (apparently) conflicting sectors: forestry or nature conservation. In addition, there are messages in newspapers which cannot be assigned to any of the two sectors (as for example forests as a symbol for crime). Political analysis relies on the fact that news messages reveal the different values of the sectors and report about their central functions.

Worldwide Urban Forestry Trends for the New Millenium

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The future of mankind is urban. In the next decade, most of the developing countries, which are not yet urban societies, will become predominantly urbanized. Urbanization of poverty is the greatest challenge. However, still most efforts to carry out forestry, recreation, and poverty alleviation have focused on rural areas, while urban people tend to live in degraded natural environments. Trees and related vegetation in urban areas have been considered less important than the built structures, roads, and utilities. However increasingly municipalities around the world have launched urban forestry programs. Only in development cooperation the forestry profession is conspicuously absent in urban initiatives. This paper examines the present status and the outlook of urban forestry around the world. The focus is on poverty alleviation, innovative approaches of public-private partnerships and multi-resource management. Major conclusions of the review are: (1) The need and influence of urban societies will dramatically change the priorities in forestry research and development, in favor of urban areas. (2) Urban forestry is a modern approach to urban tree management, encompassing long-term planning, professional coordination and local participation. (3) Urban forests are economic assets. The overall values of urban forests are such, that they are increasingly regarded as a vital component of the urban infrastructure essential in maintaining a livable and sustainable environment. (4) To develop and sustain urban forests in poor neighborhoods the initial focus must be on meeting immediate needs for basic necessities. This can be best achieved by multiple resource use. Most successful urban forestry initiatives in developing countries are those that achieve generating and sharing of short term profits with the need of long term urban forest conservation among different stakeholders. (5) Urban forestry is no longer an exclusive domain of the public sector. Diverse innovative public-private partnerships, as evolving around the world demonstrate this new urban forestry concepts in action. (6) Financing of urban forestry programs must come from a creative mix of public and private sources. Debt-for-nature swaps, trust funds with the private sector, International Conventions (e.g. UN Framework Convention on Climate Change, Convention to Combat Desertification) need to be further explored as new mechanisms to fund urban forestry research and development projects.

The Cognition of Forester and its Implication to the Establishment of Forestry Fund in Taiwan

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This study tries to draw up a forestry fund institution that is suitable for nowadays social economical situations in Taiwan. It explores on the basis of some principles in establishing fund and carried out by questionnaires, collecting data and events as well as in comparison with other countries' experiences. The results show that most respondents think the government should set up forestry fund ,and factor analysis shows that both the purpose and source of that have a concentrated trend. The purpose of that focuses on the reforestation and the source of that is looking into cost of water utilization and feedback charges of slopeland developing. This study also emphasizes the meanings of water use right cost and feedback charges in laws, as well as the practice rule. Furthermore , it is calculated the unit cost of water use for setting up a reasonable rate for different departments in the future.

People’s Dependence on Forest and the Changing Legal Profile

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People in India are dependent on forests for the goods and services produced since time immemorial. Apart from timber poles, and fueldwood, which were classically categorised as "major forest produce", the dependence is also and even to a larger extent,on several other produce which were referred as "minor forest produce". Though the nomenclature for the later has been changed in the recent years, as "non timber forest produce" (NTFP), dimension and magnitude of the problems remain unchanged. Present paper opts for two such produce viz., Bamboo and Tendu leaves (*Diospyros melanoxylon*) to elaborate people's dependence and the changing legal profile in the country.

As per the Indian Forest Act, the prime act regarding forest, bamboos are classified as timber. Poor forest dwellers use bamboo in the construction of their huts though the other modes of use vary from eating young bamboo rhizome, fencing their field to making mats, baskets and various other artifacts and selling them in the market to earn livelihood. "Nistar rules" (rules for concessional supply of forest produce to the villagers) at many places have provisions for supplying bamboo to the villagers though due to shrinkage of forest resources provisions can hardly be followed.

Tendu leaves on the other hand, are used in the large scale "Bidi" manufacturing process (Bidi is country cigarette prepare by rolling tobacco within the dried tendu leaves) and forest dwellers / villagers come in the picture in this regard, as labourers to collect the leaves from the forests and to sell it to the contractors. As per the Minor Forest Produce (Regulation) Act in most of the cases, trade in tendu leaves is a state monopoly. An amendment to the Wildlife (Protection) Act, in the early nineties has created distinct hardship in the life of the people collecting tendu leaves from the wildlife sanctuary areas.

Though National Forest Policy and various Acts did not provide an important status to the NTFPs, various management systems partially recognised its value. In "coppice with reserve (CWR)" system of management, which is an Indian modification of "coppice with standards (CWS)", the need of the local people particularly for NTFPs has been given due weightage.

In the present philosophy of forest management, in the participatory line, people's dependence on NTFPs is being considered as a crucial determinant for the success. Forest Protection Committees (FPCs) constituted by the villagers for protecting and regenerating the forests, as per the standing order of the government, have been given the 'usufructary rights' on the NTFPs. However, "Panchayat Extension to the Scheduled Area Act (PESA, 96) empowered 'Gram Sabha' (i.e. village committee) members with the ownership right on the NTFPs. This underlines the conflict between the usufructory rights and the ownership rights being enjoyed respectively by the Forest Protection Committee and the village committee members, in case they are not exactly the same. Forest play an immensely important role in the ecological security of the country. However its contribution as a natural resource being used by the people, most of whom stand below the poverty line, cannot also be undermined. An apt forest policy therefore should maintain a balance.

Shaping Public Attitudes: the Case of Forestry Professionals in Slovenia

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Research aim

The paper will analyze public discourse of forestry professionals and forest-conservation activists, acting as opinion leaders with respect to forest-related issues in Slovenia. In the second step, the paper will examine the influence of opinion leaders' discourse on attitudes of Slovenian general public toward forests.

Our explanatory model is based on a hypothesis, that public attitudes are not primarily shaped on the basis of personal contact and experience with forest, but rather through the mass media, which operate as transmitters of opinion leaders' discourse. The leading role of forestry professionals in shaping public attitudes is secured by their professional authority and privileged access to forest-related knowledge. Accordingly, they are very much an exclusive source for providing information and especially interpretation of forest-related data, facts, statistics, and knowledge in general. We will examine how successfully forestry professionals exploit the mass media (and political channels) to promote their views in public and pursue interests of their specific interest group. We do not expect a direct, 'manipulative' influence in the mass media, but rather an influence in the sense of the agenda setting theory: raising relevant issues, offering interpretations, providing accents. In this way media indirectly limit the audience's ability to see issues in alternative ways.

Methods

To asses the functioning of opinion leaders -> public attitudes model, a two step empirical analysis will be performed. Two potentially most productive methods were selected for each step. The analysis of opinion leaders' discourse will be accomplished by means of computer assisted content analysis. Key-word-in-context and frequency count procedures will be performed on a selected sample of written materials (i.e. publications and public speeches) of forestry professionals and activists. The result are expected to indicate key issues and key aspects which appear in opinion leaders' public discourse. The analysis of public attitudes will, however, be based on survey data. Various forest-related concepts were recently included as part of an annual Slovenian Public Opinion Survey, such as the evaluation of the economic, recreational and aesthetic value of forests, perceptions of forest-related threats, attitudes toward private owners, attitudes toward private vs. public forest management etc. The survey employs a national representative sample of adult population and constitutes the most relevant basis for comparing public attitudes with opinion leaders' discourse and assess the influence of the latter. We shall examine at which points and to what extent public attitudes converge with the views of opinion leaders and at which points they deviate from them.

Mediterranean Forests: Societal Changes and New Institutional Forms for Forest Management

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The 60 millions ha of forests existing in the twenty five countries of the Mediterranean Rim feature only marginally in the major international debates and research efforts about forest issues, compared to tropical and temperate forests. Probably this is due, in part, to the fact that they are not major wood producers, non wood forests products being often more important. Many times these products are positive externalities or common goods not priced by the market, but essential for other economic activities (agriculture, tourism, etc.) and for the cultural identity on which are based the life and well being of the Mediterranean societies. This non existence of the right price signals is a threat to Mediterranean forest resources, together with other threats typical of the Mediterranean ecology such as the high risks of wildfires, erosion and desertification. Because forests in the Mediterranean Rim have strong complementarities with other human activities (domestic production, agro-forestry, tourism, recreation, etc.), societal changes are transforming the uses and management of forest resources in the region, with forms which differ from country to country. In the existing research efforts focusing on the Mediterranean forests, namely the networking promoted by FAO through Silva Mediterranea, all the attention so far has been oriented towards sylvicultural topics, leaving aside the socio-economic and institutional issues. Or without a better understanding of the relationships between societal changes and uses of forest resources it will be difficult to manage and anticipate the dynamics of Mediterranean forests so heavily shaped by human activities. After surveying some of the socio-economic research that has been done on the interactions between societal changes and forest management in the Mediterranean Rim, this paper looks more closely at institutional issues. More precisely, we examine forest policy debates and initiatives, as well as the diversity of institutional forms which are emerging to deal with the changing roles of forests in the different types of Mediterranean societies. Some examples of institutional topics covered are the following: - the new forest policy laws and the development of private forest owners' organisations in countries where private forestry is important, but was not collectively organised before, like Portugal and Spain; - the different paths of institutional change to deal with forests in the public domain, like the debate and the resistance to privatisation of forests in Turkey, the creation of Collective Interest Forest Associations in Tunisia, or the shift of responsibility to the regional level in Italy since the 70s.

Monitoring the Socio-economic Situation of European Farm Forestry

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Keywords: Socio-economic, Farm-forestry, Sustainability, Forest policy, Rural development

Policy issues, such as sustainable development, forest certification and rural development, to mention but a few, imply a rising demand for information on the socio-economic situation of forestry. Socio-economic aspects have been well recognised in the recent international conferences and processes aimed at promoting sustainable development. These processes include the Agenda 21 of the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro (1992), resolutions adopted by countries of Europe and the European Union at the ministerial conferences held in Strasbourg (1990), Helsinki (1993) and Lisbon (1998), as well as the recent Forestry Strategy for the European Union (1999). However, proper tools to measure and monitor socio-economic sustainability especially at the farm level are still missing.

In the European Union, privately owned forests account for more than half of the total forest area. There are approximately 12 million private forest owners in the 15 member countries of the Union. A large part of the private forest holdings are owned by small-scale family enterprises where farming and forestry activities are combined. These management units or 'farm forestry enterprises', are often in a key role in the implementation of various policies aimed at addressing the above mentioned policy issues.

Several European countries, such as Austria, Germany, the Netherlands and Finland have established monitoring systems for farm forestry enterprises. Common to these monitoring systems is the idea to systematically collect data on socio-economic variables to help in analysing and adjusting the policies related to farm forestry enterprises.

The aim of the paper is to present the state-of-the art of the possibilities for monitoring the socio-economic performance of farm forestry enterprises, and the approaches on how the heterogeneous methods of country-level monitoring systems could be harmonised. The paper also presents generally applicable guidelines for collecting and analysing socio-economic data on farm forestry enterprises, adaptable to different purposes and various socio-economic environments.

The paper (i) outlines the major problems and importance of farm forest enterprises in Europe, (ii) introduces means and principles of how to develop a farm forestry accountancy monitoring system applicable to different purposes and various conditions, and (iii) draws special attention to the problems in including the heterogeneous characteristics of farm forestry enterprises into these monitoring systems. The ultimate goal of the paper is to get more consistent and comparable information on European farm forestry, and more specifically, on the socio-economic variables of interest.

Monitoring the socio-economic situation of farm forestry comprises three main types of problem areas, to which the paper proposes solutions: (i) selection of the accounting methods to be able to produce the desired parameters; (ii) selection of the sampling method to be able to produce statistically representative information; and (iii) practical implementation, including the organisational arrangements to run the accounting network system. These problems also interact with each other.

By adopting the principles and procedures presented in the paper, the body in charge of a new or an existing accounting network can produce information that can be better compared to the information produced by other monitoring networks, especially in the case that the other is also using the same principles as a basis for their system. The guidelines of the paper can therefore be considered as a first revisable working step in the evolution before more detailed studies on the approaches and principles adopted are further developed.

Regional Employment in Forest Sector in Europe

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The question of maintaining and increasing employment, regional income and value-added production in the remote and rural regions is reality throughout Europe. Even the role of the forest sector could often be substantial in regional development, it varies in actual circumstances a lot between different regions. Each region has its own traditions and ways to utilise their forest resources, and their capacities in utilisation of forest resources vary also. Consequently, it is difficult to find common denominators for the success of the forest sector in terms of employment and income.

This difficult task was challenged, and the opportunities of the forest sector in contributing to the vitality of rural areas in Europe were examined in a cross-national study called "Forest Resources for Work Opportunities and Regional Development" between 1995-99. The projects aim was to identify and analyse the factors of the forest sector contribution for regional level employment and income in different socio-economic environments in Europe. This paper presents the major findings of the quantitative part of the research project, including the assessment of variables characteristic to those regions where employment and regional income have been high.

The paper discusses the analyses and data of employment and income, on the one hand, and natural resource base, population characteristics, industrial structure, recreation and policy oriented variables, on the other.

The paper concludes and presents the potentials and practices in utilising local forest resources for high value added production, and discusses how forest-based income and employment could be increased. Among the conclusions of the paper are:

- in the remote regions of Europe, land use, the role of forests and the prospects for the forestry sector development differ along with the traditions and history of the region;
- regions with abundant timber resources are generally focusing on raw material production and semi-final products, whereas regions with scarce wood resources produce more high value-added products and even import wood for the processing industries;
- education and research, especially in conventional forest based activities like wood production, have largely been focused on timber production in large private or public estates. Obviously, not enough emphasis has been given to small-scale ownership structures, which are usually dominant in Europe.

Forestry Research in the National Park Bohemian Forest - Meet the Social Needs

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National Park Bohemian Forest was declared in 1991 on the border between Czech Republic and Bavaria (Germany). The total park area is 69.030 ha, mostly covered by forests. These forests are in general in unfavourable conditions. There are relatively small territories of land of natural type (swamps, peat bogs, block fields, rocks, rarely forests on extreme sites). Most of forest stands were commercial forests until 80ies of this century. They were on large areas replanted after great wind storms in 70ies of the last century. They represent nowadays even-aged spruce monocultures, sometimes of allochthonous origin.

Big storms resulting in large forest damages have repeated since 80ies of this century. The military zone presence on the Czech side caused large prolongation of the consecutive bark beetle calamity processing - no measures were taken in the Bavarian Forest National Park (Germany) at all. After National Park declaration, probably 15.000 ha were declared as I. zones, without any silvicultural treatments (natural processes only). This favoured bark beetle expansion and forest decline on large areas.

Increasing portion of the dead forest and the danger of ecosystem changes on the regional scale initialised great interest of the Czech Ministry of Environment and the National Park Administration. There is a big amount of research done in this region, but its use for forest ecosystem management is considerably limited. Despite of large amount of analytical material, there is a lack of synthesis. A new research project was initialised on ecosystem dynamics research and management concepts formulation. It is oriented especially on zones II, with silvicultural aim to establish close-to-nature forests. Its title is Restoration of biodiversity and stability of forest ecosystems in the zone of natural growth of Norway spruce on the Sumava Mts. National Park territory and will be a synthesis of 4 sub-projects.

First sub-project is oriented on Changes in forest ecosystems. Its objects are stand structure and its development, natural regeneration, anthropogenic changes in forests, dynamics of plant as well as animal communities, dynamics of introskeletal erosion. Second part deals with Dynamics of damages by abiotic as well as biotic factors, extraordinal attention is paid to the bark beetle expansion and static stability. Technologic and economic parameters of forest ecosystems restoration is a technically oriented part of the project. It aims directly the decision strategy formulation of the forest practice. Finally, Silvicultural treatments part seeks for the synthesis of all outputs for practical management of forest stands. Faculty of Forestry of the Czech Agricultural University in Prague and Research Station in Opocno of the Forestry and Game Management Research Institute are institutions responsible for this project.

Women's Role in Forest-based Systems - A Case Study from Himachal Himalayas of India

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Keywords: Women, Participation, Forests, and Himachal Himalayas

Forest resources in the Himalayas have been depleting at an alarming rate, during the last few decades and with this pace we are not only miles away from the sustainable forest management but heading for a biological erosion. Though forestry has grown from the concept of production forestry to conservation forestry yet it lacked the active involvement of local people.

Present study was carried out to understand the role of women in the forest-based systems of the Kangra valley of Himachal Himalayas. PRA exercise with some modifications was conducted in the villages and the local women were motivated to express their views fearlessly. The information gathered was recorded and analyzed critically. It was found that keeping in view the shuttling men population between cities and villages, the axe to undertake the field work - fodder and fuelwood collection, forest produce, collecting grasses from grass lands, fetching water for household use and sharing larger agricultural operations etc., falls on the rural women only. But this participation by women is treated as invisible. This is not only the case of Kangra valley alone but is also the true picture of the entire Himalayas. Depletion of forests has increased her working hours for meeting these necessities. In addition to this, the technologies generated by the scientific world, many a times do not match the rural client i.e., woman. Besides, in many cultures and castes, women are discouraged from participating in the meetings and training programs along with men and hence their participation in resource development and conservation programs is negligible. However, our experiences show that when given opportunities, rural women do participate actively in the meetings and training camps and are able to identify their problems and suggest solutions.

This study also helped in the planning of the motivation strategy on one hand and in identification of the key units on the other. It was found that with the use of the appropriate tools of motivation, the local rural women groups, which were earlier inactive, could be gradually involved. The strategy of " If you educate a woman, you educate a family" and "If you educate a girl, you educate two families" was given a live form and implemented in totality. Approximately 25 ha of land was developed under different agroforestry systems. Her preferences for the species were based on multiple utility within the household, including food, fodder, fuel, medicine and income needs. The major lesson learnt through this study was that if we want to plan effectively for any natural resource management program, input should be from the stake holders who use and depend on the natural resources and these are often women. Secondly, involvement and participation of the people is possible provided there is a committed and sincere leadership to educate, organize and motivate the people for the attainment of a common goal. This study also highlights the role of the women extension worker in developing a package of the successful women participation in forestry based systems.

Need of the hour is to change our mindset at all levels. The forest laws, norms, regulations and procedures need a radical change if this prime but silent force "women" is to be given their long due place in the forestry sector development. If we look forward to succeed in reducing rural and natural resource poverty, the balance between women and their forestry resource must be restored. The lessons learnt during this study can act as a useful tool for replicating the forest ecosystem conservation program by the society for the society in the other mountain areas of the world.

Community Participation in Sustainable Forest Resources Management in the Philippines: A Policy Review

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The participation of communities in sustainable forest management and development has been an expressed government policy in the Philippines for over two decades now. This policy is justified by the recognition that government alone cannot adequately cope with the task of sustainable development of the countries forest resources. Thus since 1971, more than ten programs and projects with participatory component have been designed and implemented; they have come to be collectively known as community-based forest management programs and projects. Given the number of existing participatory forestry programs as of date, a policy review was conducted to determine the constraints to the effective implementation of community-based forest management programs, and to recommend measures to enhance more effective community participation in sustainable forest management. The review employed variety of methods including survey of relevant data and documents and field observation and interview with community forestry program personnel and other key informants. To provide depth, the review involved case studies of six major programs. Review results indicated that the activities designed to achieve the development goals of community-based forestry have been in place, but the full realization of these goals is impeded by many constraints, the more salient of which are:

1. Community participation is high for only a small sector of the community that is better off educationally and economically. Conversely, the poorer majority who need to benefit more from the program appear inhibited, less motivated and incapable of active participation.

2. Community organizations in most community-based forestry project areas are still in their nascent stages of development.

3. The variety of tenurial instruments serves to create confusion and present difficulties in administration.

4. Restrictive policies on the harvesting and utilization of forest products discourage forest communities from actively participating in the program.

5. Access to capital is limited and the institutional mechanisms to facilitate this are weak.

6. Imbalanced education and training and support programs that emphasize technical forestry skills over management and enterprise development skills.

7. A weak extension system that hampered the diffusion to and utilization of relevant technologies by the participating communities.

8. Physical infrastructure to facilitate access to product market is poor or non-existent and market mechanisms for market mediation are underdeveloped.

9. Central and field coordination of programs are diffused thus resulting to disjointed operations.

To address these constraints, the following measures are recommended:

1. Strengthening the management effectiveness and efficiency of the executing agency (DENR) and support organizations (local government units and non-governmental organizations).

2. Strengthening community organizing to ensure the sustainability of community-based forestry programs through such ways as utilizing production incentives as entry points to the community organizing process, or integrating income generating forestry development or livelihood activities in this process.

3. Ensuring access to production incentives by speeding up the processing and awarding of appropriate tenurial instruments to community participants, devising a more liberal policy on forest harvesting and utilization, enhancing institutional capability for capital intermediation, improving market access by building more farm to market roads, and improving community access to relevant technologies by strenthening research and extension systems.

4. Reaching out to the more disadvantaged sector of the community for membership by strictly implementing, for example, the recruitment guidelines and conducting recruitment in a more participatroy and transparent manner.

Monitoring System for Non-industrial Private Forestry in Finland

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In the countries dominated by nonindustrial private forest ownership one of the prerequisites for a successful forest policy is the up-to-date information on the structure of private forest ownership and the behaviour of forest owners, as well as the knowledge of their objectives of forest ownership. The number of forest owners is usually large and the structure of forest ownership is continuously changing. Therefore the most feasible procedure to collect information on private forestry is to conduct separate survey studies based on representative samples of nonindustrial private forest holdings. As the same type of information is collected periodically, the various data can be combined into a database providing a monitoring system for private forestry. This kind of monitoring system can produce information concerning holding and ownership characteristics, forest owners' timber sales and silvicultural practices. Furthermore, the knowledge of owners' participation in forestry extension as well as understanding of their objectives of forest ownership are of crucial importance. In addition, the monitoring system can produce data for separate studies on up-to-date topics. In Finland, nonindustrial private forests are divided into 300 000 forest holdings with at least 5 ha of forest land. Private forests have an important role in Finnish forestry, supplying 70-80% of the domestic roundwood purchased by the forest industries. Until the 1960s, holdings were typically owned by farmers and they were mostly permanently resided. During the last thirty years, a rapid pace of change has taken place in the Finnish society. The main changes have been occupational differentiation and migration of the population. These changes have had a powerful impact on nonindustrial private forest ownership and on the objectives of forest owners emphasising the need to monitor the development. The Finnish monitoring system for private forestry consists of three country-wide cross-sectional data collected in 1975, 1990 and 1999. Based on this monitoring system data, the development of non-farmer and absentee ownership, and owners' objectives will be presented by graphs. In addition, the development of age structure of forest owners as well as a three stage age-cohort table on timber sales will be shown in order to enlighten the life-cycle and generational effects on cutting behaviour.

Law Enforcement In The Forests: How It Can Be Made more Effective

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Forest authorities in many countries enforce forest laws as an instrument to regulate the conduct of individuals, loggers, and timber companies in dealing with the forests in line with the forest policy of the government. Generally, the law either promotes the conduct of certain activities through the giving of incentives (carrot approach) or prohibits the conduct of certain other activities by imposing various kinds of punishment including fines and imprisonment (stick approach). In the stick approach, it is believed that imposing stringent punishment would have a deterrent effect on the occurrence of forest offences. It is always the case that the maximum punishment for forest offences are increased whenever necessary in order to deter likely offenders from committing forest offences. This paper stresses the fact that there are many factors which influence the occurrence of forest offences of which the maximum prescribed punishment is one of them. It is rather the expected punishment, and not the prescribed maximum punishment that greatly influence the occurrence of forest offences. Even though the maximum punishment is very high, due to low probability of arrest and conviction, the expected punishment can still be low. As such, the deterrent effect of high prescribed maximum punishment is now always felt by likely offenders. Preliminary results are given in this paper which show that the expected punishments for forest offenders are quite low. Forest offenders can internalise these punishments as part of their operating costs. Some suggestions will be put forward to increase the effectiveness of law enforcement in the forests.

Assigning Monetary Value to Plant Diversity on Forest Floors

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The distribution of plant species on forest floors represents an important ecological service for the sustainability of ecosystem. However, this service has usually been ignored due to its non-marketable value. The failure of market systems to capture the value of the ground floor vegetation of forest floors sends the wrong notions for value judgments. The absence of any other appropriate methods to count the monetary equivalence lead to exclude this

component in the accounting of total economic value of forests. Though, recently a few standard methods like Contingent Valuation Method, Hedonic Price Method or Travel Cost Method have been practiced to estimate the monetary value of biodiversity preservation or some other such particular uses. But the application of such methods varies with the socio-economic structure of the society. Moreover, these methods provide the economic value for particular usage of a plant species while a single plant provides a number of ecological services. Keeping this mind, the various phytodiversity components of forest floors are evaluated in terms of scores following Ordinal Analysis. The scoring is done based on the criteria of longevity and biomass productivity of a plant species for five major uses i.e. food, fuel, fodder, medicine and soil stabilization. The scores of each plant species are further converted into monetary equivalence to estimate the monetary value of all the plant species growing on the forest floors. The data generated from the floors of monoculture forest plantations of *Eucalyptus tereticornis* (an exotic species in India) and indigenous Dalbergia sissoo in the same edapho -climatic zones, has been taken as a sample study with interesting results. The floor of *D. sissoo* yields almost double monetary value than that of *E. tereticornis* on account of its plant diversity.

Role of Non Governmental Organisation (NGO's) in Forest and Mountain Development

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Forests are one of the most important natural and renewable resources, which play a significant role in the development of any country. The quality of environment depends to a great extend on the entire forest ecosystem. According to the latest official estimates on land use statistics, the forest cover at present in India is 19.52% compared to 22% at the time of Independence. In view of the growing depletion of forest wealth, there is an urgent need to launch massive programmes for meeting the basic amenities of life with the help of central and state governments, voluntary agencies, non governmental organisation and the involvement of local people to solve the problems of soil erosion, reclamation of marginal lands, shortage of fuel wood, fodder, timber an other forest products.

Transfer of technology for forest and mountain development is not a function of one individual or one single system but it is a multi dimensional conception which all the development organisation are directly or indirectly involved. non governmental organisation (NGO's) in India are found in almost all areas of human activities, such as, environment protection, human rights protection, technology transfer and the like. Being small and autonomous in nature, voluntary organisation have flexible approach in ensuing the needs of rural populance. They develop n and adopt a work culture well understood by the villagers, believe more in institutional rather than individual approach and ensure better co-ordination and team work. Since NGO s have dedicated an committed field workers with high degree of closeness to the climent group, innovativeness and ability to stimulate interest in the community as well as skill to involve the people right from planning to implementation starge, therefore, they should be treated as an important part of any development programme. The rapprot credibility and decision making ability of NGOs should be fully exploited for strenghtening the weak links in the transfer of technology programmes for forest and mountain development. The essence and objective of the government and NGO being the same, the interdependence between the two must be recognised and the efforts should be made to seek the latter's c cooperation in enhacing the peope's participation in sustainable forest and mountain development programme.

Co-management Approach in Afforestation Programmes: A Case Study

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This paper relates field experience in NW Indian district of Bundi of working with local communities under the framework of co-management in execution of afforestation works. The basic philosophy was to ensure greater involvement of the grassroots institutions and the people in general in planning and execution of forestry works so that the assets created could be sustainable in the long run. Past experience over the years suggested that forestry plantations once created were forgotten for lack of aftercare and protection. The communities for whose benefit these assets were created were often blissfully unaware of the works and the philosophy behind these. They were not consulted for site selection, nor was the need for such works expressed by them in the first place. They probably thought it was some governmental necessity having nothing much to do with them. As a result, when the department withdrew with ceasing of flow of funds the villagers started grazing in the areas and the plantations were soon destroyed.

In light of this experience it was decided that heretofore all plantation works in the district should be executed through the agency of the Village Forest Protection & Management Committees (VFPMCs). In any case, a large number of VFPMCs in the district were clamouring for allocation of funds for developmental works in their areas, and on being asked whether they were willing to take on the responsibility of executing the works themselves, their response was positive.

The institutional arrangements made were such that while formulation of the project, and technical supervision would be the responsibility of the departmental personnel, the VFPMC would primarily handle planning and decision making tasks such as site selection and choice of species, and also the nitty-gritty of actual execution of the works such as requisitioning of workers, recording their attendance and disbursing their wages.

The issues that had to be addressed under the new framework of co-management were: promoting community-based institutions/organisations, management of change in its various aspects such as attitudinal change of the forest department's employees, power-sharing, joint work ethos, and technology transfer and capacity building.

The experience gained has proved that co-management is a superior approach in respect of both the sustainability and the quality of works carried out. The villagers have been greatly enthused over the new method of working. They feel they didn't know earlier that all this was their right to know what is going on in their village where workers were engaged by the department for raising plantations, and to be consulted while deciding a work program in their own village. They have time and again expressed a sense of gratitude and discovery of their rights. They feel what should have happened decades ago has happened now after all. The phenomenon of VFPMCs has caught on like a contagion. More and more villagers are forming VFPMCs. There s a flood of proposals for new plantations to be raised. Involvement of people has triggered greater interest among communities for protection and management of their forests. This has improved the prospects of sustainability of developmental programmes and assets created thereunder. It has improved knowledge and capability of communities in self-organising and self-help. The government need not recruit an army of bureaucrats or karmcharis for launching new and larger programmes of development if the people's capacity for self-action is built up. The departmental personnel have been rid of the petty chores of marking attendance and disbursing payments. Their role has now been elevated to that of facilitators, guides and supervisors. The capacity of a forester to execute works, for example, has increased manifold.

The experience also seems to prove some of the theoretical findings of game theory and sociological research in respect of group size, homogeneity, and other such factors affecting success of community level collective action.

Research Patterns During Four and One-Half Decades of Forest Science

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In 1995 Forest Science was launched on what was expected to be "... the beginning of a long and distinguished career in the field of technical forestry publications (Demmon 1955, p. 4)." Since then it has become one of the world's leading outlets for forest science research. We examined the publication patterns during the first 44 years of the journal, looking for information on which scientists publish in the journal, what subject areas in forest science receive the most research attention, whether there was evidence of concentration on particular regions or species, and how patterns tended to shift over time.

A total of 3,231 individuals published 3,065 articles in Forest Science during its first four decades. U.S. scientists have been the most frequent contributors (86% of articles), with the remainder split equally between Canada and all other counties. Initially, scientists from other countries contributed only sporadically. Since 1992, however, foreign authorship has increased dramatically.

Three countries-Australia, Finland and Sweden-accounted for 42% of all foreign contributors and supplied more than twice as many authors as any other country. Forest Science publishes papers on a wide range of subjects but not all subject areas have been equally represented. Ecology, forest biology, forest health, mensuration, and silviculture have been the dominant areas in terms of number of articles, number of authors, and number of published pages. From 1975-1994, average article length almost tripled. Since 1994 article length has declined dramatically, falling to about what it was in the 1980's.

The average number of authors associated with an article is one measure of the degree of collaboration among scientists (Harsanyi 1993) and generally this statistic has been increasing for most science journals. Broad (1981) reported that the average number of authors among 2,800 journals indexed by the Institute for Scientific Information rose from 1.67 to 2.58 between 1960 and 1980, but that there had been considerable variation across fields. The averages for Forest Science were very similar-1.52 in 1960 and 2.19 in 1980.

For the Congress, we proposed to add to the results reported above by addressing several questions relating to the emergence of modern scientific themes in forestry research published in Forest Science. Examples include: When did concepts like sustainability, biodiversity and ecosystem management begin to appear in the journal? What was the subject matter context within which they appeared? Are they equally represented in U.S. and foreign papers? Do the citations and authorship patterns reveal international connections among ideas and scientists?

Ecological Factors Affecting Labour Supply for Taungya teak Plantations in Myanmar

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Keywords: Teak plantation, Taungya, Myanmar, reserved forests, productivity, participation.

In spite of the various efforts, degradation and deforestation of forests in tropical countries are still continuing. Agroforestry has been expected to be one of the solution to rehabilitate degraded lands. Among the various types of agroforestry systems, Taungya which originated in Myanmar, has been applied by many governmental agents as a low cost plantation system. Taungya literary means 'hill-field' and is generally used for 'shifting cultivation' in Myanmar, and is acknowledged as an agroforestry system in which agricultural crops are interplanted between tree crops. Most of the research on Taungya till the 1980's had been focused on technical aspects. More attention has been paid to socio-economic factors after the 1990's, since these aspects were admitted to be important to realize sustainable management of man-made forests as well as natural forests. For example, the demand of people participating in the plantation effects labour supply for the programme.

This paper examines some ecological factors which effect the taungya farmers attitude towards participation in the plantation. Interviews to household heads of taungya farmers, using a uniform questionnaire, was carried out in 1995 in three plantation sites at Bago range which is one of the centre for teak. Bago Range is located between Yangon and Mandalay, the two largest cities of Myanmar, and is comparatively easy to access. The range is relatively low and covered by undulated hill which forms numerous lowlands of various sizes. These lowlands are suitable for paddy cultivation but not for teak. Bago range was declared as a reserved forest by the Colonial government in the late 19th century and then was nationalized after independence. Taungya teak plantation has been organized by the Forest Department since 1856. Data showed that the Taungya farmers changed their attitude according to the productivity of land in and around the plantation site. Taungya farmers apt to quit participating in the program and settle in the reserved forests if they could utilize lowlands outside the project site, which had a higher productivity than the land allocated for taungya On the other hand the Taungya farmers tended to continue participating in the program if the land for taungya were more productive. The difference in productivity was mainly due to the type of crops which they grew. Though, the land available is limited under the present situation, so that the taungya farmers showed a high reliance to the plantation in which 2nd generation could be observed. Thus, ecological factors was one of the important conditions to supply labour for Taungya teak plantation. However, it is assumed that the control of cultivation outside the taungya programme, and the social services to be provided to the taungya farmers who have to move every year following the project, would be crucial to secure the stability of future forest management. These elements may rise the cost for the Forest Department.

An Objective and Transparent Approach to Set Forest Research Priorities: An Imporant Policy Issue

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Institutional and scientific contexts interact with government policy to define the environment for forestry research. This environment determines the economic impact of research and development and has implications for research evaluation, priority setting and resource allocation. in any research institution budget represents the sum of all resources available and is always scarce. Because resources are scarce and can always find alternative use, it becomes necessary to be selective in choosing the nature and focus of research one supports. Proper chanellization of the allocated budget is, therefore, a must for successful research administration. For such allocation a comprehensive and analytical approach that is reasonably transparent is therefore essential. The priority setting exercise simply gives an order or ranking to the various research projects and enables the researchers and professionals to interact more effectively with policy makers, funding agencies and client groups. The five formal methods of research priority setting are: Scoring (Delphi), Economic Surplus, Mathematical Programming, Econometrics and Simulation Models. The first two methods were basically used to set priorities for the forest research projects being undertaken by the Indian Council of Forestry Research and Education, India. Scoring, a more subjective method was used to set priorities at national and institutional levels and Economic Surplus, a more objective method was used to set priorities at the project level. Under the Economic Surplus method, individual research projects were evaluated under the three criterias of Economic Efficiency (that is to what extent the project can increase the contribution of forestry sector to the economy), Income Distribution (that is whether the project can reduce the disparity in income of rural and urban people in general and forest dwellers in particular) and Environmental Security (whether research project can provide some environmental security by conserving the forests). This analytical, transparent, objective, participatory and systematic approach of using economic tools for setting forest research priorities may bring the researchers and the administrators come closer. However, formal evaluation and priority setting procedures should not be used as a basis for replacing ingenuity, serendipity and scientific entrepreneurship with bureaucratic procedures.

Sustained Yield Forestry - The Implementation of an Idea

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European forestry is known for its concept of sustained yield. Foresters are proud of this management system as a moral concept. However, from a political science perspective it has to be asked how the development and implementation of "sustained yield forestry" was possible. Is it true that a "wise" government set the standard of sustained yield forestry in the interest of the people? For answering this question this paper undertakes a re-analysis of forest historical literature applying political theories to the material. This paper employs an analysis framework containing the elements: institutions, interests, and values. The first step in clearing up the politics of forest management is to identify the relevant actors in the policy field. For all of these actors their behaviour is described. This behaviour can then be explained by their interests, their values and their power resources. It is important that there is not a uniform "State": the abstract idea of the State consists of different actors: governments, interest groups and the forest administration itself have all different interests and are acting relatively autonomous. The paper looks at different historical stages of forest management regulation. Three main historical eras can be distinguished, in which different governing systems constituted different institutional settings for forest management regulation: the era of the commons, the era of the sovereignties, and the era of the constitutional state. The behaviour of the political actors, their interests and values are discussed by using different examples from forest history of Austria. Important such examples are areas with salt and ore mines, which can be found in different provinces of Austria. The broadly accepted view that the implementation of sustained yield forestry was possible because mineral coal relieved the forests from use pressure is questioned: If no interest in the forests existed any more - why would there still be efforts in implementing strong forest laws? This question is discussed by considering different hypotheses derived from political science and suggested in different studies on environmental history in central Europe. The paper presents differentiated explanations for the development and implementation of sustained yield forestry. On the contrary of the above cited popular view it holds that sustained yield forestry was not implemented against but with strong group interests. Another example of particular interest is the mountainous province of the Tyrol. Here, since the absolutist regime of the sovereign always a well-staffed forest administration existed. This usually is argumented as being necessary for securing sustainable forest management because of the specific conditions in this province: First, the protective functions of the forest are said to be of extraordinary importance for the land. Second, it is claimed that the community forests – a typical type of forest ownership in the Tyrol – need especially strong supervision. A critical review of the historical accounts question the cited arguments. A strong forest supervision lies in the interest of the forest administration itself. In contrary to other provinces with large private forest properties in the Tyrol the communities were not strong enough to defend implementation.

6.01.00 Tools to integrate nature conservation and recreation for landscape management

Evaluation of Recreational Potential of the Research Forest of Faculty of Forestry, University of Istanbul

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Peri-urban woodlands as natural landscapes must be protected, and open space systeme must be created by including these the town development master plan together with other urban open spaces. The protection, care and restoration of landscape with woodlands depend on the planning of recreation centres. In this study the Research Forest of the Facutly of Forestry, University of Istanbul has evaluated as a recreation area within the urban open space systeme. Based on the investigations aim at the determination of recreation potential of the area a frame plan has been worked out. The planning principles can be given in five headings; such as land use, use of natural resoures, transportation and settlement, recreation and conservation.

Natural and semi-natural open spaces outside of the urban areas, from a which we moved far away, as a result of the technological progress and our modern life style, should be preserved, and opened to recreation, as far as possible. In order to put forward guidelines for the general planning, it is necessary to find out the recreational potential of those areas. Due to the needs mentioned above the study presented here is carried out. It deals with the recreational potential of the Bilezikçi Çiftligi Forest, an extension of Belgrad Forest. These are the most important forests of the Istanbul Metropolitan Area.

The study consist of two stages. The first stage covers the activities to obtain the basic data needed for determination of recreational uses. Second stage consist of a general evaluation of the existing data, and of the planning principles, as well as the desicions on the site program and site plan resulting from the general evaluation of land use, natural resource use, circulation, and structuring.

Finaly the areas suitable for development for land use, natural resource use, circulation, structuring and recreational intensive use are determined and conservation principles established. These principles are summarized as follows:

- In the planning for multiple use the primary consideration should be recreation. It should be followed by hydrology, research, wildlife, and agriculture. The harvest of timber for construction and for space heating must be terminated.
- Water, which is one of the natural resources of the forest must be utilized for recreation.
- The natural plant cover of the forest and its very rich floristic composition should be conserved carefully.
- With an eye to not disturb the natural balance of the forest the wildlife should be controlled.
- In the reforesrations deciduous tree species should be preferred to conform with the plant cover of the forest.
- The existing buildings in the Çiftlik area could be opened for recreational use after restoration. A small area should be specified for game. Additions to the existing structures must be avodied as far as possible. Each new building must match the existing ones.
- To provide control at the intensive use areas a control system should be established at the gates.

Bioclimatological Parameters and Forest Management for Recreational Purposes under Mediterranean Climatic Conditions

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As the result of increasing living standards and leisure time, much attention is being devoted to problems of landscape assessment and management to enhance their recreational functions. There is need for an objective approach to problems of out-door recreation. Such a criterion is provided by the prediction of the heat stress, i.e., the sweat rate and the thermal comfort sensation of an average, recreation-seeking human being under given microclimatic conditions as influenced by the tree canopy closure which in turn is the result of management practices.

The objectives of the studies reviewed were: (a) to estimate the influence of different canopy closure resulting from silvicultural treatments used in ever-green, low-elevation Mediterranean forest ecosystems on the microclimate and the resulting sensation of thermal comfort of humans; and (b) to examine the implications of the findings for management of forests for recreational use.

Microclimatic measurements were conducted in natural and man-made landscape formations regularly used by the population in Israel for recreation. Human response to thermal environment and the mechanism of heat exchange between the body and the environment have been expressed by the Index of Thermal Stress. Thermal sensation, i.e., thermal comfort votes at given Thermal Stress was calculated.

The results presented show that the heat stress, i.e., sweat rate needed to keep homeothermy and the thermal comfort sensation are closely related to canopy closure. Specifically, gaps in the tall tree forest and oak scrub formations on S-facing slopes will provide the most comfortable sites in winter and early spring, while in the summer thermal comfort is directly related to tall tree forest canopy closure, preferably on N-facing slopes.

National Outdoor Recreation Demand and Supply Assessment Study in Finland

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A need to produce nationwide information concerning nature-based recreation and tourism has become actual in many countries. The use of forest and other natural resources has intensified. There are international and national level discussions about policy programs of sustainable forestry, and international and national programs for nature conservation (Nature 2000 in EU-countries. In Finland, many institutional changes have occurred as well. Forest and Park Service provides recreation services now partly on commercial basis, and partly as free of charge welfare services financed by government. Those are reasons why recreational use needs a strong information basis to be considered an important part of forest resource use. Also, the societal expenditure on recreation services needs to be grounded on well-documented and reliable basis.

This paper introduces the National Outdoor Recreation Demand and Supply Assessment Study (LVVI) in Finland. The project collects statistics and databases on a continuous basis in order to monitor changes in participation in outdoor activities and behavior patterns, as well as changes in the supply of recreation opportunities and the quality of services. A pilot study was made in 1997. The main study is carried out in 1998-2000.

The main issues in outdoor recreation demand study are participation rates in outdoor activities, last trip information (for both close to home trips and tourism), and distribution of visits in different types of areas (state, municipal and private lands). The study also includes special themes concerning recreation valuation, welfare and health impacts, state land use and nature-based tourism. A large population survey is the principal method of the data collection. Preliminary results presented cover participation rates, a typical visit to a close-to-home recreation area, a typical nature oriented tourist trip, and some other results of the large study. Some preliminary demand projection models are also presented.

Information concerning recreation areas, trails and other recreational services will be collected from municipalities and state agencies (Forest and Park Service, Forest Research Institute). The data includes quality descriptions of services, information about natural features of the areas, and use information. The information will be stored in GIS (geographical information system) and in the sports sites database, which is expanded to include recreation areas, trails and other recreational services than sports sites, as well. The preliminary results deal with the location of outdoor recreation supply in relation to e.g. distribution of population, classification of recreation areas according to their quality and characteristics, and the relationship between conservation areas used for recreation and specific recreation areas in different parts of Finland.

This poster will present the framework of organizing a national recreation assessment study in Finland, and some preliminary results of the demand and supply surveys. The need for the monitoring of outdoor recreation on national basis is also discussed. The nationwide databases of recreation are an important information basis for recreation policy in the context of general forest and natural resource policy. The discussion deals with the expected uses of the processed information and the possible impacts of the new information in terms of use of natural resources, institutional changes and the benefits gained by society.

The Evaluation Results of the Benefits of Tourism and Recreational Forestry Functions

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Tourism and recreational forestry functions are analysed from the standpoint of the total economic value (TEV, Pearce & Turner, 1990) as one of its component. The system of evaluating the TEV is comprised of: economic, social-ecological (Krznar et al, 1995) and social-environmental forestry functions (Krznar & Lindic, 1999; Krznar et al, 1999), where social-environmental factors are divided into tourism-recreation and health-landscape.

Analysis and evaluation were undertaken in the framework of the subproject "Evaluating the Capital Goods of Forests and Loss Caused by the Influence of Harmful Factors", which was financed by the public enterprise, Croatian Forests. The researched area was public forest on the island of Korcula, (Southern Adriatic near Dubrovnik). Korcula is the sixth largest island in Croatia, long in shape with total area of 276 km^2 and coast 182 km long, which is well separated by numerous bays (56), capes, gulfs and groups of smaller islands. It is a well-known tourist destination, which has up to 1,000,000 overnights per year. The forests cover 60% of the island area, and are composed of Aleppo pine (*Pinus halepensis* Mill.) and, in various stages of degradation, Holm oak (*Quercus ilex* L.) forests.

In this methodology a classification scale with related points evaluated the tourism and recreational forestry functions. The span of the point value is determined on the basis of estimated internal and external quality factors of these functions. The external factors are the level of tourism development, accommodation available in the region of evaluated forest, the number of inhabitants, tourists and their recreational habits and their tendency to visit the forest. The internal factors are evaluated according to the structural and aesthetic forest characteristic that are necessary for particular tourism and recreational activities, frequency of visiting and the developmental level of infrastructure.

The obtained results indicate a high potential of the forest area for tourism and recreational activities. Index values are from 0.8-1.0 in the very good (8) to excellent (9) quality categories. Contrary to this, visit frequency index was from 0.34-0.65 in the very bad (3) to satisfactory (6) quality categories. The function with the least amount of points was the level of infrastructure development, which fit the unsatisfactory (1) to critical (2) quality categories that reflect its real state, since there is a lack of sport and recreation activities in forest. The Aleppo pine associations have higher values of tourist and recreational functions than the Holm oak forests.

The evaluation of the forest tourism and recreational use and the probable number of visitors led to a conclusion that despite their exceptional tourism, sport and recreation potential. The results point towards a possible increase of the value of tourist and recreational forest functions by including these forests in to the tourism services, ensuring they are used in a planned and ecologically acceptable way.

6.03.02 Forest Terminology: How to get society understand forest terminology

How to Do Terminology Work in Forestry. Services Offered by IUFRO

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Keywords: Forest terminology, co-operation, terminology services

Efficient communication among scientists and with decision makers needs a precise and clear technical language. The network of IUFRO experts in forest science is an immense pool of living expert knowledge. Experts create the terms we use to communicate and thus constitute an ideal partner for IUFRO's services in their attempt to define and make accessible the forest technical language to a wider public.

At a time when English has become the *lingua franca* of science, it is crucial that other languages - and IUFRO has four official languages - keep playing an active role. This broadens the horizon of scientific thinking and knowledge, but also makes unequivocal communication more difficult to achieve.

Vocabularies, glossaries and terminological databases present the technical vocabularies and, if relevant, interpret them for the interested public. The role of forestry experts is to help and assist in this process of explication and definition of their own specialised language, in order to guarantee the high quality and liability of these communication tools.

IUFRO offers services with regard to terminological problems through its Working Party 6.03.02 "Trends in Forest Terminology" and its terminology project SilvaVoc based in the IUFRO Secretariat, which are interrelated and pro-active. Additionally we will show how 6.03.02 and SilvaVoc incorporate IUFRO officeholders in terminology work and illustrate the most important services that are provided by 6.03.02:
- electronic discussion groups
- terminological hotline for telematic-based terminological assistance;
and by SilvaVoc:
- on-line Bibliography of terminological publications in forestry
- terminological database SilvaTerm.

Traditionally IUFRO's role in terminology has been to make people aware of terminological differences. Our approach is therefore based more on descriptive than prescriptive principles, e.g. instead of aiming primarily at recommending definitions, it is our concern to point out differences in the use of the terms. Guidelines for quality forestry terminology projects will be distributed at the IUFRO World Congress.

As globally co-ordinated forest research becomes a priority in the context of sustainable management and global change, the need for concerted action in terminology will increase. Partners from various geographical and institutional backgrounds will have to base their collaboration on common definitions. They will also need to avoid duplicating terminological efforts. Together, WP 6.03.02 and SilvaVoc can significantly contribute to this collective effort by consolidating the network, resources and expertise they have built since 1995.

6.06.02 How are innovations applied in sustainable forestry

The Doon Valley Integrated Watershed Management Project: Marching Towards Sustainable Management of Natural Resources & Optimum Utilization of the Human Resources to Achieve Sustainability and Socio-economic Development

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The Doon Valley Integrated Watershed Management Project is one of the leading Watershed Management Projects of North India. It is a nine-year project (1993-2001). The European Union grants (95%) and Government of UP (5%) is funding it. The lead agency is the Ministry of Agriculture, Government of India. Presently the project is being implemented in 255 villages covering an area of about 1854 sq.km. Its major components are Agriculture, Horticulture, Animal Husbandry, Minor Irrigation, Soil Conservation, Energy Conservation and Forestry. It is fundamentally an environment project.

The objectives of this project can be classified into two broad categories namely: Long term and Immediate objectives. The long term objectives are: a) Arrest, and as far as possible, reverse the on-going degradation of the Doon Valley Ecosystem b) Improve the living conditions of the rural people c) Ensure positive involvement of rural people in managing their environment. The immediate objectives are: a) Management of the natural resources in a sustainable manner b) Increase productivity from land and water c) Strengthening community participation d) Improvement in the socio-economic conditions of disadvantaged groups, especially women.

The project has identified pressure for fuel wood & fodder, mining of minerals, overgrazing, faulty land use and depletion of forest cover as the major causes of degradation in the area.

The strategy for project implementation revolves around participatory approach. The villages are treated as basic units in which the resources are developed through community participation. Villagers plan their work on the basis of village plans that evolve from participatory rural appraisal (PRA). Under this, the outsider is transformed into a facilitator, who encourages the villagers to identify their resources, capabilities and priorities.

With the project entering its seventh year of operation, marked changes are visible. Income-generating activities have started. Users groups are being formed and assistance provided in establishing savings/credit groups, with revolving funds, supported by contributions from the villagers and the project. This has helped to establish the credibility of the project staff and instill confidence amongst the villagers. Though the project has land related bias, the land less poor and marginal farmers have not been forgotten. Opportunity to achieve economic stability is being provided to them through income generating activities, skill formation and cultivation of high-income cash crops.

All possible efforts are made to point out the interrelationship between the environmental and economic sustainability to the rural mass. The project has a holistic vision in which concern for environment and community are integral components of an all encompassing Eco-system.

The posters would depict precisely and concisely the project issues, problems, tried-solutions, their impact, and success stories which are definitely of great significance to other such developing countries having the similar problems and geographical conditions.

6.06.03 Targeting the real forest managers

Analysis and impediments of Extension Issues for Forest Manager

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Forest Manager is a key person who is suppose to manage the forest resources in order to maintain ecology in equilibium and sustainability, by manning the human resources working in different organizations and in and around the forest. Forest Manager may be a person working in public, private and other informal organizations. The goals, objectives and strategies used by them, therefore, would vary in content and philosophy. The management of a forest by these managers must address the vital needs of people and make available to them, especially, livelihood support system, forest produce, fuel wood, minor forest produce and timber. The experience where forest land is under control of the Government revealed that, the area under the forest is decreasing considerably causing a threat to humanity. Therefore, different agencies including Governments have come out with different forest extension strategies to maintain and increase the area under forest. The successfulness of these strategies mostly depend upon the managers who are manning and managing the forest. To make the forestry programmes as household rituals, the following extension issues may be considered.

1. Forestry extension should use education as a tool for bringing conscious learning about the importance of the forest. 2. Techniques like PRA/PLA must be used to ensure participation and to assess the inhabitant's needs. 3. The manager along with inhabitants must carry out Metric Indices Analysis, Trend Analysis, Transect Walk, Seasonability Analysis, etc., to identify the combination of tree species required by the inhabitants. 4. Manager must develop strategic alliances to link the various groups such as NGO's, community based organizations and religious groups to ensure both conservation and development. 5. Carry out campaigns in order to create as awareness about the environmental degradation and bio diversity. 6. Manger must create a base for inhabitants in order to meet their basic needs like food and shelter. 7. Tribal development should be an important goal of forest manager emphasizing on empowerment through education and development of viable enterprises. 8.

Forest Manager must initiate Self Help Groups for planning and initiating forestry programmes. 9. Manager, wherever possible should also emphasize on tree growers cooperative societies at the village level. 10. The role of men and women in maintaining the forest must be duly recognized and their roles should be made complimentary specially in traditional societies. 11. Identification and promotion of indigenous tree species must be given importance along with the promotion of commercial tree species in order to maintain the biodiversity. 12. There should be information corners attached to manager to provide the information to motivate the inhabitants. 13. Marketing news with respect to forest produce including minor forest produce should be made regularly to the inhabitants. Effective marketing channels should also be ensured. 14. Promotion and research on tribal medicine and effective use of minor forest produces by way of good marketing and value addition. 15. The upgradation of the technical know-how of the grass root level workers working under the manager and also the training programmes may be extended to the farmers. Thus it is essential that we shift from a policy of protecting forest from the inhabitants, to a participative management using suitable extension strategies.

Preliminary Study on Modern Administrative Model of Forest Science and Technology Research Result Extension in World Bank Loan Project

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Since the 1980s, approximately five World Bank loan projects in the forest sector were performed in China. The first one to implement forest science and technology research results was the National Afforestation Project (NAP). Vast experience was accumulated from this project. It is significant, from an administrative view, to sum up the experience of the NAP extension work, and to put forward modern administrative models of forest science and technology research results through extension, in order to guide future work. Through analysis and evaluation of forest extension in NAP, experience in forestry extension has been developed, and on this basis, modern administration models have been created. These models increase science and technology, possess the characteristics of market mechanisms, use the scientific administrative system, integrate management patterns, and apply high tech facilities.

Forest Wealth and Development Strategies for Indian Himalayan Region

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The Indian Himalayan region constitutes 21% of total area embracing 9% of the country's population. This region is characterized by inaccessibility, fragility, marginality, diversity, niche and human adaptation mechanism. The cattle population is nearly half of the human population. Indian Himalayan regions supports a variety of forest ecosystems which are very vital for regulating the water discharge during rainy season and in maintaining perennial flow throughout the long dry period of the year. But overuse and misuse of this forest cover by the ever increasing human and animal population has endangered the Himalayan ecosystem. The problem of deforestation in the Himalayas is a serious one and leads to landslides, declining soil fertility, soil erosion, flooding, firewood and fodder shortage and birds and other wild life disappearance.

Therefore, the development of Indian Himalayan region is possible if all the inputs are channeled towards the right direction, keeping environment as a focal point and sustainability as a primary objective. It is desirable to understand the mountain perspectives and underlying interrelationships between different mountain specificity's by the hilly people. Only those developmental approaches or models which have been designed for hills, are to be implemented. There has to be a spearate planing cell for hills. A strong extension mechanism is required for transfer of forestry and agricultural technology to rural people. For women in hills there should be female extension workers who can infuse enthusiasm and confidence in them. The youth for a like Forestry Vikas Yuvak Mandals as a rural voluntary force to monitor developmental activities, should be established. The non-governmental organizations will have to be engaged for developing effective production and marketing plan of agriculture and forestry. There is a strong need to motivate and mobilize people in hills for family planning. The domestication of only highly productive animals should be encouraged. Commercial exploitation of medical plants and herbs should be properly regulated. Vanmahotsava, World Forestry Day and World Environment Day should be preserved and practiced sincerely and honestly. Local germplasm resources of wild and domesticated animals, avian birds, crop plants, forest trees, herbs etc., should be conserved systematically for future generations. There is an urgent need to observe and study the traditional wisdom of hilly people about forestry, horticulture, animal husbandry and agriculture.

An Effective Extension Tool in Targeting Real Forest Managers and General Public

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The state of Karnataka has only 20 percent of geographical area under forest cover. With an objective of increasing forest area to 33 percent, the state forest department has fixed a target of planting 100 million saplings in the state during 1998. However, to attain the stipulated target the government has formulated virtually no extension strategies to create awareness among the landowners and general public about afforestation and eco-conservation. In this direction, the most significant extension tool employed by the department was displaying the posters. In the year 1998 Six different designs of posters, four on afforestation and two on wildlife conservation were brought out. Altogether 115 thousand posters were displayed. In the present study an attempt was made to analyze the posters developed by the State Forest Department during the year 1998, in attaining the desired effect. About 150 viewers, representing 50 each from the landowners, students and general public categories were asked to rate the effectiveness of these posters in creating awareness. For this experimental study six posters were numbered 1 to 6, each number representing a different design. Majority (86 percent) of the viewers, irrespective of their category, expressed that poster 3 was most effective in terms of message content, design, attractiveness and overall impact in creating awareness and triggering the desire for further action. 73 percent of student respondents preferred poster 5, they appreciated its colour, bold design and content. This particular poster was on wildlife conservation and blown up photographs of different animals in the poster were an added attraction for the students. While landowners preferred poster 1, general public liked poster 3. Further, 69 percent of the viewers, irrespective of their category said, poster is an important extension tool in creating awareness among the general public on afforestation, eco-conservation and wildlife preservation.

A Comparative Analysis of Impacts and Extension Approaches Adopted by a State Government, Non-Governmental Organizations, and the Corporate Sector in Forestry Expansion Programs

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This case study was conducted involving the following organizations: the Forest Department, Taralabalu Rural Development Foundation, and Golden Forest (India) Limited, representing the state government, a non-governmental organization (NGO), and the corporate sector, respectively. These three organizations serve to motivate people to become involved in afforestation and eco-conversion programs. The Forest Department has given the least attention to involving and educating the people in planning, protection, regenerating, developing, and managing the forests. Occasionally mass media, such as radio, television, newspapers, posters, and leaflets, were used to create awareness among the public. No government forest official has adopted individual contact extension methods to educate the farmers. However, wherever the joint Forest Planning and Management Project is in operation, almost all extension approaches are implemented.

The Taralabalu Rural Development, a spiritual NGO, has given utmost attention to participatory approaches in afforestation programs, with the aim of producing upward development towards a more abundant life spiritually, mentally, physically, socially, and economically for rural people. The results are highly encouraging.

On the other hand, the Golden Forest (India) Limited, has a unique approach of producing attractive advertisements in leading newspapers, magazines, and television that motivate people to invest in tree growing projects, and to collect the dividends either in cash or in the form of timber after a specified number of years. In India, involvement of the corporate sector in forestry is of recent origin. Nearly forty private companies are functioning all over the country, planting thousands of acres of land in tree plantations. Additionally, the catchy advertisements, emphasizing economic returns, have motivated individual farmers to grow trees, particularly teak, eucalyptus, and mangium, on their farmland.

Successful Communication of Research Findings Requires a Systematic Use of Different Channels

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If new research results shall be applied in practice they have to reach, be understood and accepted by those who can influence decisions, take decisions and/or implement the relevant changes. The greater part of the research findings that are implemented and the sooner this is achieved, the greater will be the return on the money invested in research. Thus the communication of research results are of strategic importance to all research institutions. The communication should be based on the answers of the following questions:

- What effects or changes do we want this research to bring about?
- Which target groups need to share the findings so that the desired changes can be implemented?
- What knowledge will these people need to be given?
- How shall we pass on this knowledge?

There are mostly a number of different channels for communication available such as publications of different kinds, courses and excursions, videos, radio, and TV. In addition to these traditional channels, modern IT offers new possibilities. In the paper different channels and their pros and cons are discussed.

If the new knowledge shall be applied in practice we normally have to use a combination of relevant channels. The choice has to be based on the subject and the target groups. Further, a successful communication system must cover all the steps that lead to a successful implementation: Knowledge, Interest, Assessment, Decision, and Implementation.

The vision for the communication of research findings can be formulated as follows: Everybody involved in forestry shall be able to access needed data and knowledge at any decision situation. Modern IT offers enormous scope for packaging knowledge in such a way that this vision can be realised.

SILVO Forestry Administration and Management System

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SILVO is a software system developed to automate the process of applying and controlling the Forestry Incentive Certificate-CIF ("Certificado de Incentivo Forestal"). The CIF is a grant given by the government to help foresters cover a portion of the expenses for the establishment and management of new commercial forestry plantations. The CIF is administered by the Autonomous Regional Corporations - CARs ("Corporaciones Autónomas Regionales") and the Agricultural Financial Fund-FINAGRO ("Fondo Financiero Agropecuario").

SILVO, version 1.0, was developed by CONIF (National Forest Research and Development Corporation) as a product of the project "Institutional Strengthening for the Sustainable Management of Planted Forests in Colombia," under an agreement prepared by ITTO (International Tropical Timber Organization), MINAMBIENTE (Environmental Affairs Ministry of Colombia), and CONIF.

The CIF includes five phases: ELEGIBILITY ("Elegibilidad"), GRANTING ("Otorgamiento"), EXECUTION ("Ejecución"), PAYMENT ("Pago"), and MONITORING ("Seguimiento").

The ELIGIBILITY phase has the objective of determining whether or not a forestry project and the person or institution are suitable candidates for a CIF grant. In this phase, the corporation should study and analyze all documents and make field visits to ensure the viability of the project.

The GRANTING phase corresponds to the formalization of the CIF through a contract between the regional corporation and the forester.

The EXECUTION phase is the development of the plan of establisment and management of the plantation proposed by the forester and accepted by the corporation.

The PAYMENT phase corresponds to the payments that FINAGRO makes to the forester. There are five payments during the first five years of the plantation. During these years, the corporation should verify the tasks planned and executed by the forester and then authorize the payment.

The MONITORING phase corresponds to the corporation's activities to verify that the forester is performing all planned activities based on the plan accepted by the corporation.

Once a CIF forestry project accomplishes all requirements, the CAR analyzes the information, visits the area, and then asks FINAGRO for the availability of the budget. The administration and management of a CIF project involves human and instituional resources that can be optimized through the automation of tasks that involve great amounts of information.

The immediate beneficiaries of this system are the CARs. Silvo helps, in an efficient way, in the administration of forest patrimony of CIF users and regions. The foresters and institutions also benefit from this resource because this is a modern tool to improve the administration and control of CIF resources and plans for establishment and management. This first version of the system was distributed to the 11 corporations that were included in the project. However, in the near future, version 1.0 will be extended to the remainder of the corporations in the country.

The SILVO system was developed to store, validate, process, and retrieve CIF project information presented to the CARs. SILVO takes into account the phases of CIF projects and their subphases or stages in such a way that the activities made by the forester, the corporation, and FINAGRO are reflected and stored by the system. SILVO is designed to record and process CIF project information, from its registration in the corporation until the last payment in the fifth year of the plantation.

In addition to the adminstration of CIF projects, the system will allow regional and national analyses about CIF plantations, planted areas, species, establishment, and management of forestry plantations plans, etc. The system also has an on-line help menu to facilitate its operation and administration.

Reforestation Behavior of Nonindustrial Private Forest Owners: Evidence from Finland

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In several countries nonindustrial private forests provide a substantial share of the timber required by the forest industries. Consequently, understanding nonindustrial private forest (NIPF) owners' reforestation behavior is essential for projections of long-run timber supply and planning of appropriate policy means to support sustainable timber production. This paper therefore seeks to increase the understanding of factors affecting NIPF owners' reforestation behavior based on theoretical considerations and empirical evidence from Finland. Unlike earlier studies, our analysis incorporates the role of ownership objectives.

In Finland, reforestation after final felling has traditionally been a legal obligation claimed by Forest Law, with private forest owners obliged to deposit a given amount of timber sales income on a special account to secure reforestation. While the basic obligation continues to hold today, major changes have taken place in the1990s. A special reforestation deposit is no longer required; the supervision of forest law has been relaxed; more space is allowed for individual decision-making in forest management; and the resources for forestry extension have been cut substantially. Although detailed monitoring results are not available, recent statistics suggest that forest owners' motivation to complete reforestation has been reduced. Thus, it would be most useful to uncover the potential reasons for the lack or delay of reforestation measures.

Our approach is as follows. Theoretically, the NIPF owner's reforestation decision is considered in a unified framework with his/her consumption and harvesting decisions under alternative assumptions on his/her objectives. The forest owner is either assumed to derive utility from consumption alone or to take into account the in situ value of the standing forest and/or the disutility from intensive reforestation measures as well. In the empirical study, the forest owners are first grouped on the basis of their ownership objectives (multiobjective owners, recreationists, self-employed owners, and investors). Using dummy variables indicating cluster membership, the owner's objectives are then included into the empirical model of reforestation success along with factors such as the owner's long-term stumpage price expectations, knowledge on forestry subsidies, and forest and owner specific characteristics.

The study is based on the monitoring data on NIPF holdings collected in 1990, 1991 and 1996 using the same sample of holdings. The 1991 data includes information on the required amounts of reforestation measures based on inventory data, stumpage price expectations for the next 10-year period, and the use of forest subsidies in the preceding 5 years. The 1996 data comprises the amounts of reforestation activities executed in 1991-1996, as well as forest and owner characteristics. The information on ownership objectives is available in the 1990 data.

Approaches to Evaluate Public Subsidies for Forestry in Finland

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Many countries are reforming their forest policies in order to respond to economical, ecological, and social sustainability requirements. Policy targets are consequently becoming more complex. At the same time, the attitudes toward public subsidies in general have become more critical. In many countries there are very few proper ex post evaluations of the forest policy instruments in economic terms. In Finland there are two major types of investment subsidies: a) annual financing through the state budget, and b) national forestry programs to expand investments. This investigation examines public support for forestry assistance and extension programs. As a case example, an analysis is presented as to how public subsidies have been used to intensify private timber production in Finland, and the major impacts and results of these subsidies. The first attempts to evaluate the results of public expenditure are discussed in more detail. The evaluation of public intervention includes two parts: 1) the evaluation of the intervention costs to government, and 2) the evaluation of the intervention effects to society. Public ownership is characteristically a forest policy instrument, which may be financed from the state budget. In private forestry, instruments may be financial and technical assistance. Estimation of the effects of forestry assistance and extension programs is complicated. One reason is that forest improvement work, or any subsidized activity, has both short- and long-term effects on timber production and supply. The reasoning behind the evaluation of the intervention effects is to address the extent to which given policy tools are sufficient to achieve long-term policy goals, without any unwelcome effects on timber markets. Benefit cost methodology is a conventional way to analyze and evaluate the intervention effects to society, but it does not normally include any kind of timber market analysis. In this paper we are testing, using an econometric model for roundwood markets, whether financial support to forest improvement activities has had any market effects in Finland. The other aim of the study is to investigate and evaluate public sector support to forestry assistance and extension programs. Results of two different approaches, benefit cost and input-output methods, are discussed and recent results for Finland are presented.

6.06.03 Targeting the real forest managers

Indigenous Farm Technologies and Extension Strategies for Sustainable Development of Dry Temperate Cold Region of Indian Western Himalaya

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Cold Deserts constitute the most fragile, isolated and marginalized uplands of the Hindukush Himalaya. Its inhospitable and harsh climate has been borne over the ages by the inhabitants by their ingenuity for their socio-economic sustenance. In the process, people have developed indigenous technologies which are not prevalent elsewhere and, for many of these scientific explanations, are not available as of this day. Cold Deserts pose great challenges and their development warrants strategic blending of acquired edaphic, abiotic, biotic and the socio-economic environment. Over the years its inhabitants have developed rich, traditional knowledge concerning crops, livestock and the environment for adapting to the inhospitable climate. The traditional cropping pattern is specified and adapted to the agroclimatic and socio-cultural needs. The sustainability of village ecosystems is ensured through indigenous resource management. The indigenous knowledge of farming, acquired through generational experiences, continues to evolve toward a better and sustainable livelihood. Now there is divergence from the traditional systems resulting in environmental degradation and decline in socio-cultural values. Hence, the documentation of indigenous technologies, with regard to land and soil management, water management, productivity (crop and animal) and natural biomass utilization, have provided an insight for complementing the old and new technologies. The mountain specific technology transfer approaches for the 21st century will involve special capsules on different crops and farming systems. The technology transfer mechanism will be more challenging and complex for the mountain areas. Specific strategies like plant clinics, vocational training, on spot guidance, distant education and video films and the internet will form an integral component. A computerized data base system with internet capabilities will be quite useful for marginalized mountain areas. A due respect has also to be paid to traditional ethos and wisdom. Participatory approaches and the farmer-scientist interactions will form the basis for incorporating the rich traditional knowledge possessed by the rural masses, and to blend the same for sustainable socio-economic development and ecological sustenance of the Cold Deserts of India.

Social Forestry Research Activities through NGO Network

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In Tamil Nadu State, India, the forest occupy 17% of the geographical area, as against the 33% fixed in the National Forest Policy, 1988. The has more than 0.3 million ha of wastelands and afforestation of these wastelands was taken up in 1984 under the Tamil Nadu Social Forestry Project (TNSFP) aided by Swedish International Development Agency (SIDA) to increase the forest areas. The Society for Social Forestry Research and Development Tamil Nadu (SSFRDT) was established in 1989 under this project to provide the necessary technical support to the Forest Department by taking up research programmes in social forestry. SSFRDT organised research activities in five sections viz. Studies for Policy and planning, Tree improvement, Agroforestry models, Growth promoters and Fodder research by establishing a network of NGOs in the State. During the last ten years, SSFRDT has helped the local people, the elected village adminstative units and the Forest, Agriculture and Rural Development Departments in their tree planting activities through establishment of Provenance Conservation Stands (PCS) for Neem, Kapok, Kodukkapuli, Nelli, Iluppai, identification of biofertilizers for Babul, Neem, formulation of nutritive feed for cattle, conducting workships and training programmes under extension activities, publication of reports on its research activities. Local people participation was established through NGO network for field trials. The SSFRDT has come to occupy a niche in the research activities relating to tree species used by the people in the villages and has helped the farmers to plant high yielding varities trees in their lands to earn an increased income, bringing about a better economic change in the society.

Need for Establishing Demonstration Plots to Translate Research Results in Forestry

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There exists a wide gap between the forest researcher and the forest manager and thus many of the research results are not put to practice. As such there is no mechanism to evaluate the reliability of some of the proven methods under large-scale field trials. In general, forest mangers stick to established management procedures and are reluctant to try out newer techniques. Thus the Forestry Scientists have the added responsibility to demonstrate the research results in order to convince the forest mangers about the efficacy of their findings.

The need for managing the teak defoliator, *Hyblaea puera*, a serious pest of *Tectona grandis*, has been presented here as an example. Studies carried out in the Entomology Division of Kerala Forest Research Institute over the last two decades have generated valuable information on various aspects of the teak defoliator problem. The most important of the research results being the elucidation of growth increment, if control measures are adopted against the teak defoliator (Nair et al., 1996). Though the forest mangers are aware of this pest problem, its impact on growth is not well appreciated. However, in recent times teak plantations have been established under the private sector in India and they have adopted intensive management practices which include control against the teak defoliator.

In the above context, we the Scientists of KFRI decided to demonstrate the impact of defoliation on growth of teak by preserving two plots in a young plantation in 1993. One left to natural defoliation and the other protected against the teak defoliator attack as and when it occurred. At the end of the 5th year, the visnal difference in growth was observable. This was further substantiated by the growth data gathered on height and GBH of the trees in the two plots. The plots are still being maintained and it is hoped that this demonstration plot will impress upon the forest managers on the need for adopting control measures against the teak defoliator.

Introduction of Group Structures in Motorized-manual Forest Work

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In the Bundesland Rheinland-Pfalz of Germany, a group work project was started in February of 1999. In more than 70% of the Forest Divisions in Rheinland-Pfalz, there is a shortage of forest workers, particularly for dangerous jobs like motorized-manual harvesting with chain-saws. This labor shortage is partially overcome by using contract workers or transferring workers between Forest Divisions. Absenteeism and accident rates are considered unacceptably high. The group work project was established to create working teams to better use the talents of the workers and allow them to share in decision-making. The intent is to reduce absenteeism and accidents, and produce more contented and productive workers. In addition to forming and training worker groups, higher level managers need to be trained as well. Implementing the project required a series of training modules involving personnel management and cooperation, team building, group teamwork, and evaluation. All training is being conducted by outside consultants, and additionally, simultaneous monitoring of success indicators, such as accident rate, is occurring. In 1999, a total of 8 Forest Districts were involved in a pilot project, which will be expanded if it proves successful.

Sticks, Carrots, and Sustainable Silvicultural Investment

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Environmental regulations and public financial assistance programs are the typical "sticks" and "carrots" facing nonindustrial private forest (NIPF) landowners in the US. This paper presents a theoretical framework and empirical evidence on the impacts of possible enforcement of the federal Endangered Species Act, and cost-share and tax incentive programs, on their reforestation investments. The results indicate that NIPF landowners' reforestation investment is influenced negatively by environmental regulations and positively by public financial assistance programs. The results imply that both sticks and carrots can be used simultaneously to influence nonindustrial private forest landowners' reforestation behavior and thus promote forest health, productivity, and sustainability.

6.07.00 Tropical Forest History

Balancing Society and Environment: A Historical Approach to Forest Management Problems in Italy in the Last Fifty Years

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The rapid development of Italian economy after the Second World War led to dramatic changes in the utilisation of forest resources, but also in the people's perception of the role of forests. In the fifties heavy utilisation were still carried out in the Alps and in the Apennine mountains. Concerning timber, the shortage of high stands and the increasing cost of their utilisation forced Italy to import more and more timber from abroad. However, most of Italian forest, placed in the central and southern part of the country, were coppice woods used to produce fuel wood and charcoal. In the fifties the introduction of new energy sources determined the end of charcoal burning and a strong reduction of fuel wood production. This caused the abandon of large extensions of woodlands and important changes in the economy of many regions. From the sixties the rapid economic growth of Italy slowly changed the social climate, especially for what concern the public perception of environmental values and damages due to common management practices. People began to perceive heavy harvesting operation to be environmentally unacceptable, but the responses of forest managers to the change in the public opinion, and the changing role of forests was quite slow, and so the political reactions. It took sometime to management theories and policies to adjust to these changes; the first attempt to change the management practice at large scale took place in the Northeast of Italy in the sixties, but the action was mostly concentrated in reducing timber harvesting. Today the problems of management are much more complex than before, as forest must accomplish a variety of purposes and their management must be integrated with the fast changes in society and adapt to case by case situations. From this point of view history is now not only a tool to understand the evolution of forest ecosystem, but a method to support the analysis necessary to plan conservation policies and the economic development of forest territories. Today the lack of knowledge about the factors, which affected the evolution of forest, is a limit to the development of effective forest policies.

History is not offering solutions but is giving the chance to analyse the processes, which affected forest dynamics during long period of time, a rare opportunity in forest research. The understanding of factors, relationships and time scale involved in the evolution of forests, allow a better evaluation of the level of risk of any decision, reducing the uncertainties and defining the limits of the action of foresters. This is especially important in Italy were economic and social development is rarely accompanied by a careful planning of environmental impact and historical analyses is rarely used to develop forest policies and management plans.

History of Forestry in the German Colonies

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Keywords: forest history, German colonies, forest activities

Nine European states (Portugal, Spain, The Netherlands, England, France, Belgium, Germany, Italy, Russia) and the USA have shaped the colonial history of the world during the last 500 years. At its height, in the late 19th century, these powers showed increasing colonial activity and initiated through the era of imperialism the 'scramble for Africa'. It was then that the newcomers Belgium, Germany and Italy gained their colonies. Germany alone acquired colonial territory of about 3 m. km^2 - mainly in the tropics. These colonies under German rule- Togo, Cameroon, German Southwest Africa, German East Africa, German New Guinea, German Samoa and the leasehold of Kiaochow in China - were 5.5 times as big as the German mother country. The German colonial era itself only lasted about 30 years, from 1884-1914.

Three stages can be distinguished in the development of the colonies:

- an experimental development phase, being characterized by the investment of German capital and the uncontrolled takeover of the colonies
- a conquering phase, establishing the balance of power according to plan, suppressing revolts of the native people, developing an administration system and evaluating the local resources
- a reform phase, in which development programs for the colonies and protection laws for the native people were launched

Forest activities were delayed by at least 20 years from the beginning of German colonialism in 1884.

During the second, developmental stage a State Forest Service identical to the German one was established. At the same time many expeditions were conducted into the heart of the colonies, aiming to collect and classify tree and shrub species, and determine their stocking volume by sample plots and their potential for commercial exploitation. The main emphasis was put on the tropical African colonies.

The major forestry problem in Togo was the low percentage of forest land (1,5% = 13 500 km^3). Hence, strict legislation was initiated in order to prevent the clearing of forest land and to declare protection forests. In the Savannah Region, cultivation trials with indigenous and exotic tree species were conducted, systematic afforestation took place, and plans were made to build a sawmill at the coast.

Forestry in German East Africa, which also had scarce forest resources (4% = 39 800 km3), included the following tasks:

- The reservation and safeguarding of abandoned forest land as crown land
- Commercial utilization of this land and its by-products (tanbark, liana rubber) on a concession basis
- Reforestation and systematic afforestation of waste land
- The setting aside of watershed protection forests
- Research on the technical wood properties of the indigenous tree species and their susceptibility to pests
- The enacting of laws on forestry and hunting

Cameroon, on the other hand, had a much higher percentage of forest land (16% = 127 200 km^2) and was the most important colony from a forestry point of view. Consequently the activities were primarily directed at making a profit by exploiting the timber, by managing the wild oil palm stands and by using the forest by-products (rubber, tanbark, kopal etc.). As a result, the export of precious timber like ebony and African mahogany showed a rapid increase by the end of the colonial era. However, it only made up about 3% of the total exports of the colony. The main export goods were rubber and cash crops like cocoa beans, palm oil and palm seeds.

In general, it can be stated that forestry in the German African colonies showed a promising development, especially in connection with the systematic opening-up of the colonies by railroads. This development, however, could not become effective till the end of the colonial era in 1914.

The Rise of Wasteland and its Recultivation in the History of the Alpine Region of Austria

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Keywords: Deforestation, landscape changes, public welfare, recultivation

In the past as well as today the way how men dealt with the forest cover has always been a controversy about exploiting, destructing and sustainable utilizing the natural resources. The comparison of forest history with the present problems of forests and forestry give evidence of similar characteristics. In case of emergency knowledge and experience as well various techniques have been developed which enabled people to handle the forest ecosystem in a sustainable way. In spite of the various research experience and scientific findings in history, today's forest ecosystem is still endangered by global overexploitation. This shows after all that the practical application of the gained proficiencies and perceptions has always been dependent on the existing political, legal, social and economic conditions. As long as the existence of a forest cover has been perceived as a matter of fact, forest legislation was restricted to a defensive attitude only and forests were protected in its hitherto existence at the best. The increasing demand of general public on the forest area led to a more and more offensive forest policy in the course of time. With regard to that as an indispensable precondition people have to be thoroughly convinced of the idealistic and financial values of forests.

The global discussion of the causes of deforestation in the tropics has led to renewed interest in the history of forests in countries which are now considered developed. What are the factors the process of deforestation and the subsequent expansion of forest area were based on? Can lessons be learned from this experience? The reason and insight of the time structure of environmental changes gained by the viewpoint of history has the effect to increase mankind's sensitivity in dealing with vital resources. Thereby recent changes of landscape, their causes, extent and dynamics are of particular interest.

At the turn of the century large unproductive areas of wasteland were noticeable on former forested areas in almost every European country and that in the plains as well as in the mountainous regions. On the territory of the Austrian-Hungarian Monarchy the extent of these waste areas came up to 430000 ha, to which the overgrazed forest pasture had to be added, covering an area of more than 950000 ha.

The submitted paper deals with the decrease of forests carried out over centuries also in the alpine region of Austria. In certain areas the overutilization for different purposes caused the destruction of forest stands possibly followed by the rise of wasteland when additional factors were contributing. The chain of causation will be discussed taking into account geological conditions, climatic influence, increase of population and anthropogenic influence on landscape changes by cultivation in context with the former political, legal, social and economic conditions. The damages caused by overutilization will be illustrated in detail on three examples: the origin of mattock, the cleared areas of the alpine region and the wind-borne sand areas of the plain. Subsequently the correctional actions and programmes having been taken in the particular regions for the recultivation and preventive measures against the further extension of wasteland are pointed out. The necessary requirements were met by the publication of various laws relating to the afforestation of the impacted regions. By that means the beneficial functions of the forests serving public welfare were improved. Furthermore the changes relating to landscape utilization are discussed causing also an improvement in rural income by the creation of additional jobs. The efforts relating to the reafforestation of the former wasteland have generally been successful looking at today’s forest cover of 46% of the whole Austrian landscape and a forest share of 0.5 ha per head.

Historical Reports on Wildlife Management and Hunting in Africa

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Keywords: Africa, hunting, conservation, literature

In the last decades of the 19th century and in the beginning of the 20th century hunting and conservation of game in tropical countries, especially in Africa, was of increasing interest in Germany.

First of all, in the 50ies, 60ies, 70ies and 80ies of the last century researchers have made long and difficult expeditions to the unknown parts of Africa, have given scientific reports on landscape, wildlife and the original life of the natives including their hunting methods. Secondly they reported how the participants of the expedition hunted to get meat for the expedition.

After 1882 (foundation of the "Deutsche Kolonialverein"; 1887 transformed into "Deutsche Kolonialgesellschaft") and the establishment of German colonies (so-called "Schutzgebiete") - Deutsch-Südwestafrika (1884-1915), nowadays Namibia; Togo (1884-1914), nowadays Togo and Ghana; Kamerun (1884-1914), nowadays Kamerun; Deutsch-Ostafrika (1885-1918), nowadays Tanzania, Ruanda and Burundi - the interest and influence on wildlife management and hunting increased enormously. Together with German soldiers and German farmers came German traditions; remainders of these traditions - especially on the field of wildlife management and hunting - can be discovered even nowadays. Experiments and plans of wildlife conservation and of game use as well as hunting experiences were subject of research work and publications.

Until now it is generally not known how many books have been written and published in German language (some of them translations of English originals) on the theme of wildlife, conservation and hunting in Africa. A recently published study on German hunting literature - Sigrid Schwenk: "Bibliographie der deutschsprachigen Jagdliteratur von 1851 bis 1945, Band 1, A -K" - has shown how many authors were involved in this subject.

The planned poster will give an overview on this new field of research, will analyse the different reasons why authors have taken this subject and show the goals of their literary works.

First the explorers, for instance Charles John Andersson (1857, 1858, 1863), Carl Graf Krockow von Wickerode (1867), Sir Samuel White Baker (1867, 1868, 1876), Gustav Fritsch (1868), Martin Theodor von Heuglin (1877), Emil Holub (1881, 1890), G.A Farini (1886), Wilhelm Junkers (1889), Adolf Friedrich Herzog zu Mecklenburg (1909, 1924). Then authors who are involved in the colonial development: Ernst Graf Hoyos (1895), Wildschutz-Kommission der Deutschen Kolonial-Gesellschaft (1912), Fritz Bronsart von Schellendorff (1898, 1900, 1912, 1915), Heinrich Fonck (1910), Wilhelm von Kleydorff (1910), Georg Escherich (1921, 1923, 1927), Hans Anton Aschenborn (1925, 1926), Herbert Kund (1931). Lastly authors of safaris: Berthold Körting (1914), Gustav von Hochwächter (1931).

6.11.01 Poverty and management of forest resources

Brazilian Mahogany in the International Market

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Keywords: mahogany, international market, sawn wood, Brazil

This paper estimated an export supply function for Brazilian mahogany sawn wood - *Swietenia macrophylla*, King. The variables applied to explain the mahogany export supply performance were the export remuneration related to domestic sales, domestic activity cycles, the extension of the road network in the Amazons region and the export restriction on tropical wood log, enacted by Resolution no 128 of the Foreign Commerce Council (CONCEX). The estimates with annual data for the period 1972-93 showed that all explaining variables affected mahogany export significantly and that there were no time lags in export adjustment. The price elasticity found for export supply was around 1.19, indicating a slight elastic supply.

Expectations of the Companies of Pulp and Paper in Relation to Future Barriers in the International Market - the Brazilian Case

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Keywords: Pulp; Paper; Cellulose; Strategic Planning; Strategic Marketing

The last years were of great expansion in the international market; commercial barriers have fallen mainly in regional blocks. The marketing strategies accompanied this evolution. To formulate these strategies it is important the environmental analysis. Why the pulp and paper sector? This sector has presented in the last years an extremely significant evolution, having responded on one hand expressive of the Brazilian exports. This way, the present work has as main objective to analyze the future expectations of the high administrations in relation to the barriers in the international markets of pulp and paper.

They were defined 22 variables for the characterization from the barriers to international level. Variable multi-items were used with the objective of increasing the validation of these mensurations. For definition of the work universe, it was used the database of the National Association of the Makers of Pulp and Paper (ANFPC). The data were collected to the beginning of the year 1996. It was requested to the high administrations of the paper companies and cellulose that responds which the future importance is (its expectation) of the barriers at international level.

It was observed that all the variables analyzed by the test presented coefficients of Cronbach alpha superiors at 0,5, considered as satisfactory minimum approach to establish a reliable level of mensuration for variables multi-item. The future expectation of the high administrations in relation to the barriers at international level was from a smaller importance to the one imagined, visualized by the value of the variable denominated "macrobarrier". Such a fact was not only owed to the smallest importance presented by "internal barriers", because even same the prospective expectation for external barriers is only indicated as of moderate importance. Although the opposing results presented a smaller degree of importance that the prospective one, the high administrations trust in that the competitiveness that can exist for the Brazilian exports of pulp and paper will be mainly responsibility of the Brazilian public sector, indicated by the biggest importance in the barrier "Brazil cost" This result reflects the expectation that the state assumes the responsibility of orchestrating structural and economic improvements increasing the competitive capacity of the companies in the international markets. The concern with the "competition of exporters of other countries", perceived as the main prospective barrier, it is significant, indicating what type of strategies they will be carried out to make in front of this threat. When we analyze the group of "internal barriers", the high administrations mention that its expectation for the recent future will be of a smaller growth of the exports mainly to the lack of capacity to increase the offer in the external market.

Economic Comparative Analysis Among Different Sizes of MDF Plants to the Brazilian Reality

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Keywords: MDF; Production cost

This paper intends to compare the economic efficiency of four MDF (Medium Density Fiberboard) industry plants: 15,000m^3/y; 30,000m^3/y; 50,000m^3/y and 105,000m^3/y, respectively. The initial presupposition is that small and medium size plants have, at least, the same efficiency than the bigger plants, because the technology costs of the small plant are lower than for the big one (105,000m^3/y). The concept of economy of scale is usually concluding that the bigger plants are more efficient and have smaller costs than the smaller plants, because the technology is the main factor of the productivity definition and unit cost. Although, it is important to analyze the relationship between the technology costs and the production of the plant, and to optimize this relationship. This paper analyses the proposal of INDI – Instituto de Desenvolvimento Industrial de Minas Gerais (Industrial Development Institute of Minas Gerais State – Brazil) and the proposal of three sizes of plants from China and Brazil. The methodology included the identification of the technical coefficients of each plant and the factor prices (glue; labor; energy; raw material; equipment price etc.) in Brazil in order to homogenize the variables and to compare the plants. The comparison of the plants included analysis of the Return of Investment; Payback and Present Liquid Value. A sensibility analysis was performed to verify the change in the results when the MDF product price or the factor prices change. The preliminary results showed that, to the Brazilian reality, the plant that produces 30,000m^3/y is the most efficient among the four. A further advantage of the small plant is the greater agility to market changes, enabling this plant size to maintain greater proximity with the clients, and consequently, a greater fidelity. In Brazil there are a lot of micro size furniture and small size enterprises (74.74% and 22.22% of the Brazilian furniture enterprises, respectively). Strategically, the small plants can reduce the raw material costs in two important ways. Firstly, by using a smaller volume of wood, the range of transportation is reduced and consequently the cost is reduced. Secondly, the use of residues in the raw material composition is important to the small plants. This also reduces the raw material cost.

Survey of Path Forest-Wood of Paraná - Brazil

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Keywords: Filière; wood sector; Brazil; Paraná; Pulp; Paper; Venner; Saw wood

The Brazilian path wood is one of most dynamic of the Brazilian economy and sudden various structural changes. For this sector, the Paraná contributed of decisive manner to the production of both pulp; paper, saw wood and plywood. Of this fact, the government of Paraná solicited a specific analysis of this path wood in the Paraná State aiming to the realization of a development politics.

It has been analyzed the physical fluxes of path wood initially, since the forest until the final consumer. Then two separating path: path of pulp and paper; the path of mechanical transformation of wood, including sawed wood and plywood. This different fluxes are under detailed analysis in order to foresee the politics of development announced.

The forest activity of Paraná State consume approximately 21 millions of m3 of timber by year, to industrial transformation. The consumption of pine (exotic specie) is approximately 17 millions of m3, 82% of the total, in second place of the consumption, it is used *Eucaliptus* (exotic specie), 1,5 millions of m3, 7% of the total, in third place; native timbers in general, except Araucária, 6% ot the total and in short *Araucaria angustifolia*, specific South Brazilian conifer with 5% of the total.

The path of pulp and paper of Paraná Sate occupies the leader position at the national. It is the first producer of mechanical pulp of the country, the second producer of cellulose and paper of all types and the unique manufacturer of newsprint of Brazil. This path consumes the major part of timber of the State, 68%, and exclusively of reforestation.

With regard to the path of the mechanical transformation, the consumption of timber is approximately 6,4 millions of m3, at the rate of 77,7% intended to the production of saw wood and 28,3% of veneer.

Of the whole of the production of region-plated, principals markets are: the furnishings with 3,25%, the packing for 2,35%, the civil construction for 16,48%, the naval construction for 1,35%, the export for 35,3% and in short the resale for 41%. It has been determined that the major part of the market of this resale destines itself to the industry of the furnishings, but at present it was not possible to quantify this transaction.

EMU and Forest Products Pricing in Europe

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Keywords: Exchange rate pass-through; newsprint; pulp; Johansen's cointegration method

The purpose of this paper is to examine the effect of a pricing currency, national currency vs. US dollar, on pulp and newsprint export pricing in the UK and German markets. Earlier studies have shown that exchange rates have an important effect on forest products trade and export pricing. The US dollar has been, and despite the introduction of Euro in January 1999, still will be, an important invoicing and pricing currency in pulp and paper trade, both in the EMU countries and in the world market. Therefore, comparing US dollar and importer currency pricing in European markets is an interesting empirical case involving both the effects of an introduction of a currency area on export industry's pricing and the effects of third currency invoicing on competition. Thus, in the present study, exchange rate effects are studied also with respect to the US dollar, contrary to earlier studies that analyzed the effects only with respect to importer countries' currencies. The exchange rate effects are examined using the concept of pass-through and a markup-model for exporting countries' export pricing. The model is estimated for Finnish exports using Johansen's cointegration method for monthly FIM/USD, FIM/GBP, FIM/DEM exchange rates, as well as pulp and newsprint export unit value time series 1986-1997.

The Finnish, Swedish and Canadian export prices, measured in importer's currency, developed fairly uniformly in 1980' and 1990's. The results indicated low pass-through elasticities for Finnish exports, which is consistant with the competitive European pulp and newsprint markets. For the hypothesized effect of US dollar nominated pricing, prevailing especially softwood market pulp, practically no evidence was found. This would imply that the use of US dollars in price nomination in the UK and German markets has not affected the market pricing. As the coefficients for the importer currencies were also very small, in the light of these results, the introduction of Euro will probably not cause significant changes in forest products pricing or competition in Europe.

Potentials of Agroforestry for Conservation of Natural Forests and Sustainable Livelihood in India

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Rural people in most of the developing countries in Asia have been depending heavily on forests for meeting their basic needs. However, with the steep rise in the population, the pressure on the natural forests during the last five decades has increased beyond the level of tolerance. In the absence of suitable conservation measures and necessary investments, the forest cover has been fast depleting throughout Asia.

In India over 45% of the forest lands are devoid of vegetal cover, depriving 20 million rural families, particularly those belonging to backward tribal communities of their means of means of sustainable livelihood. Such severe deforestation is posing a threat to the eco-system and environment, while suppressing the water supply, agricultural production and employment. Therefore, conservation of natural forests, through promotion of alternative sources of woodfuel, fodder, timber and non-wood forest produce (NWFP) will be an important component of community forestry program during the next decade. Among many options, agroforestry has great promise because of the scope for ensuring food security and cash income, while expanding the green cover on non-forest lands through active participation of the stakeholders.

Various tree based farming systems launched in different agro-climatic conditions in India have confirmed that fruit tree species such as mango (*Mangifera indica*), cashew (*Anacardium occidentale*), custard apple (*Annona squamosa*), ber (*Zizyphus mauritiana*), tamarind (*Tamarindus indica*) and Indian gooseberry (*Emblica officinalis*) establish well in semi-arid zones and generate substantial income. This system which included fruit tree species as main crop, cereals, pulses and vegetables as intercrops, fuel and fodder tree species as windbreaks, established on contour bounds could enhance the crop yield. Introduction of watershed development, empowerment of women and recycling of biodegradable waste for soil enrichment as an integral part of this program had added advantages. A family maintaining aha of land under this system could easily earn a net annual income of US$ 400/year from the fifth year as compared to a US$ 100–120/ha from traditional farming. Wastelands which are not suitable for agri-horti forestry could be utilised for cultivation of NWFP such as Neem (*Azadirachta indica*), Pongamia (*Derris indica*) and Mahua (*Madhuca indica*) and other species, which are adopted to drought conditions and produce fruits and nuts useful for oil extraction and Ayurvedic medicines.

Such tree species were well accepted by local communities for establishing on common properties for joint management, as the income from such plantations were substantially higher than the fuel and roundwood timber plantations. There is good scope to introduce fuelwood species in the interspace in NWFP plantations. With such tree based farming systems it was observed that the farmers could produce adequate quantities of biomass for fuel and reduce their dependence on the natural forests.

Sociological Research for Forest and Society: The Integration of Sociological Research with Forest Management for Fuelwood-dependent Villagers in India

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Villagers in northern India who live near the forest are dependent on the forest for most of their daily needs. It works as a lifeline for them, as they extract fuel, fodder, and other non-wood forest products from the forest for their livelihood. The main dependence is on fuelwood. Fuelwood collected from the forest is used in households as well as sold on the market for cash.

The analysis and conclusions drawn from this study highlight the importance of integrating sociological research with forest management. Consideration of these sources of information can be of substantial utility to the decision-making process for those charged with the management of forests, and for the quality of life of people whose livelihood has depended on forests.

This study demonstrates the utility and relevance of collecting three sources of information to facilitate decision-making about forest management: (1) information about how the forest is used, (2) sociological information on socio-economic conditions and quality of life for the people who use the forest, and (3) opinions and ideas of the people who use the forest concerning what they need, what they feel needs to change, and how they could contribute to beneficial changes.

The focus of the paper is on extracting information, which is simultaneously useful for forest management questions and for quality of life questions. Sociological research is used to examine such questions as the role of forest management for fuelwood use, interactions between fuelwood use and daily life, socio-economic conditions of fuelwood-dependent villagers, and policy questions regarding fuelwood use and fuelwood alternatives.

Specifically, the independent variables of the study are socio-economic information regarding caste, education, family composition, land tenure, and income. Two sets of dependent variables are examined. The first set of dependent variables gathers information about the fuelwood and the collection process: for example, type, quantity, frequency and daily time-involvement, self-provisioning and stocking, cash transactions, distance traveled from the dwelling, distance traveled into the forest due to depletion of fuelwood near the forest's edge. The second set of dependent variables solicits the views of villagers on questions that address their quality of life in relation to fuelwood-dependence: for example changes in forest management that would facilitate fuelwood availability, alternatives to fuelwood cutting, and changes in government policies that would facilitate fuelwood collection and/or alternatives. The solicitation of the views of villagers is based on principles of development practice which incorporate these views as an important part of fact-finding and potential problem-solving. Both forest management outcomes and social well-being outcomes can benefit from gathering this type of information from the people who use the forest.

Social Impact of Transmigration in Sumatra, Indonesia

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Transmigration interferes with the socio-economic conditions of local people in Indonesia. In Sumatra, where most of the transmigrants have settled, local people used to derive their main source of income from jungle rubber. They implemented a type of agroforestry by planting jungle rubber through selective and partial clearing of forestland combined with the cultivation of upland rice for a period of one to two years. Now the use of the forest by local people around areas of Transmigration projects has become limited. Therefore, in the local villages, buying and selling of rubber land have increased and the socio-economic differentiation of rubber smallholders has progressed.

Optimum Use of Agricultural and Forest Land Fund in Selected European Countries in Transition

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Keywords: Agricultural and forest land allocation, Optimum use, Countries in transition

The issue of optimum land fund use and namely of optimum land fund division between forestry and agriculture has been topical for the whole history of man's use of nature. There has prevailed univocal trend to increase the area of forests in developed European countries recently, i.e. to afforest non-forest and namely agricultural land. Extensive afforestations have been carried out for example in Spain, France and other countries, too. Up to 17 millions ha of agricultural land are estimated to be afforested within the EU. This process has been legally supported by the Directives 1609/89 and 2080/92. A significant benefit consists in the possibility to get a financial subsidy in performing the soil succession. The above mentioned trend has also started to come into effect in some European countries in transition (after changes of socio-economic conditions of these countries). There are actually two cardinal reasons for performed or proposed changes in land use:

- Environmental one, consisting in improvement of the landscape and the environment, in increase in forest cover and consequently in overall ecological stability of a territory.
- Economic one, consisting in decrease in agricultural produce surplus or in increase in forest production output.

The complex solution to the issue is considerably difficult as it involves inter-disciplinary and inter-sectorial aspects. A relevant restructuralisation of land fund impacts upon spheres of production, economy, society, environment, legislation, and institutions. Neither the harmonisation of owner's (or lessee's) intents with those of the society can be neglected. On the current experience and knowledge, the following process (concept) of agricultural land restructuralisation can be suggested in regions setting aside agricultural production:

a) Basically, the regions and localities expected to undergo the set-aside program will be presumably identified by a competent body.
b) Nature landscape potential will be assessed by relevant indicators in the region where agricultural production is expected to be set aside.
c) A system of criteria will be designed for taking a decision on proposed forms of forest stands being established depending on the original and anthropogenically affected natural conditions.
d) The expected environmental effect of established forests (or the ones being established) will be assessed in the relationship to the real natural landscape potential.
e) Procedural principles of establishment, improvement, and protection of forest stands will be set with the view to soil quality, climate, and potential adverse impacts considered in the region.
f) In cases of a more extensive afforestation, steps of forest planting, protection, and cultivation will be proposed.
g) Expected costs of forest establishment, improvement, protection and cultivation will be assessed considering the natural conditions.
h) A set of administrative measures to ensure afforestation projects and management of established stands will be performed.

The demanding character of vast agricultural land afforestation requires all steps to be carried out purposefully and organised under the principles and set procedures adopted in advance.

Economic Analysis of Forest Degradation Processes in Sub-Saharan Africa: A Bio-economic Modeling Approach

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Africa lost 24% of its forest/woodlands between 1958 and 1968 and the annual loss has been approximately 0.8% between 1981 and 1990. These losses occur both due to deforestation and degradation processes, of which the former appears to be relatively better analysed and understood than the latter. Even if these estimates of the rate of loss of forest wealth are doubtful and somewhat exaggerated, the need to understand the dynamic complex processes, particularly those of forest degradation, remain crucial for checking the negative externalities through sustainable forest management. Because of the complex and dynamic nature of these processes involving ecological, technological and socio-economic factors, the phenomena can be better understood through modeling the systems behaviour. Achievement of such a goal requires the use of theoretically sound and empirically testable biological and socio-economic models at a reasonably disaggregated level. This study seeks to use such an approach to analyse the economic causes of forest degradation in Sub-Saharan Africa by using bio-economic dynamic linear programming models at the village level. The emphasis is mainly on analysing the forest degradation processes arising out of clearing of open forest land for cultivation, cutting of wood for fuel and charcoal and use of vegetative bio-mass through grazing of livestock in three countries, namely, Senegal, Tanzania and Uganda.

A number of hypotheses explaining the role of economic factors are developed and tested by running alternate scenarios of the model for a few villages in each country. The aim is to present a theoretical basis for identifying the relative importance of different economic factors that can be used by policy makers for checking or at least slowing down the process of forest degradation and thus achieving sustainable management of forest wealth in this region of the world.

The model is specified with aggregate welfare of the village community (measured as the present day value of net income within the planning horizon from all crops, livestock, forest and miscellaneous activities as well as the imputed value of leisure time of human labour) as the final objective function in a hierarchy of objectives. Hierarchical attainment of objectives is sought subject to a number of constraints on the level, quality and distribution of key production factors, e.g., human labour, land, livestock, etc., and on market demand for crops, animal and forest products (e.g., wood fuel and charcoal), miscellaneous products (e.g., beer and bricks), etc. Incorporation of non-linear biological functions for the regeneration of stock of vegetation, i.e., bushes and trees, in miombo woodland, grazing functions for the livestock, growth functions for human and livestock population, technological improvements in crop yields, changing prices of inputs and outputs, demand functions for fertilisers, coal, wood fuel, recursive nature of cultivated land and woodland area constraints, increasing time required to collect a unit of fuel wood as one moves away from the village centre over the years, etc., are some of the highlights of the model. Besides, classification of village households into croppers, grazers and fuel wood cutters, division of the village into cropping, mixed and grazing zones, and land into upland and lowland classes, use of satisfying approach, accounting for uncertainty, etc., help the model to approximate reality better in describing the forest degradation processes. It would represent an improvement over the past efforts involving multi-country and aggregated form of analysis to understand the complexities of the involved phenomena. Funded by the European Union, socio-economic surveys and remote sensing of vegetative cover and degradation are being undertaken in each of the three countries to collect the necessary data for the proposed study.

Combining Slash-Burning Agriculture and Plantation Forest

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Slash-burning agriculture, a simple traditional plantation system is still carried out in Indonesia. This plantation system is one of the problems that causes degraded land on the forest area. This system is still used because could be operated by traditional poor farmers with a simple knowledge and low investment. Usually on the preparation land for plantation they use, slash and burning system that causes forest fire. Uncontrolled the degraded land increasingly as they le it after used and move to the new land and so on. This problem increase rapidly as the population increases. To solve the problem, it is needed to develop the system so that the farmer could settle on an area relative permanently. Industrial Forest Plantation (HTI) system that recently operates in large scale with large investment in Indonesia could be combined to the sifting cultivation as one alternative to solve the problem. The farmer who traditionally used the slash-burning agriculture system if the new system in applicable and give opportunity to increase their income. This paper explains about financial analyses of agroforestry system on the *Acacia mangium* plantation that was implemented in the trial forest Balai Teknologi Reboisasi Palembang, South Sumatera.

Problems of Non-Market Forest Services Monetary Valuation in Some Countries in Transition - Case of the Czech Republic

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Keywords: Non-market forest services, Forest externalities, Monetary valuation, Countries in transition, Czech Republic

Forests provide society with wide range of very important non-market functions - services and goods - connected with water, soil and air protection, with health, recreation and scientific cultural impacts on the society. Importance of non-market forest functions can be valued with great difficulties, from both theoretic and practical points of view.

When speaking about great problems with valuation of non-market forest benefits, questions on real aims and reasons of such problematic valuation are raised very often (both by the theoreticians and practitioners). Monetary valuation of non-market forest benefits can be used for different purposes, especially for:

- identification of share of forests' importance in natural and social welfare of the country;
- analyses of the state and development of social demands for forest externalities;
- expression of socio-economic effectiveness of multiple and sustainable forest management;
- decision making about land allocation between forestry and other kinds of land use;
- assessment of value of social losses caused by damaging of forests;
- stimulation of effective and wise use of forests, of all their goods and services;
- improving in forest planning and of forest running processes in the frame of multifunctional forestry.

In the case of the Czech Republic, the one of European countries in transition to market economy, two main methods for non-market forest services' monetary valuation are discussed and investigated. One procedure is based on a consumer surplus approach, on willingness-to-pay method, especially on the Contingent Valuation Method. The other procedure results from an expert approach, based on expert comparison of importance of non-market and market forest goods and services.

Results from the investigation, both theoretical and practical, including monetary values of individual non-market forest services and their comparison with value of market services are presented. Advantages and disadvantages of two basic approaches in conditions of most European countries in transition are discussed. The expert approach seems to be much more promising method for non-market forest benefits valuation under present conditions in some European countries in transition (the case of the Czech Republic) than the willingness-to-pay method.

The expert approach has been used in forestry and legislative practice in the Czech Republic since 1995 as a part of the Forest Act (No. 289/1995) in paragraphs dealing with the so-called "Withdrawal Fee". Withdrawal of plots of land designated for the fulfillment of forest functions (the "withdrawal") means the release of such land for other use. The fee, paid for the withdrawal of plots of land designated for the fulfillment of forest functions (categorized zones of protective forests and forests of special purpose), can be considered as the official administrative value of non-market forest services (positive forest externalities). The fee (price) is used as an economic instrument protecting forest lands and forests against deforestation, against using forest areas for other purposes.

Monetary values of individual non-market forest services are shown and discussed. Value of forests categorized (zoned) as "recreational forests", forests in suburban areas with increased health and recreational function, amounts to 791 thousand Czech Crowns (CZK) per 1 ha in 1998 but the value does not express only pure recreation importance of forests in the "recreational zone". Value of non-market forest functions in other zones, categorized by the main forest function in a respective zone, varied from 369.1 thousand CZK/ha to 1,318.3 thousand CZK/ha (for example core zone of national parks, national preserves-especially protected areas, etc.) in 1998.

The average non-market value of commercial forest as a source of non-market forest services reached 803.8 thousand CZK/ha in the CZR. For comparison, the administrative, official, value of forest, based on timber production function, amounts on average 310,2 thousand CZK/ha, which is relatively high figure criticized by many specialists. On the contrary, the non-market value of forest amounted to 3,142 thousand CZK/ha in the National Park Sumava in 1998.

6.11.04 Bridging the gap between monetary and non-monetary valuation of environmental amenities

The Different Concepts of Value and the Contingent Valuation Method.

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Keywords: contingent valuation, values, lexicographic preferences, forest regeneration

This paper provides a framework to analyze how economic values are related to some other value concepts. Thus, it also clarifies the role of economic values in forest policy. The paper provides tools to analyze different value categories in the contingent valuation (CV) method. Contingent valuation has traditionally measured only the preference structures assumed in economics.

It is not surprising that the word value has many meanings. Philosophers have mentioned ethical values since Aristotle's time. The disciplines of social sciences, e.g., sociology, social-psychology, economics, all have their own meanings for value. There are, however, some structures of values that most social scientists probably can accept. In particular, the two following classifications of values are useful.

First, we can make a distinction between end values, instrumental values, and functional values. The difference between end values and instrumental values is important. End values are typically basic things human beings desire, like wisdom, happiness, freedom, equality, beauty, pleasure, and friendship. Instrumental values are the means to achieve a purpose related to some end value.

Functional values concern the purely non-human technical contributions an object has to another object. Second, we can separate held values and assigned values. Human values, i.e., end and instrumental ones, are held values. Held values refer to internal beliefs and attitudes held by individual humans. They are the ideals or models of the world that are desired.

Assigned or attached values are connected to some objects. Valuation takes place in the interaction between a human and an object, for example between a recreationist and a forest. The assigned value is the relative importance or worth an individual expresses in this interaction. Actions and words are two modes that can be used to express the assigned value. Further, a discussion, market transaction, voting, or survey is a possible interaction where assigned values can be realized. Assigned value expressions are influenced by the perceptions of end, instrumental, and functional values. It is thus worth noting that value expressions do not only reflect person's held values, but many contextual factors can also affect them.

The structural characteristics of value expressions, later called preferences, can be categorized with four types: non-rational, weakly comparable, non-compensatory, and exchange. The non-rational expressions deny any possibility to value a good. An individual with weakly comparable preferences may choose between alternatives but is unable to make a general value ranking. Non-compensatory preferences can produce a value ranking between alternatives, but is unwilling to make trade-offs between them. Moral issues and essential goods and services are, for example, ranked as non-compensatory characteristics. In economics, lexicographic preferences are an example of this preference structure. Exchange preferences use a common measure against which all alternatives can be valued.

In economics this kind of commensurable preferences is normally assumed. The contingent valuation literature has theoretically and empirically recognized different preference structures. For example, the lexicographic preferences have been measured in several studies with attitude-like statements and in a few studies with paired comparisons. Two methods have seemed to produce different estimates for the number of respondents having lexicographic preferences. In this study, we report a CV experiment where two methods are compared. The topic of the survey is the nation-wide forest regeneration policy concerning private forests in Finland.

6.11.07 Social science contribution to wildlife protection

The Myth and Realities of Forest Resource Conservation in a Tribal Village: An Ethnographic Inquiry into the Khasis in Bangladesh

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A number of popular environment-related myths have been observed in the course of the fieldwork. The content and implication of these myths have been evaluated in light of the `modern' knowledge as depicted in academic texts and `scientific' quarters. For example, there is a long myth, which in essence connotes that betel leaf including its farming techniques was an exclusive divine gift by the `hill gods' to the khasis in order for them to entertain and treat guests. The information on various aspects of the agro-farming technology, as collected from the `divine inspiration' - such as minimum tillage, use of trees as living support for betel plants, use of living fence around the plantation etc. - are in remarkable conformity with modern knowledge.

6.14.00 Urban forestry

People's Participation and Community Organization in Forest Management: Issues in Joint Forest Management in Madhya Pradesh in India

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Forest plays an important role in the life of Indian rural residents from social, economic and institutional point of view, The National forest policy of 1988 significantly emphasized the involvement of the people, specially the tribal and women, in the protection, development and management of forest. In consequence after various experiments by the progressive foresters, Joint Forest management (JFM) has been a resolution passed by the Ministry of Forest and Environment on 1st June, 1990 for introducing collaborative forest management involving the local people in the forest protection and management and the voluntary agencies. So far 21,000 forest committees in the 19 states of India have been formed. It envisaged an institutional arrangement for the local people to jointly with the government to protect and manage the forest resources in return for a share in the yields from it. The state of Madhya Pradesh, the largest state in the central part, has an area of about 44.3 million ha. of geographical area. Of this about 19.6 million ha. area of the state is classed as agricultural land, of which 4.3 million ha. are irrigated. The live- stock population has been estimated as 45 million heads and migratory herds are through to number about 2 million during the year. The total human population of the state was estimated as 55.18 million in the 1991 census, giving at a rate of 2.6 percent per annum between 1981 and 1991. Of the total 15.3 million are tribal peoples and 9.6 million scheduled castes. Poverty in the rural areas is estimated to be 41 percent of the total area.

Under this socio-economic condition and the burden of the rural poor on the natural resources, in compliance of Govt. of India order, the Forest Department of Madhya Pradesh, has passed the JFM Resolution of the state on 1991 giving importance of people's involvement in forest protection and management. The amended resolution 1995 was passed to give more opportunity to the woman and weaker sections along with NGO's involvement. The Forest Deptt. has taken serious attempt under World Bank forestry project since September 29, 1995. Two types of people's institution - the Forest Protection Committee (FPC) and Village Forest Committee (VFC) - formed on the basis of crown density, set up various social norms rules and operational system to protect and manage the forest resources and to avail the usufructuary benefits and others net profits. As the sate is well known for the concentration of the indigenous peoples (23.22%) who mainly belong to the small farmers, marginal farmers and landless labors in the land-holding capacity, after inception of the JFM progamme the income generating activities for the sustained livelihood got the first priority either by providing employment or skill development in small-scale enterprises. The village resource development fund for community banking formed of the transfer of money from the various heads of government fund has provided support in income generation activities. In this care and share philosophy some good outcomes have been developed through collaborative and co-management system of protection and management for encouragement of natural regeneration and bio-diversity conservation. The promotion of indigenous knowledge system, redress of local problems, participatory and decision-making process, equitable benefits sharing are the key features in this forest management system.

On the various case the following issues have been identified: Awareness level has been raised but the institution building does not occur to that extent due to negligence in confidence building, unequal participation in the functioning of the forest protection, bureaucratic control by forest department, question of the equitability in the sharing of the benefits, social conflicts, less women's participation, lack of co-ordination between state govt. departments, conflicts related to the distribution of loan, no commitment of the sustainable income generation etc. Still many conflicts exist between villager's expectations and needs, and state guidelines for forest management and product sharing. Motivation in the development activities, more devolution of management responsibilities to forest committees and commitment for the equity sharing is the major issues to address for the sustainability in this management regime.

Community Involvement in Forest Management - A New Chance for Forest-related Rural Development in Tanzania?

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The increasing displacement of Miombo woodlands is a special problem in African dry lands. The yield of traditional management of these ecosystems is not longer sufficient to cover the needs for food supply and cash crop of the growing rural population.

The current situation in Tanzania offers an excellent opportunity to influence natural resource management in the region. Forest Faculties, Colleges and NGO have embraced community forestry and have made it part of their curricula.

The know-how about the multiple use of Miombo woodlands is a basis for further develop-ment of properly resource utilisation systems. These systems should not only guarantee the capability of the woodlands to fulfil the subsistence needs of local household, but also generate income through marketing of products from the woodlands. Basic for the willingness of people for a good resource management is their commitment mainly influenced by there stakeholder status and their legal access to resources and profit from resources.

Based on this presumptions a study in North Eastern Tanzania about actual woodland utilisation and chances for further development of resource utilisation was compared with success stories concerning Social & Community Forestry Projects in Northern Tanzania to find out, how sustainable land use systems can be implemented with chances for success. In the research area the marketing of woodland products, also of Non Wood Forest Products (NWFP), fundamentally can be considered as an incentive for the conservation of the woodlands. The acceptance levels for accelerating propagation of utilisation and marketing of NWFP vary between and within communities. Social & Community Forestry can give incentives for conflict management, and for the dissemination of information for production and marketing.

Community Resiliency and Change: a Socio-Economic Assessment of Resource Dependent Communities in the Upper Columbia River Basin

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In 1995, the U.S. Forest Service and Bureau of Land Management were charged with doing a biophysical and socio-economic assessment of the Upper Combia River Basin (Columbia River Basin Ecosystem Management Science Assessment). As part of the assessment, empirical data from the U.S. Census Bureau were gathered in 1995 on all 387 small rural communities in the Inland Northwest and Northern Rockies to assess the characteristics of those communities. In addition, a random sample of 198 communities was selected and 1,350 representatives of the communities completed a ‘Community Self-Assessment Workbook’; they then participated in community self-assessment workshops that provided data on their community’s current characteristics and conditions (i.e., community character and attractiveness, social cohesion, civic leadership, quality of life, business attractiveness, economic diversity and resource dependence, and the community’s preparedness for the future). Resource dependence included measures agriculture, travel and tourism, timber and mining. Community officials were also contacted to provide other documentable or recorded details about each community’s character and conditions, (e.g., rate of population growth, economic changes, school and utility capacities, distance from major transportation routes or nodes, etc.). Results of this assessment and surveying project will be presented, as well as their implications for future management of the region’s natural resources.

Forest and Landuse Structure in Urban Landscape in Tokorozawa, Japan

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This study aims to show the historical change of Forest and land structure in Urban Landscape in

Tokorozawa, Japan. I digitized the vegetation map in 1956 and 1985 and analyzed 29 years of forest and landscape change using Geographic Information System. Tokorozawa is the city about 30 km north from Tokyo metropolitan area and its area is about 7,200 ha. In 1956, it had 1,940 ha (26.7%) of forest and 4,038 ha (55.7%) of agricultural field. But in 1985, there were rapidly decreased to 1,150 ha (15.9%) of forest and 2,343 ha (32.3%) of agricultural field. In contrast, urban area was growing up from 367 ha (5.1%) to 2,046 ha (28.2%). So the landuse change showed that Tokorozawa was dramatically grown up form forest and agricultural town to Satellite City of Tokyo. In the same time, forest use was changed. In 1956, forest was an important role to supply timber fuel charcoal and fertilizer for agriculture. So it was easy to find out the effect of forest use in the vegetation in 1956. Sympathizing with the rapid economic growth, a lot of substitute ware developed and imported, so the importance of traditional forest use was rapidly reduced. In 1985 in some area, we could find out that panted conifer forests ware naturally regenerated to deciduous substitutional community.

***Prosopis juliflora*- A Metallophyte for the Biorecovery of Aluminium from Urban Industrial Enclaves**

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Keywords: *Prosopis juliflora*; biorecovery; aluminum

Human, industrial and agricultural activities result in increased release of heavy metals in to the environment. Since, heavy metals readily accumulate in soils, their concentrations are likely to increase continuously. Severe pollution of urban soils can originate from heavy emitters of air borne particles. Major fall out problems result from mines, old smelters and foundries.

Coimbatore District (Tamil Nadu) harbours around 620 metal based industries. Of which, 32% are die-casting industries, which are potential source of aluminum pollution. Several plant species are indicators of soil heavy metal pollution. Rhizosphere soil and root samples of *Prosopis juliflora* were collected from 8 different sampling areas (S1-S8) around non-ferrous aluminum based industries with soil aluminum concentration ranging between 3-36 $\mu g\ g^{-1}$ of soil. The aim of this study was to assess the potential of *P.juliflora* in decontaminating heavy metal pollutants in soils. The results indicated higher aluminum accumulation of 25-79 folds in roots compared to their availability in the soil. Aluminum accumulation in *P. juliflora* roots were maximum in S3 (896 $\mu g\ g^{-1}$) and minimum at S4 (211$\mu g\ g^{-1}$). *P. juliflora* accumulated other metals (Cu, Cd, Hg and Ni) also indicating its capacity to accumulate several heavy metals. Therefore, the results clearly shows *that P. juliflora* could be used in decontamination programmes in metal polluted soils and also the suitability of using *P. juliflora* roots as an indicator of heavy metal pollution.

Urban Forestry Constraints

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Continuing with that previously exhibited and published by the IUFRO Int. Congress held in Montreal, Canada during the year 1990, I have prepared a new contribution.

URBAN FORESTRY CONSTRAINTS is a pertinent title leading with an scientific understanding of the spatial dimensional dynamic declining our living spaces. We will be able to enhance this content by laying out an analysis coupled with a more complete meaning shown by the author's paper named: NEW SCIENTIFIC ANALYSIS ON MICROMETEOROLOGY WITHIN BIOMETEOROLOGY SOURCING DATA APPLIED TO URBAN FORESTRY" (Outlooks for our wellbeing at Indoor and Outdoor sites) which becomes printed in this Congress too. Settings of long-term scientific purposes are here clarified: Spectrality; Profile Principal and Secondary Components into Urban Forestry Biometeorology Simulation; Insights of the Subject Contexts made out into a Modeled "MOTIB" Project (Modules of Transfrontier Investigations on Biometeorology) which gives structural concepts and scientistKeywords. From these arises an upgrade meaning for one named: "totalities" in Forest Sciences, applied now to Urbanism Life Amelioration with a minded mitigation of diverty Urbanism Constraints.

So, Forest Coverture, as a biological and physical Entity, plays a new role in successes Entropy and Entalpy sourrounding our daily life. The neighbouring behaviour of these processes towerds our daily sensed thinking and keeneye strives underline the format of this scientific contribution without ignoring the nature of both "NATURE" and "HUMANS". Forest Biogeocenology and Forest Biometeorology could be judged as a

"United Disciplinary Forum" for any scientist dedication abroad.

6.15.00 Reconsidering study objectives and teaching methods

Identifying & Evaluating the Educational and TrainingNeeds in the Disciplines of Forest Products and Wood Science

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Key Words: Education; Needs Assessment: Wood Products: Technology Transfer; and Marketing

As scientists and practitioners in the fields of Wood Science and Technology, we often teach what we have been taught. This practice is in direct contradiction to current management and marketing philosophies that require us to understand the needs of the customer (students and adult learners). Through the years, the needs of this clientele may have changed as the forest resource and its products have changed. This paper presents the results of three independent studies that assessed the educational and training needs of individuals from the forest products industry. Two of the studies were conducted in Oregon and Virginia (United States) to evaluate adult educational needs for the development of continuing educational classes for adult learners. A mail survey to over 2000 forest products companies in the two states was conducted to collect primary data. The results indicate strengthening in areas of management and marketing, as well as communication. Personal contact was the highest method of teaching effectiveness. At the time of the research (1994-1996) electronic technologies rated the lowest form of a teaching medium.

The third study evaluated the current educational practices and needs from one of the leading Wood Science and Forest Products Programs in North America (Virginia Tech) by undergraduate, graduate, and employers of students. Mail surveys and personal interviews were used to collect primary data.

Participants rated training in traditional wood science areas high, while improvement was needed in communication and personnel management areas. This research has lead to adjusting the methods of teaching at Virginia Tech. Courses were redesigned to increase writing and speaking assignments, as well as team building skills.

The results from these studies may provide a foundation for strengthening Wood Science and Technology programs around the world and assist those programs that are struggling with student enrollments. These results indicate that Wood Science and Forest Products programs need to increase emphasis in the management and marketing aspects of their programs. This study also indicated that education in traditional wood science areas (such as drying, production and chemistry) were meeting students needs.

Environmental Education of Forests Using a Mobile PC

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Keywords: Environmental education; Mobile PC; Tree identification; GPS

The objective of this study is to educate students as well as citizens in a better use of an up-to-date information system so that they are able to learn better about nature and ecosystems in forests and to make informed decisions that will protect or conserve them. Not a few visitors often spoil or damage forests and their environment, for example, by littering or picking up rare plants. We believe that they do not understand enough why the forest and environment are important and that they need to be educated effectively and enjoyably on why forests should not be damaged. In this context, environmental education of forests has become more important for all people.

We developed a new information system for environmental education of forests. In this system, users can learn more and better about nature and ecosystem in forests with a mobile PC. It has a user-friendly interface, which is easy to use for those who are not accustomed to using computers. It has three main programs of navigation, tree identification and an eco-museum. We would like to give brief explanation of them.

Navigation: the system has a Global Positioning System (GPS) so that users are able to know their positions in forests. We know it is difficult to catch signals coming from GPS satellites in mountains because slopes or tree canopies block them. We conducted some basic researches on the utilization of GPS in mountains. It is also known that point positioning causes positional errors of max. 100m. The way to obtain more accurate positions is to use Differential GPS (DGPS), in which we use two GPS receivers as a rover and base station. We employed real-time DGPS, in which real-time corrections are transmitted by radio or by mobile phones. As a result, we found that positional errors were reduced to max. 10m in forests. In this system, users can input information or data of nature observation into a mobile PC as a text or picture. The data are accompanied by date, time and accurate position automatically when it is recorded in a mobile PC. The users can make a map of nature such as trees, plants, insects and animals with this system. In addition, this system has functions to navigate users and to provide them with useful information on nature according to their positions.

Tree identification: we know it is not easy to identify trees because there are so many species and they are sometimes very similar to each other. We developed an expert system to identify tree species in order to make it easier to identify trees. This system deals with only broad-leaved trees at present, however, it enables you to learn such tree species without a professional teacher or a guide. When you meet unknown tree species, you can identify the tree just by answering some questions. They are, for example, whether the tree is liana or not, whether it is alternate, opposite or whorled and whether it is simple, palmately compound, odd-pinnately compound, even-pinnately compound or bipinnately compound.

Eco-museum: it introduces you to trees as well as plants, animals, birds, fish and insects living in forests. It also shows you historical and cultural aspects of forests. In addition, eco-museum gives visitors the information on forestry because forest production is one of the most important aspects of the forest. Furthermore, we can walk in forests virtually using amazing 360-degree photos of forests even when we are in our rooms. This system can be used in classrooms as well as in forests.

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7.00.00 Division 7 General Session

Forest Liming and Root System of Beech (*Fagus sylvatica*): A Study Case in the Sauerland region

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High acid loads led to acidification of forest soils. To compensate soil acidification, forests in North-Rhine-Westphalia are limed since the early eighties. As a consequence of forest liming, it is feared, that the root system of trees could degenerate into a shallow rooting. This would effect stability negatively. Up to now studies on the development of shallow root systems as a result of forest liming do not exist. To improve the knowledge on this topic, root ditches were excavated in a beech stand (age 130 to 150 years) on a limed (1983 and 1990 each 6t/ha) and an unlimed control plot. Root distribution, soil morphology and pH of the soil suspension were recorded. On the limed plot the pH of the soil suspension was significant differences between the two plots. Only a slight increase of finest roots (diameter 0-1mm) in the depth of 70 to 90cm was recorded on the limed plot. A correlation between soil-pH and beech root distribution could not be found. The study shows, that old beech trees did not develop a shallow root system on the limed plot compared to the control trees 15 years after liming.

The Effect of *Sphenoptera chalcichroa arenosa* (Col., *Buprestidae*) on Sustainable Management of *Acacia nilotica* (L. Willd. Ex Del) in the Sudan

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Acacia nilotica is the most valuable timber producing species in the Sudan. It is well adapted and regenerates successfully on the flooded sites along the River Nile and its tributaries. The area planted with *A. nilotica* has been progressively increasing and has now become established at 840-1260 ha per annum. The total plantation area in the Blue Nile State alone comprises 6000 ha. The contribution of *A. nilotica* to the total sawn timber production in Northern Sudan was estimated in the range of 40-50%. It contributes to fuel wood production by 10-15% and more than 80% of the total energy needs in the Sudan comes from wood. *A. nilotica* plantations started to suffer a die-back since late 1950th. Investigation of this problem was carried out in selected forests in the Blue Nile State where the plantations are even-aged and approaching maturity. The objectives of the study were to survey the infested forests to determine the cause and the magnitude of losses and factors affecting the spread of die-back. In all infested trees, larvae of *S. chalcichroa arenosa* were consistently found tunneling beneath the bark of the branches of all dead and dying trees. These tunnels disturb water passage in the vascular system which results in loss of vigour and die-back. This has resulted in considerably greater losses in all growth parameters especially tree D.B.H., height, volume and mean annual increment (M.A.I). The reductions as a result of infestation recorded were: 30%, 21%, 54% and 60% per year in D.B.H., height, volume and M.A.I, respectively. Since these forests were managed on a 10-year working plan to provide sustainable volumes of wood each year, the losses caused by the larvae of *S. chalcichroa arenosa* resulted in wood production that is extremely less than the forecasted volumes prescribed in the working plans due to the high losses as a result of the die-back. Considerable efforts were needed to create correction factors to the yield regulation and/or to efficiently control the beetle. Water stress (positive or negative) and siltation were the major factors affecting the incidence of the die-back. In good flood years the Nile deposits huge amounts of silt which may hide more than one meter of the basal part of the stem which weakens the tree and made more susceptible to beetle attack. Also, in poor flood years the plantations were severely stressed as well due to water shortage for irrigation. Thus, these fluctuations in Nile flooding play an important role in the incidence of die-back.

Impact of Forest Pests on Forest Sustainablility in Least Polluted Areas of Lithuania

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The main aim of forest monitoring in protected areas is to determine and predict the condition of forest ecosystems and their changes with respect to the regional variation and impact of air pollutants. Scots pine (*Pinus sylvestris* L.) is one of the most sensitive species for pollution in Lithuania and therefore it was chosen to be the main research object. In Dz–kija National park the investigations of forest condition have been carried out since 1992. Since 1993 pine stands have experienced intensive damage by insects *Lymantria monacha* and *Dendrolimus pini*. Only after application of biologic insecticide FORAY - 48B against Nun Month and Pine Caterpillar. In 1995 and 1996 the defoliation of Pine trees started to decrease and regeneration process has been registered. Data on long-term changes in defoliation and tree increment as well as estimated regularities and peculiarities of pest impact on tree condition and increment are presented in the article in question. Impact of biotic and abiotic factors on tree condition regeneration process are investigated. It is estimated that dominant trees in the stand are most sensitive for unfavourable biotic (impact of forest pests) and abiotic (climatic) factors. Their losses in foliage as well as increment if to compare with the trees from the other tree status groups are biggest. But the potential possibilities of these trees are very high because they do not experience energetic losses due to concurrent fight with other neighbouring trees. Therefore the condition regeneration process of these trees as well as annual tree increment occurs most intensive. Suppressed tree foliage losses due to pests were least, but their energetic losses due to concurrent fight were big and therefore the regeneration potential was very low. The main factors which affected tree defoliation and productivity in Dzûkija National Park were unfavourable climatic factors - droughts in 1992 and 1994. As a result of such a situation outbreaks of forest pests were registered. Therefore today it is quite difficult to estimate the anthropogenic impact and first of all the impact of long-range transboundary air pollution, which could have had an essential affect on Scots Pine stand dynamics.

CO2 Profiles in Coastal Mangroves Forest and Pasoh Forest Reserve

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Two ecotypes of tropical rain forests namely primary and coastal mangrove forests were selected for measurement of CO_2 profile at different height during a dry period between September and October 1998. The aim of the study was to determine the spatial and temporal concentrations of CO_2 in these two ecotypes in order to establish a baseline data on the CO_2 emission from various type of forest ecosystems. Results of the study showed that a similar diurnal change of CO_2 concentrations were observed at different height levels in both ecotypes. High CO_2 concentrations were recorded in the nighttime while in the daytime, the CO_2 concentrations were fluctuated between 335-390 ppm. The profiles of CO_2 concentration show that at ground level of coastal mangrove forests CO_2 concentration were ranged between 335 ppm and 440 ppm, while the primary forest of Kenyir were between 330-370 ppm. On the other hand, the concentrations of CO_2 at Pasoh forest were ranged between 340-530 ppm. Results of the study also suggest that seedlings at the forest floor were continuously exposed to higher concentration of CO_2 (335-530 ppm). Consequently, study on the effect of elevated CO_2 on tropical rain forest seedlings need further elucidation.

Effects of CO_2 Enrichment on Gas-Exchange of Tropical Hardwood and Pioneer Species Seedlings Grown Under Low and High Light Intensities

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The terrestrial biotic response to increased CO_2 concentration is important to understand in recognising the natural sinks for industrially produced CO_2, in predicting the effect of CO_2 elevated on crop and forest production, and in quantifying possible impacts of increased CO_2 on growth and carbon storage in natural ecosystem (Commins and McMurtrie, 1993). In achieving a deeper understanding, a study has been carried out on the effects of CO_2 enrichment on four selected tropical hardwood and three pioneer species seedlings at Department of Environmeantal Science, Universiti Putra Malaysia. The main objective of the study was to determine the effects of CO_2 enrichment on the gas exchange of the species subjected to different light growth environments. Seedlings were exposed to two level of CO_2 concentrations mainly at 350 and 700 ppm. Growth and physiological responses were measured. There were significant increased in relative growth rate (RGR) of seedlings established under low light conditions (50%) as compared to full sunlight exposure. Maximum photosynthesis (Pmax) was found in species grown under full sunlight, consequently had smaller leaf area and leaf number. The result also indicated that pioneer species (*Macaranga triloba*) had the better performance of the studied species in response to changes in irradiance.

Teak defoliator, *Hyblaea puera* Cram. in Bangladesh and Its Management Options Based on Some Research

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Keywords: Teak defoliator; *Hyblaea puera*; Bangladesh; Pest management

Teak (*Tectona grandis* L.f.) has been a major plantation species in the hill forests of Bangladesh, comprising about 70-80% of the total plantations established. Teak defoliator, *Hyblaea puera* Cram. (*Hyblaeidae*: *Lepidoptera*), is a major pest causing varying intensities of defoliation every year. The population of *H. puera* could complete their life cycle within about 22 to 39 days, depending primarily on temperature. A succession of about 13 generations was possible in a year. Defoliation started at the onset of the monsoon. Generally one to two population peaks occurred during April-July, followed in some years by a third peak during August-September. The infestations were distributed in discontinuous patches well separated in space and time, and within each patch the population was even-aged suggesting the possibility of a short-range migration probably linked with the pre-monsoon wind movement. Seven host plants including a mangrove were recorded of which teak was the most preferred food. Fourteen species of birds, four species each of insect predators and parasites and one species of fungus were identified. The maximum mortality attributed to all the parasites ranged between 19.2 to 41.7%.

An epidemic outbreak occurred in about 10 years cycle. General flushing of teak occurred during March-April. During initial build up phase trees with comparatively tender foliage were most heavily attacked with larval population distributed on tender terminal leaves of the canopy as tender foliage is essential for the initial establishment and survival of the young larvae. However, mature larvae could later attack older leaves. The commonly observed escape of some teak trees from the defoliator was due to asynchrony between their flushing time and the pest's population cycle. Thus raising plantation of early flushing varieties of teak seems promising as early flushers had a greater chance of escape from the attack. The invading pest population in small patch of initial build up sites could probably be eliminated by spraying with a microbial insecticide. High temperature and relative humidity prevailing during this season in Bangladesh further widens its prospect of use. Removal of alternative host plants particularly *Callicarpa arborea* in or near teak plantation during the deciduous period of teak would reduce the probability of population build up. Inundative release of selected parasite in early population build up phase and silvicultural measures conducive for shelter and breeding of resident natural enemies are expected to have a significant role in reducing the pest population. As *Tectona hamiltoniana* and teli variety of *T. grandis* were found to be resistant to teak defoliator, the possibility of inter-specific hybridization to transfer the resistant gene to *T. grandis* without sacrificing the wood quality and productivity seems promising.

Detection of Phytoplasma in Spike Disease Affected Sandal Using Serological and Molecular Biological Techniques

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Sandal (*Santalum album* L.), a semi-root parasitic tree is famous for its highly valuable scented heartwood and oil. The species is distributed in South East Asia, Australia and the Pacific Islands. Spike disease caused by phytoplasma, a non-culturable mycoplasma, confined to phloem tissues is the major disease of sandal. Spike disease affected trees die within two to three years after the appearance of visible symptoms of the disease. Early detection of the disease is hampered due to lack of suitable immunological and molecular biological techniques.

Initially the diseased plants and its hosts like *Lantana* and *Zizyphus* were screened for the presence phytoplasma using a DNA binding fluorochrome, 4,6,diamidino-2-phenyl indole (DAPI). The concentration of phytoplasma was found to be more in the phloem and inner bark of stem of diseased sandal rather than the leaf, petiole and root. No phytoplasma could be located in phloem of healthy sandal and hosts of diseased sandal.

Phytoplasma was purified from the inner bark and stem tissues using a differential filtration technique. The technique takes advantage of the property of phytoplasma to pass through 0.45 μm membranes. The purity of phytoplasma was assessed using electron microscopy. The purified phytoplasma was injected in rabbits to raise polyclonal antibodies. Ouchterlony double diffusion test confirmed the specificity of antibodies against phytoplasma, indicated by the formation of percipitin bands against the extract of diseased sandal only.

Direct and indirect ELISA techniques were used to detect the presence of phytoplasma in diseased sandal and its host. Phytoplasma was found to be confined to diseased sandal and not in hosts of diseased sandal.

Dot immunobinding assay (DIBA), a technique utilising the same principles of ELISA but employing a nitrocellulose membrane as the adsorbent rather than polystyrene plate in ELISA was used to detect the presence of the pathogen. This technique was found to be cheaper and very efficient. The test could confirm the presence of phytoplasma within three hours compared to ELISA which requires >6 hours.

The pathogen was also detected in situ using immuno fluorescent techniques wherein FITC conjugated-goat anti rabbit antibody was used as the probe to detect phytoplasma. This method is highly sensitive since minimum quantity of phytoplasma can be detected in the tissues.

Oligonucleotide primer derived from the highly conserved region of 16 S ribosomal RNA gene(rRNA) was used in the detection of phytoplasma. The primer pair could amplify the gene (558 bp) after 24 cycles of polymerase chain reaction (PCR) amplification. Restriction fragment length polymorphism (RFLP) analysis of the PCR products using Alu I restriction enzyme indicated that sandal spike phytoplasma belongs to the I group of phytoplasmas. Absence of phytoplasma in hosts of diseased sandal utilising these techniques confirms that sandal spike phytoplasma is specific to sandal.

Ecofriendly Method to Control the Bark Feeder/system Borer, *Indarbela Quadrinotata* (*Lepidoptera*: *Indarbelidae*)

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Casuarina and Teak are two of the important commercial tree species grown largely in many parts of the country. *Casuarina* is a multipurpose tree, which is used as fuel, fodder, poles and in pulp and rayon Industries. It also serves as shelter belts in areas of high wind velocity and arresting sand dunes in the coastal areas. Teak is the most valuable indigenous timber trees of India which was mainly cultivated by the Forest departments till 1990. Since 1990 many private entrepreneurs have started cultivating teak through intensive management aiming high yields in a short rotation. Higher returns promised from these species have prompted the farmers and Non Government Organizations (NGO-s) also to grow them in agricultural field as agroforestry models, in the recent times. Though a number of insect species are known to cause damage and effect the growth of these plants, borer are the most serious ones which directly attack the timber at different ages and seriously affect the timber quality, of which *Indarbela quadrinatata* is one among them. It is a polyphagous lepidopteran pest commonly known as bark feeder. It is one of the key pest of *Casuarina* attacks the stem and branches of the plants, particularly in younger plantations at the age group of 2-8 years. Heavy mortality of *Casuarina* trees due to this pest attack in certain plantations and trials raised in dry land has been recorded. Feeding injury made on the plant by the pest may also facilitate the infection by pathogenic microorganisms, especially the dreaded Blister bark disease of *Casuarina* caused by *Trichosporium vesiculosum*. It is thus evident as the incidence and spread of the disease is observed to be more in the plantations subjected to the attack of the pest. Of late, the pest is also found to attack young teak saplings. The intensity of attack is more in irrigated plantations. The attack of the pest on the stem affect the quality of the timber and also sometimes leads to canker formation on the main bole.

Efforts on development of ecofriendly management strategy of the pest resulted in detection of an affective entomopathogenic fungus, *Beauvereia bassiana*. Record of this fungus on the pest is the first report. More detailed studies on its pathogenicity, efficacy and efficiency in terms of larval mortality in the laboratory as well in the field in a given time were undertaken and effective doses for field application were worked out. The result of the same is presented and discussed in the paper.

Soil Characteristics and Vegetation Development in an Age Series of Limestone Mine Overburden of Dry Deciduous Zone

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Spoil characteristics and vegetation development in an age series (2, 5, 8, 15 and 25 years) of lime stone mine overburden of different microsites (flat, slope and lime patch margin) at Katni, District Jabalpur, Madhya Pradesh, India were studied. Analysis of variance indicated significant differences in almost all the physicochemical characteristics and nutrient status of the mine spoils due to age and microsites. All the spoils irrespective of age and microsites were alkaline in reaction (pH varying from 7.9 to 8.7) whereas the adjacent forest soil was acidic (pH 5.7). Organic carbon increased more than 5 times after 25 years of succession. Total and available nitrogen also increased significantly whereas $CaCO_3$ decreased significantly with age of spoils. Plant community composition changed with age as also with microsites. Species diversity increased and concentration of dominance decreased with age. There was an increasing trend of species richness with age. Impact of microsites on soil and vegetation development was prominent. With the modification of the spoil characteristics, there was a gradual development of ecosystem leading to succession of plants. Process of succession can be enhanced by broadcasting the seeds and propagules of the pioneering species invaded in 2-yr and 5-yr old sites so that quick ecological restoration can be achieved. To revegetate the mine spoils of such type emphasis should be given to those species which can aid in sustainable development of mined-ecosystem.

Keywords: Limestone mine, spoil characteristics, microsites, community characteristics, species composition, ecorestoration

Bioindication of Different Stresses in High Altitude Forests and Subalpine Belt (Julian Alps) in Slovenia

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Determination of the stresses operating on a forest ecosystem demands the use of several bioindication methods. Air quality indicators were assessed from an inventory of forest decline based on the assessment of tree crowns and lichens. Photosynthetic pigments, ascorbic acid and major macronutrients were studied in Norway spruce (*Picea abies* (L.) Karst.) and mountain pine (*Pinus mugo* Turra) needles as indicators of physiological and biochemical stress. Analyses were carried out on selected forest plots and transects in predominantly unpolluted areas within Triglav National Park, Julian Alps, Slovenia. It was assumed that air pollutant input in forest ecosystems is of two kind, e.g. local from the air pollution sources in the valleys on the Nord-West part of the national park and transboundary source at high altitudes, in the subalpine mounatain pine ("Krumholz") belt. For some bioindication methods, there was good agreement with measured air quality and climatological parameters. The best agreement was found between total foliar sulphur in needles and epiphytic lichens, especially in more polluted areas. Agreement with forest decline inventories and analyses of some needle stress physiological/biochemical parameters was less convincing. Soil characteristics and climatic parameters, influenced also by biotic parameters and forest stand history and management further decreased the strength of agreement. It was concluded that chosen indicator species allow differentiating among several stresses which occur in these very specific ecosystems.

Keywords: high mountain stress, air pollution, bioindication, Norway spruce, mountain pine, photosynthetic pigments, ascorbic acid, macro nutrients, epiphytic lichens, Slovenia

The Factors Effecting Infestation of *Picea obovata* Cones by *Adelges* (*Adelgidae, Homoptera*)

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The study of ecology of insect larva, developing in unusual condition, is interesting for estimation of host-plant vulnerability and its response to unusual consuming. The investigations allow us to reveal the possible pest insects. Infestation of conifer generative buds by chermes (*Homoptera, Adelgidae*) is not characteristic of these insects. Usually *Adelgidae* larva of different generations feed on needles or under bark of coniferous trees, or develops in vegetative bud of spruce and transforms the latter into gall. The purpose of this work was to determine the factors effecting

infestation of *Picea obovata* Ledeb. generative organs by adelges and study their influence on development of spruce cones and seeds. The study was carried out in the Krasnoyarsk region in 1992-1998.

It was determined that among six species of adelges found in this region only *Pineus cembrae* (Chol.) infested female generative organs of spruce. In particular years up to 34,1% of cones is inhabited by this chermes. The development and behaviour of adelges larva in spruce macrostrobiles and scale modification resulting from larval feeding were studied. Cover scales degrade fast in not infested cones. On the contrary, in infected cones under effect of larva the hypertely of cover scales happens, Basic seed scales thicken, but in general growth of seed and seed scale are inhibited. Apparently, it is connected with that adelges usually form galls. Alata-migrans of the *P. cembrae* emerged from cones in June, 5 days earlier than from galls. It was revealed that infestation of spruce female generative organs took place when chermes population density in the stand is high and generative buds prevail over vegetative ones in the shoot. Phenology of *P. cembrae* allows them to assimilate successfully unspecific food object. However the number of survived larva was dependent upon density of colonists in the cone. The higher density of chermes larva in a cone, the lower their mortality is. Peculiarities of biotope and individual trees making possible infestation of spruce cones by adelges were revealed.

Predicting Risk of Leaf Blight Infections on Eucalypts

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Eucalypts and other Australian tree species are of major economic, social and environmental importance to many countries. The most commonly grown eucalypt species in South East Asia is river red gum (*E. camaldulensis*). The future of eucalypts in Vietnam has been threatened by the appearance in the late 1980s of severe leaf blight epidemics in southeast and central Vietnam. Badly affected trees suffer reductions in growth rate and crowns. Even main stems may become deformed, with losses in merchantable volume. Several pathogens are involved, with *Cylindrocladium quinqueseptatum* leaf blight (CqLB) being an important causal agent.

With the support of the Australian Centre for International Agricultural Research (ACIAR) a major project is being undertaken to minimise disease impacts on eucalypts in South East Asia. One sub-project, which is briefly described here, is developing methods to identify areas of high disease risk at sites in mainland South East Asia and around the world.

Climatic interpolation and the use of simple simulation models have greatly improved techniques for matching tree species to site. Recent advances in mathematical interpolation allow climatic conditions to be estimated reliably for most locations in the world, whilst computer models allow complex growth-environment interactions to be simulated in more realistic ways. This disease hazard sub-project is applying these methods to identify areas of high risk for CqLB disease in plantations.

A literature review was carried out to determine which environmental factors are associated with C. quinqueseptatum infections. Very simple rules related to temperature and rainfall were developed to identify high risk areas. They were input to several climatic mapping programs previously developed to identify areas suitable for planting particular tree species. Each of these PC-based climatic mapping programs includes interpolated data estimated for tens of thousands of locations.

The simple model of CqLB risk proved to be useful for carrying out preliminary assessments of vulnerable areas in Vietnam, India, Africa, Australia and Latin America. In addition to identifying areas from which CqLB has already been reported (e.g. southern Vietnam, southern India, eastern Madagascar and northern Australia) the model suggested other potentially vulnerable areas (e.g. parts of Central and Western Africa and Central America).

Trophic Inter-Relationships Among *Milicia Excelsa*, *Phytolyma Lata* (*Homoptera: Psyllidae*) And Hymenopteran Parasitoids.

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Phytolyma lata is a galling-forming psyllid which seriously hamper the sustainable production of *Milicia excelsa* in Africa. As part of an integrated approach to manage this pest the influence of host plant genotype on parasitism of gall-inhabiting nymphs by Hymenopteran parasitoids was studied.

Seventy *M. excelsa* seedlings belonging to one of three genetic groups - Resistant Genotype (RG), Moderately Resistant Genotype (MRG) and Susceptible Genotype (SG) - were established in the field in a Randomised Complete Block Design.

Parasitism rates were determined respectively in the dry and wet seasons. Significant differences in percent parasitism were found among the three genotypes during the dry season but not the wet season. Percentage parasitism in the wet increased as SG < MRG < RG. This trend was attributed to the predominantly small galls that developed on resistant genotypes. It had already been established through a related study that the size of gall formed on *M. excelsa* by *P. lata* is inversely related to percent parasitism. We conclude from the study that integrating biological control and host plant resistance will be a very feasible management strategy against *P. lata*.

Monitoring of Phtophthora-decline of alder (*Alnus* sp) in Eurpoe with Special References to Austria

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Decline of Alder (*Alnus glutinosa, Alnus incana*) caused by a species of *Phytophthora* resembling *P. cambivora*. has been a problem in several European countries since 1993. Epidemic occurrence is limited so far to the southern parts of the U.K., where numerous stands of Alders lining waterways are affected. In other countries, such as Austria, Denmark, France, Germany, the Netherlands, Norway and Sweden the distribution has been more a local one up to 1998. Nevertheless the disease intensity can reach values over 50%. Investigations in *Phytophthora* strains of numerous provenances conducted in the U.K. showed a high similarity in pathogenicity, but there are considerable differences in disease intensity and progress. Research is currently done in several European countries to elucidate the biology of this *Phytophthora* and its role among the complex of other factors. Within the scope of a Concerted Action a monitoring system was established following a standardised scheme. Plots comprise 50 trees each and are investigated once a year, in addition to isolation trials of *Phytophthora* from stem lesions. The main criteria of assessment are the condition of the tree, the distribution of symptoms in the crown and on the stem, the occurrence of insects mining the stem or attacking the branches and of dieback fungi in the crown. In Austria 9 monitoring plots have been established between 1997 and 1999, five of them with *Phytophthora* confirmed as the main cause. Intensity of diseased trees varied from 20 to 50%. Within the complex of other factors contributing to the decline root rot fungi, especially *Armillaria* sp., dieback and bark attacking species (*Ophiovalsa suffusa, Valsa oxystoma*) as well as insects mining the stem, mainly *Cossus cossus* (goat moth) are the most important. The role of climatic extremes (drought and frost) as predisposing factors is discussed.

Seed Pests and Their Impact on Quercus Regeneration in Western Himalayan Region of India

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Ban Oak (*Quercus leucotrichophora* A. Campus ex. Bahadur) is an important fodder tree species of Himalaya. Its natural pure stands occur on the southern aspect in the outer ranges of western Himalaya. Besides ecological significance, it is a principal source of firewood, charcoal and agricultural implements to the hill people. The species seeds abundantly and the mature healthy seeds have a germination capacity of 80-90 per cent. Its seeds are heavily attacked by the insect-pests, birds and wild animals resulting into the significant seed loss. Reduced availability of sound seed on the forest floor thus, hampers the natural regeneration. Insect-pest infestation is the principal contributory factor towards the loss of sound seeds. Seed losses due to pest infestation, its impact on natural regeneration, and germination capacity have been studied and the results obtained from 12 different locations covering the entire ban oak zone of Western Himalaya are given in this paper.

The mature seeds of ban oak start falling on the ground during the month of December and continue till February. Studies on the proportion of sound seed to the infested ones fallen on the forest floor have amply shown that infested seeds were more than double the quantity of sound seeds. Out of three distinct groups of insects viz; nut weevils, moth larvae and gall forming cynipids, the maximum damage was due to nut weevils, *Curculio sikkimensis*. The adults lay eggs on the young acorns above the cupule by making a puncture with the help of a long snout during July-

August. One to many larvae develops inside the acorn by making galleries. This leads to the death of seed in many cases. The per cent seed infestation on tree crown remained between 15-35 per cent, except at one location (up to 60%) and on forest floor it was more than 50 per cent. Per cent germination of the total fallen seed on the forest floor varied from 0.5-4.5 at all the 12 different locations. Healthy and infested acorns each weighed about 490 and 740 number of seeds in one kilogram. The extent of insect damage to the seed influenced the per cent germination. Seeds infested to the extent of 25, 50, 75 and 100% showed upto 45, 30, 8 and no germination, respectively. The per cent germination in sound acorns ranged between 80 to 96 per cent.

The Introduction of *Pauesia juniperorium* (stary) (*Hymenoptera: Branocidae*) into Malawia for the Biological Control of *Cinara* Sp. NOV: (*Homoptera: Aphididae*)

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From 1986, the cypress aphid, *Cinara* sp.nov. was reported causing extensive damage to erotic and native cypress stands an Malawia. Since 1991, the Forestry Research Institute of Malawia (FRIM), with technical support from CABI Bioscience, has been undertaking a classical biological control project against the pest.

In 1994 and 1995, the parasitoid *Pauesia juniperorum* Stara, collected from western Europe and screened at CABI Bioscience, UK, was shipped to Malawia for rearing and direct field release. The field releases were made in cages containing aphid ingested branches during the months August to early October. Parasitoids released in 1994 did not establish. However, in 1995, females released in cages provided a large number of progeny with an evenly balanced sex ratio. These were allowed to disperse naturally from the cages. Regular branch samples taken later in the year showed that the parasitoid has dispersed several hundred meters from the cages. Mean parasitism on branches was 48 per cent. The parasitoid is now widely distributed in the south and centre of the country. The impact of the parasitoid on the cypress aphid is discussed.

Factors Influencing the Mortality and Health Trends of the Sessile Oak in Hungary

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The large scale decline of the sessile oak (*Quercus petraea* MATT. LIEBL) was one of the most spectacular and important forest health problems both in Hungary and the neighboring countries (Austria, Romania and Slovakia) in the last two decades.

Experimental plots with individually numbered trees (ca. 300 trees/plot) were established in 1982 all over Hungary to study the process of sessile oak decline. 27 of these experimental plots are located in NE-Hungary. The health condition of the sample trees at the experimental plots has continuously been scored on a 4 degrees scale (5-4-3-2), twice a year (late May and mid September) since 1983.

This survey evaluates the autumn scores of more than 4500 sample trees at these 27 plots in NE Hungary recorded between 1983 and 1998. The social status of the sample trees (Kraft classes) was also recorded. The following indices were calculated based on the health scores recorded tree by: mortality index, mortality trend index, health index, health trend index. These indices were correlated with the drought index, and the yearly population level of the geometrid caterpillars. The drought index is defined as the average temperature of the growing season (in Co) divided by the weighted sum of the precipitation in the growing season (in 100mm).The population level of geometrids is expressed by the forested area damaged by them.

It is clear that the drought index and the mortality index follow a highly similar pattern. Between 1983 and 1989, when the drought index showed a decreasing trend, the mortality index also decreased. The rates of mortality between 1989 and 1992 were hardly more than 1%, and occurred mainly among the suppressed trees, so it can be considered as natural self-thinning. After 1991 when several seriously dry years followed each other the mortality index started to increase significantly, and mortality was recorded among the dominant trees too. The mortality index reached its peak in 1995 with value of 4.6%. Following 1995, when the drought index decreased significantly again, the values of the mortality index dropped too. This is also evident that the mortality index shows a delayed (ca. 2 years) response to the change of the drought index.

There are significant positive correlation between the yearly values, 2-, 3- years moving averages of the drought index, and the yearly values of the mortality trend index. Reverse correlation was found between the drought indicating variables (yearly values, 2-, 3-years moving averages of the drought index) and the health index. When a given year or a 2-3 years long period was extremely dry the health conditions of the sample trees got significantly worse.

Significant positive correlation was found between the population level of geometrids (yearly values, 2-, 3-years moving averages) and both the mortality index/mortality trend index. In the years when the geometrid population was high in the spring higher and increasing tree mortality was recorded in the autumn. Significant negative correlation was found between the population levels of the geometrids and both the health index and the health trend index. When the geometrid population level was high in spring, the health status of the sample trees got significantly worse in autumn.

Sphaeropsis sapinea: An Important Pathogen in Exotic Pine Plantations

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Sphaeropsis sapinea is an opportunistic pathogen of conifers, world-wide. This pathogen posses a serious problem, especially in areas where it has been introduced, while it is not considered to be of great importance elsewhere, where pines are native. In South Africa, New Zealand and Australia, *S. sapinea* is one of the most important pathogens of exotic *Pinus* spp. The fungus can persists in pine tissue as a dormant endophyte until physical or environmental predisposition initiates a pathogenic response and the appearance of disease symptoms. Disease symptoms include die-back, stem cankers, stem malformations, collar rot, root disease and blue stain. In South Africa, timber losses due to post-hail associated die-back of *P. patula* and *P. radiata* trees have been estimated at more than half the potential value and about a quarter of the potential volume of wood produced. Effective control measures to reduce losses caused by *S. sapinea* in exotic pine plantations, necessitates an understanding of the biology and population genetics of S. *sapinea*.

The population structure of *S. sapinea* on native trees differs from the situation on exotic trees. The degree of diversity has recently been determined from a South African and Indonesian population using vegetative compatibility groups (VCGs). A larger number of VCGs were found in the exotic South African population in comparison to the population from Indonesia where native *Pinus spp*. are known to occur. This finding contradicts the general assumption that a lower degree of diversity exists in introduced populations, compared to well-established native populations. The higher degree of diversity determined for the South Africa population can probably be attributed to multiple introductions of the pathogen with pine seed into the country.

Sphaeropsis sapinea isolates can be characterized in three distinct types based on RAPD analysis, size of conidia and virulence. These different types are referred to as the A, B and C morphotypes. Isolates of the C morphotype have significantly longer conidia and are more virulent than those of both the A and B morphotypes. Based on cultural characteristics, texture of conidial walls and ITS sequences, isolates of the A and C morphotypes are more closely related to each other than to those of the B morphotype. Isolates belonging to the A morphotype were the most common, and include those from South Africa. The C morphotype has recently been reported for the first time and includes isolates from Indonesia. The differences in virulence among isolates of the three morphotypes will influence effective management and quarantine practices.

Two dsRNA mycoviruses, SsRV1 and SsRV2, as well as various other dsRNA fragments, ranging in size from ca. 8 kb to 1.6 kb, have been isolated from world-wide collection of *S. sapinea* isolates. The complete genome sequences of both SsRV1 and SsRV2 has been determined and these viruses have accordingly been classified as belonging to the Totiviridae. No conclusive evidence has thus far been found to link the presence of these dsRNA fragments to changes in the normal phenotype of the pathogen. The *S. sapinea* isolates screened, either had multiple infections by more than one dsRNA fragment, or single infections.

Mycoviruses have potential to be used to reduce the impact of pathogens such as *S. sapinea*. This is called hypovirulence, which is a spontaneous reduction in the virulence of the pathogen, as has been shown for the chestnut blight fungus, Cryphonectria parasitica. Hypovirulence-conferring genes of *C. parasitica* or synthetic hypovirus transcripts could potentially be incorporated into the SsRV-viral genome in order to induce hypovirulence in *S. sapinea*. We envisage an integrated disease management approach in order to reduce losses due to *S. sapinea* infection, especially in exotic plantations. Such an approach would include breeding and selection for resistance, the manipulation of dsRNA associated with *S. sapinea* and careful site selection to minimize mechanical damage and stress.

Arthropod Diversity of Exotic vs. Native *Robinia* species in Northern Arizona

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Commercial forestry worldwide depends upon the use of exotic tree species because of the benefits that can be gained from improved production. However, the use of exotic trees in plantations has been rife with misconceptions from both supporters and opponents of their use. Many foresters tend to discourage the use of exotics predicting that the exotics would have higher numbers of insect pest species than the native trees. However, there are many examples when exotics have had fewer insect pest problems than natives of similar taxon.

This study was a comparison of arthropod species data sets for species of woody plants in their native and exotic range. Data sets comprised 26 pairs of arthropod species lists; the paired data sets consisted of the number of arthropod species in the native range of the plant and a corresponding data set from where the plant grows as an exotic. Plants in the study came from many genera such as: *Pinus, Robinia, Abies, Chamaecyparis, Cupressus, Picea, Pseudotsuga, Thuja, Tsuga, Prosopis, Tamarisk, Cytisus,* and *Schinus.*

Preliminary results indicate that there is greater arthropod species colonization on woody plants in their native range. We further analyzed whether the number of arthropods are influenced by the time a plant species has been growing in a non-native range, and whether the area of plant cover influences arthropod colonization of the native and the exotic plant species.

The Buffering of Acidifying Nitrogen and Sulphur Deposition in the Soil on the ICP Forests Intensive Monitoring Plots in Finland

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Acidic deposition, resulting from the emissions of sulphur and nitrogen compounds, is a potential stress factor for forest ecosystems by accelerating soil acidification. The capacity of podsolic forest soils to neutralise and buffer the anthropogenic inputs of hydrogen ions is dependent on a number of processes, e.g. cation exchange, silicate mineral weathering and Fe and Al buffering systems. As a result of the buffering and neutralisation reactions, the chemical composition of rainwater changes as it passes down through the soil profile. Monitoring the chemical composition of the soil solution is therefore a key indicator in estimating soil acidification and the buffering capacity of the forest soil.

The capacity of the soil on 16 ICP Forests intensive monitoring plots to buffer acid inputs has been monitored since 1997 on the basis of bulk deposition, stand throughfall and percolation water samples collected during the snowfree period. The plots were located in Norway spruce and Scots pine stands. Zero-tension lysimeters were inserted at depths of 5, 20 and 40 cm measured from the ground surface, with 5 replications per depth.

At all the sites, the input of protons in stand throughfall has been effectively buffered or neutralised by the time the percolation water has reached a depth of 40 cm. The pH of percolation water at this depth depends on the neutralising and buffering properties of the subsoil. There was considerable variation in the pH increase in percolation water at depths of 5 and 20 cm, because the rate of buffering or neutralisation depends on a number of soil properties, e.g. thickness of the organic layer and E and B horizons, the soil texture, which determines the percolation rate of the water and the degree of interaction between the percolation water and the soil, and the base saturation of the organic layer and uppermost mineral soil layers.

There was a clear increase in sulphate concentrations in percolation water with increasing soil depth. The main reason for this is that sulphate is a relatively mobile ion in the soil; the sulphate-adsorption capacity of the organic layer and underlying E horizon is relatively low, and most of the sulphate is adsorbed by the Al and Fe sesquioxides precipitated lower down the soil profile in the B horizon. The amount of water percolating down the soil decreases with increasing soil depth as a result of evaporation from the soil surface and evapo-transpiration by the tree stand. This results in an increase in the sulphate concentration with increasing soil depth.

The nitrate concentrations in percolation water were extremely low. Nitrogen in a plant-available form is the primary factor limiting tree growth on forest soils in Finland, and it is clear that a nitrogen input (e.g. as nitrate) will be rapidly taken up by the roots of the trees and ground vegetation. These results also support the conclusion that the nitrogen status in the soil on these plots has not reached so-called nitrogen saturation. Furthermore, the C/N ratio in the organic layer on all these plots was well above 25, and there is not likely to be a risk of nitrification and nitrate leaching into the ground water.

In conclusion, according to the change in rainwater/soil water acidity as it passes down through the soil profile, the buffering capacity of the soil on the ICP Forests (level II) monitoring plots was relatively high. The sulphur concentrations in bulk deposition, stand throughfall and percolation water were the highest on the plots located in southern Finland. The nitrate concentrations in percolation water on all the plots were extremely low as a result of efficient nitrogen uptake, and the risk of nitrate leaching into the groundwater appears to be negligible.

Zinc Mobilisation in Forest Soil Near the Harjavalta Cu-Ni Smelter, SW Finland

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Introduction

Zinc is a micronutrient that is essential for the metabolic functioning of higher plants and animals, but in high concentrations it is one of the trace metals potentially most hazardous to the biosphere (Kiekens, 1995). A number of studies have been carried out on the detrimental effects of Zn emissions from Zn smelters on soils and surface waters, but relatively little attention has been paid to the fact that many other nonferrous smelters (especially Cu-Ni smelters) also emit considerable amounts of Zn into the environment. For instance, up until 1991 the smelter at Harjavalta, SW Finland, emitted more Zn than Cu or Ni, even though it is generally referred to as a Cu-Ni smelter. Although heavy metal emissions from the smelter have been considerably reduced during the past decade (Helmisaari et al. 1995), in 1995 there were signs of an increase in the Cu, Ni and Zn concentrations in percolation water (20 cm depth) in the immediate vicinity of the smelter. The aim of this report is to present long-term (1992-98) trends in percolation water Zn concentrations close to the smelter, to assess whether Zn leaching is likely to affect ground water quality, and to determine whether liming agents could be used to counteract this potential hazard.

Materials and Methods

Percolation water samples were collected during 1992-1998 at a depth of 20 cm on one control and two treated plots in a severely damage Scots pine stand located 0.5 km from the Harjavalta smelter. The experimental layout and the pre-treatment and analysis of the water samples are described in detail in Derome and Nieminen (1998). Mg-rich limestone (2 t/ha) was applied to one of the plots, and a correction fertiliser (1 t/ha) consisting of slow-release powdered minerals (including 20% calcium and magnesium carbonate) and a mixture of fast-release, water-soluble salts (including Cu and Zn, 0.8 kg/ha) to the other.

Results and Discussion

The uppermost soil layers at the site are severely contaminated with a range of heavy metals including Zn (Derome and Lindroos, 1998). Despite the strong reduction in Zn emissions from the smelter, during 1995-98 there was a clear increase in the Zn concentrations in percolation water on the control plot (Fig. 1) in 1996. The deposition of Mg, K, SO4 and Ni within the stand increased strongly during 1995-96, but there was no increase in Zn deposition. In addition, during 1992-96 there was a net loss of Zn from the 0-40 cm soil layer down into deeper layers, i.e. the output of Zn in percolation water (40 cm depth) was greater than the input to the soil in throughfall (Derome and Nieminen, 1998). The corresponding fluxes for Cu and Ni were negative, i.e. the pools of Cu and Ni are increasing in the 0-40 cm soil layer. Zinc is more mobile than Cu or Ni in the soil: it forms soluble complexes with chloride, phosphate, nitrate and sulphate, and soluble complexes and chelates with organic matter (Geering and Hodgson, 1969), and has a lower affinity for cation exchange sites than Cu and Ni. The increased deposition of Mg, K, SO4 and Ni in

1995-96 appears to have increased Zn mobilisation from the organic layer in 1996. The liming and correction fertiliser treatments reduced the Zn concentrations to about half the level on the control plot. The initial increase in 1992 was presumably due to the displacement of Zn in the overlying soil layers by the added cations (primarily Ca2+, Mg2+, K+), and to the small addition of Zn in the CF treatment. The subsequent decrease in the Zn concentrations was presumably due to the immobilisation of Zn caused by the increase in soil pH values resulting from liming (Kiekens, 1995).

Fig. 1. Effect of liming (LT) and correction fertilisation (CF) on the Zn concentrations in percolation water (depth 20 cm) at a distance of 0.5 km from the Harjavalta smelter during 1992-1998. O = control. The bars indicate the standard error of the mean. (not shown)

Conclusions

Despite the considerable reduction in emissions from the Harjavalta Cu-Ni smelter, there is strong evidence to suggest that the large amounts of Zn that have accumulated in the surface soil of the forest ecosystems surrounding the smelter during the past 50 years are susceptible to mobilisation and may be carried deeper down into the soil. This poses a potential threat to groundwater quality in the area. Liming at suitable doses will help to prevent this problem.

Evaluation of Chemicals For the Control of Sapstain on Rubber Wood

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As soon as the tree is felled it is prone to microbial degradation. Mould fungi and sapstainers are the primary colonies of the felled tree. So far numerous preservative chemicals have been evaluated for the effectiveness against mould and sapstain. But only a very few have been found to possess all the requisite of a good preservative. In late 1960s Sodium pentachlorophenoxide (NaPCP) was introduced as an antisapstain chemical throughout the world. However, over the years, the growing concern regarding the toxic compounds and their related environmental problems has brought down the use of NaPCP. At present the ban on the use of Pentachlorophenol and NaPCP in most countries has led the search of an alternative antisapstain chemicals which are effective and environmentally safe Study conducted in Kerala Forest Research Institute revealed that sapstain caused by *B.theobromae* is a serious problem in the proper utilisation of rubber wood in Kerala. Different chemicals were screened for their efficacy in controlling sapstain caused by *B theobromae* on rubber wood. The fungicides evaluated were Captafol, Busan 1009, Hylite extra and Chlorothalonil. The efficacy was first evaluated on wood blocks, then in the field. Different concentrations on the Fungicides were also tested. Busan 1009 (1% a.i) in combination with boric acid (1%) was found to be effective in controlling sapstain.

Chlorothalonil, was also found to be effective in controlling sapstain . Among the two different types of stacking tested, open stacking found to reduce the fungal infection on the wooden planks. During rainy seasons, the concentration of the fungicide has to be increased for better control of fungal growth. The details of the fungicidal evaluation will be highlighted in the paper.

A Comparative Study on the Abundance and Diversity of Ichneumonid Wasps (*Hymenoptera: Ichneumonidae*) in Selected Forests and Non-Forest Habitats in Peninsular Malaysia

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A comparative study on the abundance and diversity of Ichneumonidae wasps in the selected forests and non-forest (agriculture) habitats of Peninsular Malaysia was conducted from July to November 1998. The forest or non-agriculture habitats selected were Kuala Lompat Wild Life Reserve Forest (Primary and undisturbed forest) in Pahang, and Universiti Kebangsaan Malaysia-Permanent Forest Reserve (secondary forest) and Bush areas around Univerisiti Kebangsaan campus in Bangi, Selangor. Whilst the agriculture habitats were an orchard of star fruit and sapodilla of the Malaysian Agriculture Research Institute of Malaysia in Serdang, Selangor, and Rubber and Oil Palm plantations of the New Labu Estate in Nilai, Negeri Sembilan. The insect wasps were caught using four Malaise traps per habitat per week for three months period. Insects caught were brought back to laboratory, sorted and identified up to subfamily levels.

Result showed that Bush areas had the highest numbers of Ichneumonidae's subfamily recorded and Ichneumonidae individuals per subfamily collected compared to other habitats including the

Kuala Lompat Wildlife Forest Reserve. The Universiti Kebangsaan Permanent Forest Reserve recorded the least number of Ichneumonidae subfamily (10), which is much lower than that of agriculture habitats.

Overall, the highest and lowest number of individual Ichneumonid collected was from the Kuala Lompat Wildlife Forest Reserve and rubber plantation habitats respectively. The number of Cryptinae individuals was the most abundance in all habitats followed by the Pimplinae and Ichneumoninae. There was strong and significant relationship between the number of Ichneumonid individuals collected and the subfamilies and habitat types. This suggests that the abundance of Ichneumonid wasps influenced by the subfamilies and types of habitat.

This study had successfully collected 49% (17) of the Ichneumonidae subfamilies recorded worldwide (35), indicating that Ichneumonidae diversity is high in Malaysia. The Shannon Weiner diversity index value (H') indicated that the diversity of Ichneumonidae subfamilies was significantly different among the habitats. Although the KLFR is the primary forest, the value of H' of Ichneumonidae subfamilies of the Kuala Lompat Wildlife Forest Reserve was significantly lower that that of bush areas. Interestingly, the bush areas had the highest H' value than that of other habitats, suggesting that it has plenty of resources such as food and host for the wasps to survive and reproduce. The availability of food and resources in any particular habitat could increase the number of individual (abundance) per subfamily, and this would indirectly increase the H' value of the Ichneumonidae subfamily. Results of this study also indicated that better understanding on wasp biology and ecological needs can increase their diversity in disturbed habitats (forest or agriculture). High diversity of these wasps is very important to us as they could act as biological control agents of insect pests of economic trees or crops. Further study with longer sampling periods and increase number or types of habitat use should be conducted. This would give better estimation and view of Ichneumonidae population abundance and diversity in Malaysia.

Biochemistry and Molecular Biology of Interaction between Phytoplasmas and *Paulownia* Related to the Pathogenic Mechanism

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Paulownia infected with phythoplasma displays unique exteior symptoms, witches' broom (loss of apical dormancy) and phyllody (abnormality of floral organs) as well as interior symptoms, ans abnormal accumulation of callose in the affected sieve tubes. The *in vitro* cultured healthy and graft-transmitted plantlets of several *Paulownia* clones were used for study related metabolic changes to phythoplasma infection. It was found that the level of free indole-3-acetate acid (IAA) and catechol decreased significantly in the diseased plantlets and change of IAA is also consistent with the decline of catechol. This strongly suggests that auxin degradation is directly involved in the symptom development of the disease. The activities of peroxidase and IAA oxidase increased distinctly in the infected plantlets. The isoenymes of both enzymes were analyzed by means of native acidic and basic polycrylamide gel electropherensis (PAGE) as well as isoelectric focusing on agrose and PAGE gels. Findings showed that there is stronger activity of IAA oxidase on the basic (cationic) peroxidase isozyme bands, whereas acidic (anionic) peroxidase isozymes have weak IAA oxidas activity. The tissue print of peroxidase and IAA oxidase on nitrocellulose filter revealed that the main alteration of both enzymes occurred in the affected vascular tissues, the areas of the phythoplamsa colonization. A peroxidase isoenzyme with high IAA oxidase was purified by (NH4)2SO4 precipitation and a series of chromatolography onto Sephadex G-25, cellulose CM-52, Sephadex DEAE-A50, and Sephacryl-2000HR columns. The partial amino acid composition, molecular mass, pl value, porphyrin and gycosylation of the purified enzyme ere characterized. The immunological property of the enzyme was evaluated through western blotting with the use of commercial antihoseradish peroxidase antibody. By using a pair of specific primers to the ipt gene Agrobacterium iumefanies and blunt ligation technique, a 427 bp fragment of ipt gene originated from the poplar stem gall pathogen was cloned and the cRNA probe was prepared, the hybridization of the phythoplasma

DANN with cRNA probe was conducted. In addition, the abnormal acculmulation of callose in the affected sieve tubes was shown to be correlated with the severity of the witches' broom symptoms. The sythesis and decomposition of the callose in response to the pathogen infection were also investigated by analyzing ß-1,3-glucan synthase and ß-1,3-glaucanase activities and its isozymes. Based on this finding, an IAA oxidation hypothesis which explains the symptom development of *Paulownia* caused by phytoplasmas is propsed. The treatments of infected *in vitro* cultured plantlets with various plant growth regulators, phenolic compounds antioxidants as well as tetracyclines also supported the proposed mechanism.

Paulownia Witches' Broom Disease in China, Present Research Status

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As a widespread disease which has been found in almost every *Paulownia*-growing area of China, *Paulownia* witches' broom disease caused by phytoplasma has been one of most serious problems that Chinese artificial timber industry is faces with. The present research on this disease in China is introduced and evaluated in this paper. It covers the geographical distribution and damage done by the disease, symptomology, etiology, histology, physiology and biochemical changes of infected plants, pathogen localization and distribution, pathogen transmission, factors influencing disease epidemic, and control measures. The recent progress in the area of the propagation and application of phytoplasma-free seedlings by means of *in vitro* culture technique, the molecular detections od pathogen using DNA hybridization and polymerase chain reaction based on the 16S rRNA gene conserve sequence, and approaches on the pathogenic mechanism related to the unique symptom development associated with phytoplamas infection are discussed in more detail. Based on the analysis to the key factors of influencing disease prevalence in China, a new phytoplasma infection cycle model and enovating control strategies are proposed.

Damping off Pathogeny of *Pinus merkusii*

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Damping-off incited by *Rhizoctonia solani* and *Fusarium oxysporum*, is one of the problems associated with the production of *Pinus merkusii* seedlings in seedbeds for the establishment of forest plantations in Indonesia. The pathogens are able to cause damping-off of seeds and seedlings younger than 7 weeks old. *R. solani* is more aggressive than *F. oxysporum*. The older the seedlings, the lower the incidence of the disease, indicating that the older the seedlings the more resistant they are to damping-off.

F. oxysporum and *R. solani* produce adaptive C1-cellulase as well as pectinase. The C1-cellulase activity of *F. oxysporum* is stronger than that of *R. solani*. Conversely, the polygalacturonase - a component of pectinase- activity produced by *R. solani* was higher than that produced by *F. oxysporum*. The higher activity of pectinase produced by *R. solani* is suspected to make this pathogen more aggressive than *F. oxysporum* because polygalacturonase plays an important role in the host tissue maceration and in the exposure of cellulose to cellulolytic enzymes leading to the cell wall degradation.

In the stem tissues the peroxydase activity increases with the age of the *P. merkusii* seedlings and reaches its peak when the seedlings are 3 weeks old. Thereafter, the peroxidase activity gradually decreases with age. Unlike the peroxidase activity, the polyphenol oxidase activity is very low, fluctuates, and there is no consistent pattern related to the seedling's age.

Lignification is a natural process in plant cell development. The lignin content of hypocotyl seedling tissues gradually increases with age. The increase is suspected to make older seedlings more resistant to damping-off. Lignin could increase the host resistance by structural and/or biochemical defence mechanisms. In the case of damping-off of *P. merkusii*, lignin content in the root collar tissues is suspected to directly increase the seedling's resistance to damping-off, mainly by structural defence mechanism.

Peroxidase is thought to be the main enzyme that oxidizes monolignol to initiate the lignin synthesis in plant tissues. The increase of peroxidase activitty tends to be followed by the higher increase of lignin content in the tissues.

The Impact of *Sirococcus* Shoot Blight on the Development and Growth of Norway Spruce (*Picea abies* [L.]Karst) in Young Plantations.

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The mitosporic fungus *Sirococcus conigenus* (DC.) P. Cannon & Minter causes shoot blight and seedling mortality on many conifer hosts in the northern temperate zone. The disease occurs in nurseries, young plantations, natural regeneration and sometimes in mature stands. In middle Europe the most common species damaged by this fungus is Norway spruce. The most recent outbreak started in the early eighties. The primary damage is to the current shoots which affects growth. Young trees suffering from multiple infections may show crown deformation or even die.

The aim of our study was to investigate the impact of *Sirococcus conigenus* shoot blight on the development and growth of Norway spruce in young plantations, by examining the increment losses due to various intensities of infection. Investigations were carried out at Schöneben (920 m eve, Upper Austria) in a 0.75 ha plantation that was established in 1978 on former farmland. Trees originally had been planted with a 2 by 1.5 m spacing. Within this area, infestation occurred mainly in four patches. A systematic sampling design, 20 by 15 m was used, establishing 19 plots, each having a plot radius of 3.6 m. Within each sample plot the diameter at breast height (DBH) of each tree was measured and classified into four damage classes (0=no damage, 1=light, 2=moderate, 3=severe damage). From all trees classified, five trees of each damage class were randomly chosen, their height was measured and stem disks at 0.3 m and 1.3 m were taken for further analysis. Using this data, plus an additional 35 heights representing all DBH classes, height diameter curves were constructed for each *Sirococcus*-damage class. Tree ring analysis was carried out using the Johann`s Digitalpositiometer.

Results of this study clearly indicates that *Sirococcus* shoot blight significantly affects radial and height growth of infected trees. Average DBH of lightly damaged tree class was 80% compared to the average diameter of the healthy class, moderately and severely damaged tree classes were 72% and 55% respectively. Taking the annual radial increment of the healthy trees as a reference (100%) the relative development of radial increment of the damaged trees over time was studied. The light and moderate damage classes showed lower but constant relative radial increment over time. Damage class 3 (severe damage) is lower and constant for several years then the growth rate declines visibly. Additionally, comparisons of the ratio between increment at DBH and the increment at 0.3 m for classes 0,1 and 2 show similar relationships, while for the severe damage class, this ratio is higher. This may be a result of multiple infections and dieback of terminal shoots found on severely damaged trees. The DBH/DH 0.3 m ratio of trees from all other damage classes, however, indicate a similar radial increment at breast- and stump-height.

The different *Sirococcus* damage classes of shoot blight also reflected different height growth. Heights of healthy trees had a range from 4.7 m (DBH 5c m) to 11 m (DBH 19 cm), while heights of severely infected trees ranged from 2.9 m (DBH 3 cm) to 5.8 m (DBH 9 cm). The diameter height curves of the lightly and moderately infected trees appear between the two.

In summary, *Sirococcus* shoot blight had a dramatic impact on the growth of Norway spruce in young plantations. This research was conducted as part of the Special Research Program "Forest Ecosystem Restoration (SF008)" , funded by the Austrian Science Foundation and the Ministry of Agriculture and Forestry.

Physiological and Biochemical Effects of Methanolic Extracts of Neem and Chinaberry Seeds as Natural Insecticides

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Insecticidal effects of ethanolic extracts of neem trees seeds (*Azadirachta indica* A.Juss), chinaberry tree seeds (*Melia azedarach* L.) and damsisa plant (*Ambrosia maritima* L.) against different developmental stages of the cotton leafworm, *Spodoptera littoralis* (Boisd.) were previously evaluated and their physiological effects on its reproductive activities were investigated in our laboratory. In the present study the effects of the critical concentrations, the least sublethal concentrations which exhibited significant reduction in the reproductive activities, of ethanolic extracts of the above mentioned plant materials on the protein and free amino acids (FAAs) contents of the male reproductive organs and spermatophores (SPs) of *S. littoralis* were investigated by both larval treatment, by oral application method and adult treatment, by oral application method.

Critical concentrations of such three extracts significantly reduced the fresh weight and protein contents of the male accessory glands (MAGs) and SPs by both methods of treatment. The reduction in the fresh weight and protein contents in the testes was significant. Sixteen FAAs were detected in the MAGs as well as in SPs. In the untreated males the FAAs contents were found to be higher in the MAGs than in SPs . Treatment of larvae or adult male moths by neem seed extract strongly and significantly reduced the total FAAs contents in both MAGs and Sps since reductions were about 62% and 36% by larval treatment and about 55% and 41% by adult treatment, respectively.

Injection of MAG substance extracted from treated males, with the critical concentrations of the three plant extracts, into newly emerged virgin females caused lower stimulation of egg laying when compared with the MAG substances extracted from untreated males. Moreover, the female ovipositional activities were significantly reduced by the injection with MAG substances extracted from treated males. Feeding *S. littoralis* larvae on caster leaves on male moths on sucrose solutions treated with the critical concentrations of such plant extracts reduced the toxicity of the extracted MAG substances to the injected female moths. However, in all of the above-mentioned results the neem seed extract exhibited the highest potency followed by the chinaberry seed extract and then the damsisa plant extract.

Studies on the Effects of Nutrition Management on the Recovery of Damaged *Pinus massoniana* in the Air Polluted Area

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In this paper, the effects of nutrition management on recovery of damaged *Pinus massoniana* lamb forest were studied. Based on the comparison of nutrient contents in conifer of damaged *Pinus massoniana* lamb before and after nutrition management, the way for supplying content of lack elements in and developing nutrition balance were explored and concluded. The results showed that nutrition management could promote the recovery of damaged forest in polluted areas. According to nutritional diagnosis, the lack of Mg in all of nutrient elements was serious and universal phenomenon in experiment plot of Guangzhou, which only accounted for 52.8 of healthy *Pinus massoniana* lamb. The N/Mg value was far from it on relevant nutrition condition. The degree of base saturation was quite low, which was only 2.5% on layer of 0-10 cm, and 1.8% on layer of 20-30cm. The highest value of Mg/Al and Ca/Al was only 0.011 and 0.019, respectively. The acidity of soil was serious. After nutrition management, the content of Mg in conifer was increased generally, of all of treatments, the B treatment was the most effective, since the Mg content in conifer were increased by 37.1% in comparison with before, and the N/Mg value was much closer to the state of nutrition balance. The degree of base saturation of soil was increased, which was increased to 8.3% on the layer of 0-10 cm and to 7.4% on the layer of 20-30cm, respectively. The highest value of Mg/Al was 0.104. The tendency of acidity for soil was preliminary controlled, the chlorosis extent of conifer was obviously relieved as well.

Entomological Monitoring in Boreal Forests

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The consequences of mass outbreaks of destructive insects in the boreal forests are comparable with those observed after forest fires. Russia accounts annually for 2,200,00 ha of the pests`nidi. The outbreaks of such insect species as *Dendrolimus sibiricum, Ocneria monacha, Bupalus piniarius, Monomachus urussovi* are observed every year over the vast areas, doing great harm to virgin forests of Siberia and Far East. Therefore, we consider entomological monitoring as a significant constituent of forest health monitoring, ensuring, if done properly, conservation of the most important resource and the ecological functions of forests.

The monitoring program envisages the following main tasks to be solved: 1) study of forest health and insect populations under specific ecological conditions; 2) forecasts of the dynamics of insects`numbers and their impacts on the forest ecosystems; 3) timely detection of insects`outbreak nidi; 4) making optimal decisions on forest protection, with allowance for the resource and environment-forming functions of forests.

The monitoring information base shall be compiled by several ways. On the one hand, forest account and field data provide the ecological information on numerical and structural parameters of insect populations, their relations with feed-plants, and on the other hand, the insect habitats`database can be compiled. The predictors of forecasting the pest numbers are distributed into the four blocks allowing assessment of: a) site conditions; b) climatic and weather situation; c) forest conditions; d) basic parameters of interactions between insects, feed-plants, competitors and natural enemies at different stages of pest outbreaks.

The monitoring methodology is based upon modeling the gradation processes, extensive application of mathematical methods for substantiation of the optimal methods for sampling and processing of source ecological data, as well as for making practical decisions. The important constituent of entomological monitoring is the application of remote sensing methods based upon the data collected over many years with respect to the number s of main destructive insects, as well as upon a landscape-ecological approach for analysing spatial distribution of pests`nidi. The structure and distribution of pests`nidi, derived from satellite photographs, can be used as physiognomic indicators of the natural territorial complexes. This allows predicting the extent of potential forest damage as well as to select the key sites for the pest surveillance during the period between successive outbreaks.

The spatio-temporal dynamics of pests`outbreaks shall be studied by using a specialised GIS Protection of Forest against Destructive Insects. Depending on the target tasks of entomological forest monitoring, we distinguish between regional, subregional and local levels of data aggregation.

At a regional level that is based on singling out landscape zones, mountain and altitudinal belts, landscape provinces, the combined analysis of spatial data shall be carried out for detecting the insect species areals and the probable mass outbreak zones, as well as for the development of long-term forecasts and optimal forest-protection strategies. At a subregional level, the nidi`s structure and typology, forest resistance to pest attacks shall be studied, and the middle-term forecasts of the nidi`s development shall be made, within the bounds of separate landscape units. At a local level, the short-term forecasts of the nadir development shall be made, the models to describe spatio-temporal population dynamics shall be constructed, and the results of forest protection measures shall be evaluated.

To improve the forest -pathology interpretation methods, we need to have a wider set of survey facilities. In this connection, the combined utilisation of national security systems and civil satellite photographs of low and medium resolution (NOOA, LANDSAT, SPOT, and RESURS-F) has been very promising. Each type of survey makes it possible to derive a certain information concerning spatial distribution of pests`nidi, their location within a relief, extent of stands`damage, efficiency of forest protection, as well as other important parameters describing insect epidemics. The use of satellite photographs that reflect time series of long standing is of particular significance. Such photographs retaining the tracks of past outbreaks can be extremely useful when compiling a data base to describe forest damage cycles and nidi’s natural structure. The use of those data is very promising for a long-term forecasting of the spatial dynamics of insect populations, as well for the assessment of insect damage and insect influence on forests within a region. The developed system based on the research results over a long term of years, proved to be highly efficient when carrying out forest protection measures against *Dendrolimus sibiricus* Tschv. in 1994-96, covering more than 1 million ha of dark conifer forests in the Krasnoyarsk Territory.

Pathogenic Fungus Associated with the Mass Mortalities of Oak Trees in Japan.

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Keywords: mass mortality, *Platypus quercivorus*, *Raffaelea* sp., *Quercus* spp.

Recently, mass mortality of oak trees has been discovered in several coastal areas along the Japan Sea; more than fifty-thousand oak trees were killed in one year. No severe diseases like oak wilt disease in America, or pests, have previously been observed in oak trees in Japan. Many of the trunks of the dead trees had been attacked by ambrosia beetles, *Platypus quercivorus*, which belong to the *Platypodidae*, but the biotic and abiotic mortality factors have not yet been explained. Several similar studies that examined the cause of mass mortality in the southern beech, *Nothofagus cunninghamii*, in southern Australia, found that the death of the trees was strongly associated with attack by *P. surgbranosus* and infection by *Chalara australis*. Field studies, conducted in deciduous stands in several areas where more than twenty percent of the oak trees had died, observed the following characteristics of mortality. The first symptom, wilting, was observed in early July. The foliage of wilting trees turned red during the summer, and fifty percent of the trees then died between late August and the middle of September. Dead trees were infested by many *P. quercivorus*, but infested trees were not always killed. Identical dark brown discoloration was observed in the sapwood on the crosscut surfaces of the trunks of infested trees. Death was observed only in two species of oak trees, *Quercus serrate* and *Q. mongolica* var. *grosseserrata*. To clarify whether a pathogenic fungus was associated with the mass mortality, isolation and inoculation tests were conducted. *Phialophora, Cryphonectoria, Graphium,* and *Raffaelea sp*. were isolated from the discolored sapwood, necrotic inner bark, and gallery walls of dead and wilting trees. Of these, *Raffaelea* sp. was most frequently isolated from the discolored sapwood. *Phialophora, Fusarium,* and *Raffaelea* sp. were also isolated from body surfaces of larvae, pupae, and adult *P. quercivorus*, and *Raffaelea* sp. was isolated from the mycangia of females. Only *Raffaelea* sp. was isolated from both the trees and the insects. An inoculation test using the fungi that were frequently isolated indicated that only Raffaelea sp. could kill both *Q. serrata* and *Q. mongolica* var. *grosseserrata*. The results of the isolation and inoculation tests strongly suggest that *Raffaelea* sp. is associated with the mass mortality of oak trees in Japan and *that P. quercivorus* is the fungus vector. This is the first report of mass mortality of oak trees caused by *P. quercivorus* and *Raffaelea* fungus anywhere in the world.

Impact of Diseases in Nurseries, Plantations and Forests in Central India

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Diseases are known to be the most destructive agents affecting the planting stock in forest nurseries and consequently the plantation yield thus affecting the forest productivity. However, the losses due to diseases are not so apparent in plantations and natural stand till partial or total death of trees occurs or the expected growth rate is not achieved. Pre- and post-emergence damping-off, wilt and root-rot diseases have been found quite common in forest nurseries of Madhya Pradesh in central India, in moist as well as dry climates, affecting most of the species being raised, causing severe losses to emergent crop which have been estimated up to 70% mortality. Progressive reduction in seed germination, seedling growth, biomass and survival has been estimated due to these root- diseases. Plantations are being intensively managed to increase productivity by reducing genetic variation, eliminating competing vegetation, maintaining optimum stand density and other silvicultural operations and thus exposed to risk of atack by diseases due to drastic change in the ecosystem. *Ganoderma lucidum* has been found to cause more than 50% mortality in an Acacia arboretum raised in a reforested site in Madhya Pradesh. Charcoal root-rot by *Macrophomina phaseolina* in tropical pines and some hardwood species and particulary in coastal areas of Orissa, has been observed as one of the major deterrents to the expected yield. Heart-rot damage in *Tectona grandis* (teak) and *Shorea robusta* (sal) has been assessed which affect 38-88% trees in the former and 58-77% trees in the latter species in natural stands, entailing a loss of about 11-12% in the wood volume, accounting for about 30 million rupees annually. Increased urbanization and industrialization is responsible for polluting of air and in turn causing stresses on trees growing in and around such areas. Air pollution from thermal power plant has been found to reduce the vigour of trees and to increase their susceptibility to root pathogens, canker fungi and insect pests.

Endophytic Fungi in the Needles of Austrian Pine with Particular Reference to *Cenangium ferruginosum* Fr.

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Research on endophytic fungi in needles of Austrian pine was conducted on two autochtonous and six alochtonous growing sites of Austrian pine in the period of three years. Contents of nutrients (N, P, K, Ca, Mg), sulphur (S) and lead (Pb) in the needles of sampled trees were analysed. Samples of 1-8 years old needles were taken from lower branches of 15-60 years old trees six times (in four months intervals: March, July, October). Suitable method for isolation of endophytic fungi was chosen and adapted. Altogether 99 fungal taxa were isolated and 56 fungal species were determined. Dominant species were: *Cyclaneusma niveum* (Pers.:Fr.) DiCosmo, Peredo & Minter (17,2%*), Cenangium ferruginosum* Fr. (15,4%), *Phialophora hoffmannii* (Beyma) Schol-Schwarz (7,8%), *Cyclaneusma minus* (Butin) DiCosmo, Peredo & Minter (5,2%), *Lophodermium conigenum* (Brunaud) Hilitz. (4,5%) and *Hormonema dematioides* Lagerberg & Melin (4,2%). The whole sample was infected 39% (2187 isolations from 5592 segments of 1864 needles). It was established that there exists specialisation of certain endophytes on the level of hosts genus (*Pinus*). There are differences in the growth of mycelia of five most frequent endophytes on different temperatures: 100 C, 200 C, 250 C, 300 C, 350 C, on different amounts of available water in growing media: aw1 = 0,98, aw2 = 0,96, aw3 = 0,94 and on acidified growing medium pH = 4,5. The occurrence of endophytes was different in trees growing on sites with different ecological conditions. There are no significant differences in number of isolations from trees from natural and artificial origin of stands and no differences regarding the age of trees. The species composition and the number of endophytes depend on the time of sampling, they are diminished in more polluted areas. Significant differences in species composition and in the number of isolated dominant endophyte species exist among isolations from the base, from the midst and from the top of the needles and with some fungal species between young and old needles. The content of ergosterol in buds and needles was determined (it was in the range from 0,006 up to 0,15 µg mg^{-1} d.w. of needles) and also in five most frequent endophytes (it was from 0,064 to 0,57 µg mg^{-1} d.w. of the fungi). Ergosterol content is only partially suitable measure for quantification of fungal endophytes in needles. It was established that stored seed, fresh seed and callus of Austrian pine do not contain endophytes. Fungus *C. ferruginosum* destroys the callus in double cultures.

Keywords: endophytic fungi, Austrian pine (*Pinus nigra* Arn.), biology of endophytes, ecology of endophytes, double cultures, latent infection, pathogenicity, mutualistic symbiosis

Chestnut canker - From Doom to Reflourishing of Sweet Chestnut in Slovenia

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Chestnut blight (*Cryphonectria parasitica* /Murrill/Barr) was introduced to Slovenia in the year 1950. Up to the year 1960 the disease has spread over the whole range of sweet chestnut (*Castanea sativa* Mill.) which comprise nearly 25% of forest area (232.000 ha). All the quarantine measures to eradicate the disease were in vain and sweet chestnut was gradually disappearing from the forest.

In the beginning of eighties hypovirulent forms of chestnut blight were discovered also in Slovenia. They were frequent in western part of the country near the Italian border but in continental part of Slovenia they were not found. In the nineties the apparently hypovirulent forms of the disease gradually spread in varied frequency to the whole growing area of sweet chestnut.

The pathogenicity tests revealed that the virulence of isolates from apparently hypovirulent infections varied from avirulent to normal virulent forms of the disease. It seems that besides known viral inducer of hypovirulence the conditions of the environment and mostly the vigour of the host influence the expression of hypovirulence.

The hypovirulent infections appear mostly as superficial infections of bark in regions where it is present for a long time and as healing necroses of bark in areas where it has appeared recently. The frequency of virulent, typically hypovirulent and intermediate forms of chestnut blight differs among regions.

Temporal observations showed unexpected and unexplained fast dissemination of hypovirulent forms of the disease. Death of old sweet chestnut trees because of chestnut blight occur infrequently. It is confined to young trees, mostly sprout stems from stumps. The intensity of the disease diminished and with changed tending practices, with promoting and preserving high population of hypovirulent strains of chestnut blight fungus, the perspective of sweet chestnut is promising.

Forest as an Indicator of Regional Environmental Changes Lithuanian Case Studies

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Keywords: environment, pollution, biological indication, tree, human, animal.

Biological assessment of environmental changes in changing world is of paramount importance.

Over the last ten years multidisciplinary research on interacting components of regional system "Lithuania" (65.6 th. km^2, 2.02 mil.ha forests, 3.7 mil. population) and pollution load has been conducted. Increase (1960-1990) and a two-fold decrease (1991-1995) in the concentrations of different ingredients of pollutants in the air, water and soil has been assessed. Biological indication of these drastic pollution changes according to the physiological reaction of tree and its increment, according to the state-of-art of forests in the screen of regional monitoring (4x4 km), according to the mutagenic effect of pollution on animals and humans, their immunity systems, according to the spreading of malignant tumours and mortality of humans has been investigated. The investigation was carried out by 162 scientists of different specialities from 30 research institutes and universities united into state scientific Programme ECOSLIT.

It has been ascertained that cumulative effect of pollution (increase, decrease) influences negatively and positively the whole vital chain of the regional system, respectively: affects the state-of-art of forests (physiological stress of trees, defoliation, increment) immunogenetic changes in humans, cattle's, field voles, the spreading of cancer diseases and life duration of humans. It has been proved that trees are a susceptible bioindicator of pollution changes. In accordance with the state of art of trees it is possible to determine the chronology of environmental changes and its geographical location. Changes in biopotential of tree, electric conductivity in growing tissue, K+ion transport via cellular membranes, appears at once (hour, day, month the some year) following the environmental change. The concentration of proline in needles increase in 1-2 year while changes in tree damage and its effect on crown defoliation transformed through internal structures of an individual appears 3-4 years later. Also changes in mortality of human population and spreading of viral infections in animals noticeably appears 3-5 years later following the environmental changes. Changes in the immunity systems of humans and cattle organisms depending on the reaction investigated slightly differs, but appears depending on age group within 1-4 years. Changes in the anomaly of the heads of spermatozoa and the mortality of the embrions of grey voles (*Microtus arvalis*) appear within 2-3 years. Economic losses or profit for separate components of regional system is discernible after 4-5 years after the environmental changes and in Lithuanian case comprise about ±10% of GDP.

In conclusion it should be stressed that significant abatement of (air, soil and water) chemical pollution in the regional system activates reparation process with certain delay in the whole chain of life:

- K^+-ion transport via cellular membranes, proline concentration in the needles and crown defoliation of trees in forest diminish;

- Chromosome aberration frequency in humans and animals becomes lower, the human and animal immunity systems restore noticeably, the spreading of viral infections and diseases of cattle dicrease.

Is Resistant Variety of Japanese Cedar to *Semanotus japonicus* (*Coleoptera: Cerambycidae*) Also Resistant to *Epinotia granitalis* (*Lepidoptera: Tortricidae*)?

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It is well known that not only sugi bark borer, *Semanotus japonicus* (Coleoptera: Cerambycidae) but cypress bark moth, *Epinotia granitalis* (Lepidoptera: Tortricidae) are the most important wood-boring pests against Japanese cedar, *Cryptomeria japonica* (L. f.) D. Don, and Japanese cypress, *Chamaecyparis obtusa* (Sieb. et Zucc.) in Japan. There have been several *C. japonica* resistant varieties against *S. japonicus*. To detect whether those resistant varieties were also resistant to *E. granitalis*, firstly I studied boring period and boring system of the 2 pests in the laboratory or in the field. Boring period of *E. granitalis* was early April to mid-May, whereas that *of S. japonicus* was late April to October, suggesting that the boring period was earlier and shorter on *E.granitalis* than on *S. japonicus*. At the beginning of boring in the bark, larval body weight was larger on *E. granitalis* than on *S. japonicus*, whereas, at the time just before pupation, the larval body weight was much larger on *S. japonicus* than on *E. granitalis*, suggesting that, while boring in the bark, *S. japonicus* larvae ingested more nutrition than *E. granitalis*. *E. granitalis* selected boring system as repeating the boring in the bark and escaping from the bark for several times to the pupal stage, whereas *S. japonicus* selected the boring system as boring in the bark all the time until pupation.

Secondly, I released *E. granitalis* larvae into trunks of *C. japonica* trees that were regarded to be highly resistant to *S. japonicus*. On the contrary to the prediction, most of *E. granitalis* larvae grew to adult stage, suggesting that even though resin flow from inner bark which was regarded to be most important to protect the attack of *S. japonicus* larvae was available for protecting the attack of *S. japonicus*, the resin flow could not protect the attack *of E. japonicus*. The reason was assumed by the difference of boring period boring system between the 2 pests: *E. granitalis* larvae bored before metabolism of host trees become active, the boring period of *E. granitalis* was shorter because of small ingestion of nutrition and *E. granitalis* larvae could escape from wood if the resin flow deterred the course of boring.

Effect on Cement Dust on Physiological Attributes of Some Selected Tree Species

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Interest in air pollutant injury to tree species of economic importance is increasing in developing countries. Cement dust is an important pollutant witch affect vegetation in the vicinity of cement factories. The present study was conducted in the adjoining areas of one of the cement factory, The Gagal Cement Works, Himachal Pradesh . Fifteen econo,ically important tree species were selected for the study. The species were *Toona, Dalbergia, Cassia, Eucalyptus, Popular, Bombax, Mangifera, Citrus, Litchi, Psidium, Rosa, Bpugainvillea, Acacia, Pinus* and *Ficus*. Cement dust was found to increase the leaf temperature from 31,3øC (control) to 35.2øC. The effect was more prominent in case of *Citrus, Dalbergia* and *Bomax* species.

The rate of photosynthesis was influenced significantly by the cement dust. The average rate of photosynthesis under control condition was 17.5 mol m^{-2} sec-1. The average rate observed in the vicinity of the factory was 6.5 mol m^{-2} sec-1. The photosynthesis was affected more in *Mangifera, Citrus, Toona* and *Cassia*. The rates of transpiration and stomatal conductance were drastically influenced by the cement dust and impact was observed more prominently in case of *Citrus, Litchi, Dalbergia, Cassia* and Poplar. The average rate of tranpiration and stomatal conductance observed under the control conditions were 18.6 mol m^{-2} sec-1, respectively. The same when observed in the vicinity of the factory were 6.7 mol m^{-2} sec-1 and 0.48 mol m^{-2} sec-1, respectively. *Pinu***s** was observes to be the last affected tree species by the cement dust.

The Frosty Mildew in *Quercus acutissima*: A Serious Foliage Disease in Japan

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Quercus acutissima bed logs are most valuable for cultivation of the shiitake mushroom and the tree has been grown in nurseries and planted in forest stands in several districts of Japan, although in small amounts. Since 1986, the occurrence of a foliage disease has been a problem in the southwestern districts. Suto (1993) described it as a new disease named “Frosty mildew”. In the present study, the damage, the symptoms and signs, and the causal fungus of the disease, pathogenicity of the fungus, and chemical control of the disease are reported.

In Shimane Prefecture, the disease occurred in several nurseries and young planted stands of *Q. acutissima* up to 15-year-old. The infection of the disease started from a limited part and expanded to a whole nursery or stand. In some epidemic areas, 50% or more leaves of the trees were infected and shed. In 1993, it was unusually cold and rainy in July and August, and in one stand almost all the planted trees were heavily infected. The disease occurred repeatedly in the stand infested in the previous year.

From early September, brown to red-brown spots appear on the leaves and rapidly enlarge circularly or irregularly, often spreading to the leaf margins and becoming confluent. The infected leaves are prematurely shed. Occasionally the tips of the young shoots are infected with the fungus, and become brown to die. Conical white to yellowish tufts, propagules of the causal fungus, are scattered on the adaxial surface of the infected leaves and on the shoots, being visible with the naked eye. Small black discoids, sclerotia of the fungus, are produced on the fallen leaves.

The propagule is multicellular, conic, white to yellowish, 480-830 µm high, 200-630 µm wide, consisting of a detachable subglobose stroma-like base and 1-2 conical bundles of hyphal appendages. The propagules are dislodged at a slight touch and disseminated. Sclerotia are orbicular, black, thin, 3-4mm in diameter. The fungus could not be identified because true conidia and the ascogenous stage were not observed on the sclerotia.

Mycelial agar disc and single propagule of the fungus were inoculated onto the leaves in June and October. Of several species of *Quercus, Q. acitissima* was infected most heavily, and *Q. dentata* and *Q. serrata* slightly. The inoculation on the abaxial leaf surface caused the symptoms of the disease, but the inoculation on the adaxial surface did not. The propagule of this fungus is considered to be an infection source and to infect the leaves by penetrating through stomata. In the screening test of 11 fungicides *in vitro*, benomyl and thiophanate-methyl completely suppressed mycelial growth of the causal fungus at 0.1 ppm and 1 ppm, respectively. The propagule of the fungus was inoculated on the leaves onto which the test chemicals had been were applied. Benomyl, thiophanate-methyl, and chlorothalonil prevented the symptom appearance even when the fungus was inoculated three weeks after the chemical application. These fungicides, therefore, are considered to be useful for the practical control of the disease in the field.

Les insectes et nos Forêts de chênes

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Le présent travail tente d'hiérarchiser les agressions des insectes sur les peuplements de chênes en Algérie et de relativiser ces derniers eu égard des autres contraintes que subissent ces écosystèmes. Les résultats des recherches entreprises par une équipe de recherche sur l'ensemble du térritoire national montreront l'importance des problèmes sylvicoles et écologiques et les insectes importants au plan économique qui s'attaquent à ces peuplements feuillus.

This present work of synthesis recapitulates realized observations these last years in the oak forests of height, by scientists and engineers forestiers. This attempt tempts of the impact of insects on the future of populatings oaks considered problems sylcicoles and those bound (connected) to the bad exploitation of the forested products. This work is the outcome of numerous years of extensive searches and observations on ground within the framework of the diagnostic of the pn‚nomŠne of decline the oak forests in Algeria very important these last years. Finally, we give imperative measures to be set to protect the natural forests of oaks of height.

Are Exotic Plantation Tree Species More Susceptible to Termite Attack than Native Species?

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Keywords: Isoptera, termites, *Coptotermes curvignathus*, hosts, attack, plantations, susceptibility, resistance, exotics

Termite attack is a problem that has had a significant impact on plantation forestry in Southeast Asia. The pest responsible for the damage is Coptotermes curvignathus Holmgren, a termite species capable of killing living trees within a short period of time. It has often been said that exotic plantation tree species are more susceptible to attack *by C. curvignathus* than native species. In the early years of the planting of rubber (*Hevea Brasiliensis*) in Peninsular Malaysia, it was suggested that the reason for the abundance of *C. curvignathus* in plantations was that the tree species was not naturally selected to resist attack. Subsequent authors commented that the termite tends to affect exotic tree species more than native species, citing rubber and conifers as examples of susceptible exotics. Indeed, the severity of *C. curvignathus*, as a pest in plantation forestry in the peninsula, was felt most greatly with the planting of exotic conifer species, such as *Pinus caribaea* and *Araucaria cunninghamii*. The belief that exotic trees are more susceptible to attack has been reiterated in reviews on termite feeding relationships and the importance of *C. curvignathus* in forestry. It has, additionally, been suggested that, besides possible acquisition of resistance by native plants, the termite may be unable to recognise toxic foreign trees.

The evidence used to suggest that exotic tree species are more susceptible to attack is somewhat circumstantial and there is evidence of equal, if not greater, susceptibility of some native tree species. In Papua New Guinea, a closely related termite species, Coptotermes elisae, occurs in natural conifer forests of native *Araucaria hunsteinii* and is known to prefer this species over the exotic Australian *A. cunninghamii* grown in plantations. There are also a number of introduced tree species grown on a plantation scale in parts of Southeast Asia, which have not been reported as being particularly susceptible to attack by *C. curvignathus*, among them *Gmelina arborea* (Verbenaceae) and *Acacia mangium* (Leguminosae). Studies showed that the termite was present on up to about 5% of 4 year-old

Acacia mangium trees, but that tree mortality was relatively low. Attack was usually confined to the heartwood, which was accessed through pruning wounds, leaf abscission scars or wood damaged by other insects.

Many native tree species in Malaysia appear to be more susceptible to attack than *Acacia mangium*. In the present study, all trees in a 50ha plot (1.0 x 0.5 km) of natural dipterocarp forest were examined for symptoms of attack by *C. curvignathus*. The termite was found to be capable of killing a large number of species of native trees, but also had clear preferences. Tree species that were susceptible to attack were *Canarium* spp. and *Dacryodes* spp. (*Burseraceae*), *Buchanania sessifolia* (*Anacardiaceae*) and *Koompassia malaccensis* (*Leguminosae*). Among the very abundant species that were never attacked was *Gironniera parvifolia* (*Ulmaceae*). The susceptibility of some native tree species to termite attack is also apparent from a number of early reports, notably *Koompassia malaccensis* (*Leguminosae*), *Shorea spp*. (*Dipterocarpaceae*) and *Campnosperma auriculata* (*Anacardiaceae*). These hosts are common in peat soils and, thus, it has been suggested that the high incidence of *C. curvignathus* on peat soils is due to the abundance of suitable hosts rather than soil characteristics. Other native species said to be commonly attacked are *Styrax benzoin* (*Styracaceae*), *Myristica* sp. (*Myristicaceae*) and *Macaranga* (*Euphorbiaceae*). We, therefore, conclude that native tree species can be as susceptible to attack as exotic species, and that the affinity of the termite for species such as conifers and rubber bears no relation to the fact that they are exotic.

Bark and Wood Boring Insect Pests of Scots Pine in Czechia

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Long history of human intervention has resulted in the following composition of forest trees in Czechia: 54% spruce, 18% pine, and the rest is composed mainly of oak and beech. Even though the pine stands play a minor role in our forestry, in certain areas they represent the dominant part of forest stands. Drastic change in ecological structure of forest ecosystems and weather conditions has favored the development of forest insect pests which play limiting roles in the development of forest stands. During the first half of this decade, the abundance of pine insect pests increased rapidly due to very warm and dry summers in several consecutive years. In combination with neglect of forest protection in pine stands and inadequate control methods, we recorded considerable damage to pine forests. From 1993 to 1996 224 thousands m^3 of infested trees were cut down, which resulted in high economic losses for our forest industry. Because of the necessity to solve these problems our research program in the department of forest protection in FGMRI was developed. We focused our activity on the main wood and bark boring insect pests of pine, especially *Ips acuminatus*. Our project combined basic research on the biology as well as developing methods for forest protection. As a result of our research we prepared methods for the control of *Ips acuminatus* which is established on the basis of using trap trees baited with pheromone dispensers. The pheromone dipsenser containes a mixture of racemic ipsdienol, ipsenol and S-cis-verbenol. For greater effeciency in the pheromone traps it is better to substitute racemic ipsdienol with +ipsdienol. Prescriptions of control strategies and monitoring systems were published in leaflets for single pests. Publishing of the final results as a whole is being prepared. Results of our research were introduced in the field and are now commonly used.

Tree as Indicator for Determination of Alteration in Environmental Conditions (by Use of Enzymes, Cations and Anions Studies)

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Iranian remote sensing scientists in 1998, after examining 1267 satellite pictures estabilished the widespread distribution of smoke and soot over Iran and penetration of oil slicks into the coastal habitats of the Northen coasts of Persian Gulf.

As such, a study was designed to trace the pollution strees in Mangroves and other tree species of Iran in the impacted regions. In order to gather scientific evidence for damaged inflicted on natural resources of Iran, several different approaches have been taken. For example, penetration of smoke and soot and oil slicks has been validated by remote sensing technology and mathematical modeling approahes; deposition and distribution of contamination has bee confirmed using field sampling and factual obeservation; degree and kind of damage has been determined using reliable scientific methods.

This research was done seven years after environmental pollution that casued by Persian Gulf War. Sampling was done from annual growth rings (1990-1998) of *Ziziphus spina-christi* and *Avicenia officinalis* in a large region of Iran (south and southwest). Annual growth rings of 1990 and 1998 were selected as control for before and after pollution, respectively. Tree were selected from GuatrBadar-e-Abbas, Boushehr and Shoushtar. Guatr had the most distances from pollution center but Shoushtar and Boushehr were in the center of pollution. Enzymatic and isoenzymatic alterations (peroxidase, estrase and amylase), cations contents (K, Na, Ca, and Pb) and sulfur contents were detemined.

Quantitative and qualitative alteration of peroxidase, amylase and estrase were determined. All trees (from any location) showed reaction aginst pollution, but level of reaction was different that depends on characters of trees (species and genotype) and ecological parameters. Results indicated all of trees reacted against air pollution and acid rain. Dependend on physiological characters on species of trees, reactions are different (enzymatic patters as well as enzyme activities). Alterations of amylase was more than perocidase and estrase. Probably stress had the most effect on sugar compound. The alterations of enzymatic patterns are stable or unstable. Peroxidase enzymes activity is affected regularly by ecological parameters (for example altitude and latitude) too.

Cationic (K, Na, Ca and Pb) and anionic (sulfur) alterations were shown in all of trees by environmental pollution as stress. These alterations are seen with differing ecological parameters (altitude and latitude), too. Quantitative and qualitative studies of enzymes were done by spectrophotometers and gel eletrophresis methods. Sodium and potassium were mesaured by flamephotometer. Calcium and sulfur were determined by titration and turbidometery methods.

Induced Resistance of Pine Trees Against Pine Wilt Disease by Avirulent Nematode Inoculation

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Keywords: pine wood nematode, Japanese pine sawyer, disease control

Pine wilt disease caused by the pine wood nematode, *Bursaphelenchus xylophilus*, is a most serious forest disease in Japan. The disease has also been spreading in some areas of Eastern Asia in a last decade. Recently, environmentally friendly control procedures against the disease have been required besides the use of pesticides and nematicides. In such situation, it is known that prior inoculation with an avirulent isolate of the pine wood nematodes induced the resistance of young pine trees in the nursery against the disease. Delayed symptom development of the disease was also observed in mature pine trees on a country side forest by the prior inoculation with avirulent nematodes. These studies, however, needed post inoculation of the virulent nematodes as challengers because the pine wilt disease did not occurred naturally in the research fields. The pine wood nematodes are transmitted to the healthy pine trees by the Japanese pine sawyer, *Monochamus alternatus,* in nature. Further studies have been needed under natural condition.

We report here that the result of the avirulent nematode inoculation to the pine trees on a forest where the pine wilt disease is an epidemic naturally. The Japanese red pine, *Pinus densiflora*, and the Japanese black pine, *P. thunbergii*, on a forest stand at Chiyoda experimental station of Forestry and Forest Product Research Institute were inoculated with an avirulent strain of the nematode, OKD-1. 20,000 nematodes were inoculated to the pine trees on 27 May 1998 as treatment, but nothing was inoculated to the trees as control. Survival rates of the pine trees, the marks of vector insects on some dead trees and nematodes isolated from the trees were observed at may 1999. 94% of *P. densiflora* was alive in the treatment but 88% in the control. 92% of *P. thunbergii* was alive in the treatment, but 85% in the control. Larval frass of the Japanese pine sawyer and *B. xylophilus* were observed from some dead trees in the control. This observation indicated the pine wilt disease occurred naturally in this forest. Percentages of living trees were higher in the treatment than in the control. This result suggests that inoculation of avirulent nematodes prevent rapid spread of the disease in the natural condition. Furthermore, these differences in the survival rates of the pine trees between the treatment and the control might be larger after the treatments over several years though the differences were not large values in this experiment. We still consider that the inoculation of the avirulent nematodes should be one of the possible control procedure of the pine wilt disease and continue the studies.

Heart-rot in Japanese cypress - Damage of Japanese Cypress Forests Caused by Butt-rot and Stand Conditions at the Foot of Mt. Unzen -

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Keywords: butt-rot, Japanese cypress, volume lose, *Tinctoporellus epimiltinus*, stand condition

The forests of Japanese cypress (*Chamaecyparis obtusa* (Sieb.et Zucc.) Endl.) at the foot of Mt.Unzen were investigated for the damage caused by butt-rot. The diameter of butt-rot at the cut end (D), and the heights (H) and volume (V) of butt-rot were measured in 118, 97 and 84 trees suffering from butt-rot in stands 25, 35 and 50 years after planting, respectively, and their relationship determined. In the 25-year-old stand, H = 15.095+7.2076xD, and V = -367.41+36.587xbasal butt-rot area at the cut end. In the 35-year-old forest; H = 17.131+8.5007xD, and V = -3004.70+ 71.888xbasal butt-rot area at the cut end. In the 50-year-old forest; H = 62.749+9.352xD, and V = -5188.70+112.93xbasal butt-rot area at the cut end. The volume of butt-rot in the 25-, 35- and 50-year-old forests was 0.1438, 1.006, 1.433m3 per 100 trees, respectively. The older tree, the higher was the butt-rot and the larger was the volume of the butt-rot.

In the 35-year-old stand, the influence of butt-rot on yield volume was investigated. The volume of rotten part was 0.9169m3, 6.95% of the expected yield volume. The volume of logs that were cut off and left in the forests was 4.1569m3. The loss was about 4.5 times larger than the rotten part in volume. The lost volume was 31.5% of the expected yield volume.

In the 25-year-old stand, the pathogen was isolated from 64 trees, 52% of trees suffered from butt-rot. Among the isolated fungi, *Tinctoporellus epimiltinus* (Berk. et Br.) Ryv., which is a tropical or subtropical fungus known as the pathogenic fungi of butt-rot, accounted for 15.6%. Some unidentified Basidiomycetes fungi were also isolated.

The age of the stand and gradient of the land seem to influence the degree of the damage of Japanese cypress trees caused by butt-rot. The soil condition also seemed to affect the damage. This damage is not a problem for non-commercial thinning, but is a serious problem for commercial thinning and final cutting because of loss of commercial value. We should take into consideration this damage when we operate on long-term rotations.

The Role of Bark Beetle Species (Col., Scolytidae) in the Hungarian Coniferous Forests

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Hungary is a small Central-European country with a forest coverage of 18.2% (1640000 ha). Besides of the different broad leave tree species (*Quercus, Fagus, Robinia, Populus*), 15.1% of the Hungarian forest stands consist of coniferous tree stands. Aside from a few natural *Pinus sylvestris* and *Taxus baccata* stands most of those are close-to-nature to man created monoculure. The three most important coniferous species are *Pinus sylvestris* (9.1%1, 48243 ha), *Pinus nigra* (4.2%, 68666 ha) and *Picea abies* (1.5%, 24336 ha). The pine stands concentrate to the south-west and central part, till the spruce stands to the western Hungary. Both genus are either economically (wood production) or ecologically (soil and landscape protection) important.

In the last ten years the mass outbreak of bark beetles has been caused enormous economic losses in all parts of Hungary. The attacked area varied from 3000 to 7000 ha/year and altogether 33000 ha was attacked, which plead nearly 14% of the total coniferous area.

In our long term study through several field investigations and labour experiments we assessed the health conditions of the Hungarian coniferous stands and the reasons of the mass outbreak, started in the late 80's. The use of felled trap trees allowed us to define the species abundance. On *P. sylvestris*

34 bark beetle species live, but only a couple of them cause economic losses: *Tomicus piniperda*, *T. minor, Ips sexdendatus* and some *Orthotomicus* sp. On *P. nigra* there were 22 species detected, but no one could be characterised as economically important. On *P. abies* are 28 scolytids living, and the most important species are *Ips typographus, Pityogenes chalcographus, Polygraphus poligraphus* and in some special cases *Dendroctonus micans*.

The spatial analysis of the felled timber after bark beetle infestation and the presence of bark beetle species allowed us to make the right adjudication about its real economic importance. The results were converted into a GIS based map as well.

Effect of VAM Fungi on Growth and Root-Knot Resistance of Taiwan *Paulownia*

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Keywords: Taiwan *Paulownia*; root-knot nematode; VAM fungi

Taiwan paulownia (*Paulownia x taiwaniana*), a natural hybrid of *P. fortunei* and *P. kawakamii*, which produces high quality timber, is an important fast-growing tree species for artificial plantations in Taiwan. However, it is susceptible to root-knot nematodes (*Meloidogyne incognita*), which infest roots of Taiwan paulownias, and cause severe damages to root tissues. Tree growth is seriously retarded. Subsequently, trees are more susceptible to other pathogen infections, and root rot or even death may occur. Thus, effective growth promotion of trees and biocontrol of root-knot nematodes are of great importance in sustainable management of Taiwan *Paulownia*.

In this study, VAM fungi, *Glomus etunicatum*, *Gl. fasciculatum*, and *Gl. mosseae*, were inoculated onto roots of 5-month-old Taiwan *paulownia* seedlings with 96±5 spores per seedling. One month later, Each seedling was inoculated with 50±6 root-knot nematodes. Then, seedlings were maintained in a growth chamber with photo-intensity of 340-400 umol·m^{-2}·s^{-1}, photoperiod of 12-hour light and 12-hour dark, and temperature of day 25±1 and night 20±1 for 2 months. The results revealed that the average height of seedlings inoculated with VAM fungi, VAM fungi + root-knot nematodes, root-knot nematodes, and control were 42.6 cm, 36.1 cm, 22.7 cm, and 29.5 respectively. The average number of root knot of seedlings inoculated with VAM fungi, VAM fungi + root-knot nematodes, root-knot nematodes, and control were 0, 82, 315, and 0 respectively. The average endomycorrhiza formation rates of seedlings inoculated with VAM fungi, VAM fungi + root-knot nematodes, root-knot nematodes, and control were 43.9%, 42.5%, 0, and 0. Results of seedling nutrient analysis with inductively coupled plasma atomic emission spectrometer showed that content of phosphorus and potassium was the highest in seedlings inoculated with VAM fungi among all treatments.

The Monitoring of Forest Condition in Finland

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Keywords: forest condition, monitoring

Since 1985, Finland has been participating in the International Co-operative Programme on the Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests), which was established by the United Nations Economic Commission for Europe under its Convention on Long-range Transboundary Air Pollution. In 1986 the European Union adopted the Scheme on the Protection of Forest against the Atmospheric Pollution.

The Finnish Forest Research Institute (Metla) has been responsible for the monitoring of forest condition in Finland since 1986, carrying out an annual large-scale survey of the crown condition on a network comprising 460 permanent sample plots (Level I) using internationally harmonised methods. A survey of needle chemistry was started on the same plots in 1987, and a soil survey carried out during 1985-89 (supplemented in 1995).

The Pan-European Programme for Intensive and Continuous Monitoring of Forest Ecosystems (Level II) was initiated in 1995 in order to gain a better understanding of the effects of air pollution and other stress factors on forests. By the end of 1997, 17 Scots pine (*Pinus sylvestris*) and 14 Norway spruce (*Picea abies*) sample plots had been established for intensive monitoring purposes in different parts of Finland.

The forests in Finland are less defoliated than those in most of the other European countries. In the first years of the monitoring programme, during 1986 to 1989, defoliation increased in all tree species. Since then the tree crowns have recovered. However, a slight increase in the defoliation of broadleaves in 1992-1993 and in pine in 1993 was observed. No essential changes have been

observed in the defoliation level of any tree species in recent years. In 1999 the average degree of defoliation on Scots pine (*Pinus sylvestris*) was 9%, on Norway spruce (*Picea abies*) 18%, and on broad-leaved tree species (mainly *Betula* spp.) 11%. High stand age and unfavourable climatic and weather conditions greatly affect defoliation in Finland. No clear connections have been found between air pollution and tree crown condition at the national level.

The causal relationships between forest condition and environmental factors have been studied since 1995 on the Level II plots. Defoliation on the Level II plots was slightly higher than that on the Level I plots, apparently to be due to differences in the stand structure. The stands were characterised by a lack of nitrogen and low phosphorus concentrations, and potassium deficiencies were apparent on peatlands.

There were clear relationships between the concentrations of many nutrients in the needles and the organic layer of the soil. The strong South-North climatic gradient in Finland appears to be main reason for the S-N gradients in the total nitrogen and sulphur concentrations and C/N ratio in the organic layer. There is also a strongly decreasing S-N gradient in the deposition of nitrogen and sulphur compounds, and an increasing gradient in the average pH of bulk precipitation. It is very difficult to separate, with any degree of certainty, the effects of deposition on the soil chemical status from those attributable to climatic conditions. However, the strong correlation between the geographical location of the plots and the deposition and soil parameters indicate that both the climatic conditions and deposition should be taken into account when evaluating the chemical properties of forest soil.

Fifteen Years of Monitoring Forest Condition in Europe - Scientific and Political Implications

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Keywords: Europe; Monitoring; Forest condition; ICP Forests; Air pollution

For 15 years, forest condition in Europe has been systematically and continuously monitored by the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) of the United Nations Economic Commission for Europe (UN/ECE) and under the Scheme on the Protection of Forests against Atmospheric Pollution of the European Union (EU). Using harmonized methods laid down in a manual, 34 European countries have been assessing crown condition and to a great extent participated in soil and foliage surveys on a large-scale grid comprising about 5 700 sample plots. On 774 per-manent observation plots, inten-sive monitoring is performed, comprising assessments of crown condition, foliar condition, soil condition and soil solution chemistry, tree growth, ground vegetation, air quality, atmospheric depositions and meteorological conditions.

Results show that forest decline on the large scale developed far less dramatically than feared in the early 1980s. However, a general deterioration of crown condition is shown for the most frequent coniferous and broadleaved tree species, which can hardly be explained by natural stressors alone. Defoliation is particularly evident in those areas of central Europe where air pollution is highest. A recent recuperation of *Pinus sylvestris* in some of those main damage areas has been attributed to favourable weather conditions and improved air quality. There are indications for a spatial coincidence of air pollution, soil acidification, nutritional imbal-ances and defoliation of trees. On the large scale, however, these relationships are rather weak, and drought, insects and fungi are thought to be the primary factors influencing the temporal and spatial variation of crown condition. Air pollution is con-sidered to act as a pre-disposing, accompanying and locally triggering factor. More specific large-scale results are expected from ongoing integrative evaluations of crown, soil and foliage data, as well as from the planned upscaling of processes identified at the intensive monitoring site.

First results of the intensive monitoring indicate that nitrogen depositions are twice as high as sulphur deposi-tions, with nitrogen depositions dominating in western Europe and sulphur depositions dominating in central and eastern Europe. On 45% of the plots, nitrogen depositions exceed a critical level of 1000 mol_c/ha/yr, beyond which nitrogen leaching and an adverse impact on ground vegetation may occur. On 15% of the plots, acid depo-sitions (sulphur and nitrogen compounds) above 1500-3000 mol_c/ha/yr were found, which are thought to cause nutrient depletion and increased aluminium concentrations in the soil. Critical levels for nitrate in the subsoil threatening the filtering function for water resources are exceeded on 18% of the plots.

Impacts of Insect Outbreaks on Forest Sustainability: Spruce Budworm Decision Support System Use in Canada

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Spruce budworm (*Choristoneura fumiferana* Clem.) outbreaks are natural disturbances that cause heavy spruce (*Picea* sp.) and balsam fir (*Abies balsamea* (L.) Mill.) mortality in eastern Canada and thereby result in large uncertainty in forest structure and productivity. These outbreaks are a natural component of forest succession, but must be taken into account in forest management planning, if plans are to be accurate.

Managers need tools to predict outbreak occurrence and effects on forest development, to ensure that expected timber supply/stand types will be present at the expected time of harvest/other usage, and to utilize silviculture and management planning to reduce the severity of future outbreaks. The Spruce Budworm Decision Support System (SBWDSS) was developed by the Canadian Forest Service from 1992-95. The SBWDSS links prediction and interpretation models to the ARC/INFO GIS, under an ArcView graphical user interface. It assists forest managers to predict budworm outbreak effects on forest structure and productivity, forecast forest growing stock and sustainable harvest levels, optimize protection (biological insecticide use) programs, and use silviculture and harvest scheduling to restructure forests to reduce future damage.

From 1996-99, the DSS was operationally implemented, on a cost-shared basis with industry and the provincial government, on all 8 million ha of forest in New Brunswick, Canada; it is also being implemented for test landbases in Alberta, Ontario, and Quebec. The SBWDSS models marginal timber supply benefits (m^3/ha) and the forest structure consequences of alternative management actions and facilitates incorporation of effects of insect damage into forest management planning. A defoliation-based stand growth model (STAMAN) and a timber supply model (Woodstock or FORMAN+1) are used to forecast forest development with and without defoliation. Volume loss (m^3/ha) is then calculated for each stand based on both direct (stand-level) and indirect (harvest queue disruption) marginal timber supply impacts associated with applying protection. The SBWDSS permits evaluation of cost/benefits and consequences of management, optimizes pesticide use (if desired), and improves visualization of the consequences of pest outbreaks and management strategies on forest performance indicators.

Strategic planning analyses evaluating the consequences of budworm outbreak occurrence, protection policy, and of protection exceeding the target foliage retention level of 60% or of part of the landbase not being protected have been conducted. Analyses for a 532,000 ha landbase in New Brunswick indicated that "normal" and "severe" budworm outbreak scenarios, defined based on future defoliation, would result in total losses of 4.7 million and 13.3 million m^3 of spruce-fir timber. Simulations indicated that sustainable harvest levels 20-30 years in the future were very sensitive to reductions in yield caused by defoliation. If insecticides were applied but defoliation exceeded the foliage protection target by 20% on 20%, 40%, or 60% of the landbase, harvest level reductions in years 15-20 of 370,000, 735,000, and 1.1 million m^3 would be necessary.

Geochemical Mapping of Elements in the Carpathian Mountain Forests Using Foliar Analysis of White Fir (*Abies alba* Mill.)

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Keywords: Air pollution; Foliar analysis; *Abies alba*; Carpathian Mountains

The Carpathian forests represent unique reservoirs of many endemic, rare, and unusual plant and animal species in Central Europe. White fir (*Abies alba* Mill.) is well distributed in the Carpathian Mountains. This species has attracted significant attention of scientists because of its decline and reduced genetic diversity caused by air pollution. Research sites were established in Slovakia, the Czech Republic, Poland, Ukraine and Romania in December 1995. Altogether 483 trees of predominant or dominant class in the second age category (21-40 years old) were sampled. Samples of needles were analyzed unwashed. Concentrations of elements were determined with atomic absorption spectroscopy: Al, Ba, Ca, Cu, Fe, Mn, Mg, Na, Sr, Rb, Zn (Perkin-Elmer model

3030B); Co, Cd, Cr, Be, Ni Pb, V (Perkin-Elmer model 3100, HGA-600); As, Se (AAS 3030B, MHS-20 Perkin-Elmer); Hg (trace mercury analyzer TMA-254, Tesla Holesovice). Concentrations of F were determined colorimetrically by (SPECOL 11 Carl Zeiss Jena), of S with a LECO SC 132 analyzer and of N with a LECO SC 228 analyzer. Observations of fir needle surfaces were performed with a Scanning Electron Microscope JEOL 840 A and by using an EDX analyzer LINK 10000. Particles deposited on surface and in stomata were assessed according to their morphology and EDX spectra. Particles deposited on fir needles were assigned into 4 basic categories (biological, mineral, coal-oil ash, and industrial particles) The accuracy of data was verified by comparison of the analysis of standard plant samples with results obtained in 109 laboratories within the IUFRO quality assurance working group. The samples were evaluated by common statistical methods.

Based on foliar analyses of *A. alba* the greatest load by air pollutants is in Slovak part of Carpathian Mountains, namely in the surroundings of industrial plants where also the highest values of studied elements were found. Between concentrations of Al, Be, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Li, Mg, Mn, N, Na, Ni, Pb, S, V a Zn in the needles of *A. alba* we found statistically significant difference between all study countries except for Sr and Rb. Evaluation of metal concentrations in needles was discussed in relation to pollution of the forest environment with heavy metals and limit values of the studied metals for plants. The highest values of the studied elements were found in Slovak portion of the Carpathian Mountains in the vicinity of industrial sources. The highest values of Al, Ba, Cd, Cr, F, K, Mg were found near to the Termal Power Plant ENO Zemianske Kostoóany and the Aluminium Plant in Ziar nad Hronom. The highest concentrations of Cu, Fe, Hg, Zn were determined in the localities influenced by the Non-ferrous Metallurgic Plant in Krompachy and the Mercury Processing Plant in Rud•any. High concentrations of As, Fe, Mn, S, and V occurred in the vicinity of the Ferrous Metallurgic Plants in Podbrezov and Kosice. Elevated above normal concentrations of Be, Cr, Na, Ni and Pb in fir reflect regional pollution of the environment with these elements. Elevated concentrations of Co, Se and Li, in the absence of Slovak sources of these elements indicate effect of a long-range transport from the heavily polluted areas in Poland and the Czech Republic. Liming of the pollution-weakened forest stands was a probable reason for increased concentrations of Ca in fir needles. This study proves that fir needles can be used as bioindicators of contamination of the environment with heavy metals.

Stomata of observed needles of *A. abies* contained aluminium as a part of minerals, ashes (Al- Si) and particles Al_2O_3 (vicinity of aluminium plant); iron as a part of particles of minerals, ashes and Fe_2O_3 (vicinity of metallurgy complex and thermal power plant); potassium as a part of mineral and biological particles and Mn, Na, V, Ni, Zn, Cr, As, Ba and Cu were found in the vicinity of non ferrous plants. This fact is especially important in the assessment of elements with significant nutritive value.

Chemical Composition of Deciduous and Coniferous Vegetation, Mosses and Humus as Environmental Indicator in Slovakia

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Keywords: air pollution, foliage, mosses, humus

Effects of high concentrations of pollutants have resulted in large-scale dying. 85% of forests in Slovakia exihibited symptoms of damage. Concentrations of Al, Ba, Be, Ca, Cd, Co, Cr, Cu, F, Fe, Hg, K, Li, Mg, Mn, N, Na, Ni, Pb, Rb, S, Se, Sr, V and Zn in the foliage of five forest tree species (*Picea abies* Karst., *Pinus sylvestris* L., *Abies alba* L., *Fagus sylvatica* L., and *Quercus* sp.) three mosses (*Pleurozium schreberi*, *Hylocomium splendens*, *Dicranum* sp.) and humus from 3063 plots are completed with their contents related to the limit values and composition of individual particles in stomata of leaves.

The foliage, mosses and humus were not washed before analysis. The samples were taken by monitoring specialists in August 1994 and mosses also in August 1991, in accordance with international methodology. Concentration of elements was determined with atomic absorption spectroscopy: Al, Ba, Ca, Cu, Fe, Mn, Mg, Na, Sr, Rb, Zn (AAS Perkin-Elmer, model 3030B); Co, Cd, Cr, Be, Ni, Pb, V (AAS

Perkin-Elmer, model 3100, HGA-600); As, Se (AAS Perkin-Elmer, model 3030B MHS-20); Hg (TMA/254, Tesla Holesovice). F was determined colorimetrically (Spekol 11, Carl Zeiss Jena), S with LECO 132 analyser and N with LECO SC 228 analyser. Analytical data published in paper were verified and tested. The foliage was evaluated by scanning electron microscope JEOL 400 A and X-ray analyser LINK 10000. The particles deposited in the stomata of foliage (external content) were assessed as to their morphology and EDX spectra. The samples were evaluated by common statistical methods.

The average of element concentrations in the foliage of forest tree species was (in mg.kg-1): Al(151), As(0.57), Ba(65), Be(0.02), Ca(11021), Cd(0.20), Co(0.18), Cr(0.80), Cu(7.3), F(6.2), Fe(159), Hg(0.10), K(7503), Li(0.18), Mg(1458), Mn(1121), N(18165), Na(42.0), Ni(3.44), Pb (2.42), Rb(10.8), S(2163), Se(0.06), Sr(25.9), V(0.81) and Zn(42.7). The equilibrium of individual elements in plants is a precondition of their normal growth. Surprisingly, in contrast to data presented by Markert (1993), only highly positive correlation pairs (r>0.9) of locally emitted elements were found. External concentration and higher standard deviation in industrial areas confirm an effect of polluted air.

Concentrations of elements are higher compared to literature values. More than 75% of foliage surface contained Fe, Ca, Al, K. The highest values of Al, Ba, Be, F, K, Li were found in the vicinity of aluminium plant; Co, Mg, Rb, V of magnesite plant; As, Cu, Hg, S, Se, Zn in the region of non-ferrous metallurgy +mercury plant; Cd, Fe in the vicinity of ferrous metallurgy; N, Sr from military area and Ca, Cr, Ni from the National Park Low Tatras. In comparison with the content of heavy metals excluding of Cd- cover humus always contained more such elements than mosses. In comparison 1991/94 the content of Cd, Pb, Zn was reduced and the contents of Cr, Cu, Fe, Ni were increased.

The State of Health and Intensive Monitoring of Forests in Croatia

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The state of forests in Croatia have been monitored since 1987 according to the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) at 87 bioindicative level 1 plots, located according to a 16 x 16 km network. It has been established that their state of health has, since monitoring began, continually declined. That is, the falling of needles and leaves and changes in their colour has increased since 1995, after which period there has been major improvement. In 1987, there was considerable damage of 7,9% in Croatian forests, 27.7% in 1995 and 19.6% in 1998.

Intensive monitoring of the state of forests is also undertaken according to ICP-Forest methods on 7 permanent level II plots, which are located in various regions in Croatia in various phytocenoses. On the plots, the state of the crowns is assessed and the electric resistance of the tree`s translocation system measured. Trees that do not have any visual signs of crown damage, i.e. healthy trees that fall into the class 0 of damage, have lower electric resistance than trees that fall into classes 1,2,3 of damage. For example, the Fir species (*Abies alba* Mill.), healthy trees (defoliation 0 class, needle loss up to 10%, degree of defoliation "none") have an average electric resistance of 9.2 KΩ, class 1 trees (10-25%, slight defoliation) have 9.8 KΩ, class 2 trees (25-60% moderate def.) have 12.4 KΩ, while class 3 trees (>60%, severe def.) have 17.3 KΩ. Measurements were undertaken in August 1997 and 1998. For class 4 trees (dead) electric resistance was not measured, as the translocation system was inactive.

To determine the state of crowns in level II plots, besides the ICP Forests methods, a unique method of the Forestry Institute is utilised. This method is the interpretation of aerial photographs of top crown details. Aerial photographs are taken with a special portable device, by which a capsule with a mounted camera is launched vertically from the ground, and within the scope of the upper point of movement, automatically photographs a particular motif and returns to the ground in a free fall. On aerial photographs, the degree of defoliation and discolloration in the upper isolated section of the tree crown is assessed, rather than being measured. Through the use of this method, objectivity of research as well as visibility of the most physiologically active crown parts that are not visible from the ground is attained.

Aerial photos show fir trees on Medvednica mountain on permanent sample plot No 103 (in proximity to the city of Zagreb) with different scales of damage and an oak tree on plot No 102 (in proximity to the city of Jastrebarsko).

Cylindrocladium blight a new disease of *Syzygium cumini* from India and its Management

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Leaf spotting and blight, a new disease of *Syzygium cumini* caused by *Cylindrocladium quinqueseptatum* was recorded at New Forest, Dehra Dun in India in 1988. The disease appeared in the second week of September as small spots on leaves on two months old seedlings raise in root trainers containing the potting mixture consisting of one part soil and two parts each of sand and farm yard manure. The disease continued progressing as was evident from increase in number of spots on the leaves and more and more leaves being infected following precipitation amounting to 83.5mm on 12th September. However, the disease escalated with leaf spots turning into leaf blight and subsequently leading to seedling blight following fairly good rains amounting to 156mm in the fourth week of September. Data recorded on 23rd September showed that the disease incidence was 100% whereas defoliation and mortality were 63.8% and 24.5% respectively. The disease further escalated with more precipitation and assumed serious proportion by the first week of October when defoliation increased to 83.5% and mortality of seedlings to 63.5%.

The x and brought within the economic injury level by spray at weekly intervals starting from the 10th of September. Five applications of the fungicides were found effective. Though the disease incidence in treated seedlings was 100%, it remained restricted to development of only a few spots on the leaves. Moreover, none of the leaves was blighted and shed prematurely and there was no causality unlike control seedlings in which defoliation and mortality were to the extent of 83.5% and 63.5% respectively. A comparison of the biomass between treated and untreated seedlings in November end showed reduction in biomass to the extent of 772% in the latter. On the other hand, when Blitox (0.2%) was applied similarly, the mortality of seedlings was dipped to 9.8% and the seedlings were defoliated to the extent of 30%. Premature defoliation and blighting of leaves in large number in Blitox treated plants had adverse impact on plant growth as was evident from reduction in plant biomass by 671% as compared to seedlings treated with a mixture of Bavistin and Dithane M-45.

Some Important Nursery Diseases of Tropical Forest Trees, Their Impact and Management

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During the last 8 years xxx in forest nurseries established under social forestry and agro forestry xxx Pradesh, India to detect new disease outbreaks, evaluate damage xxx of economically important diseases. The following diseases hither xxx recently recorded and described. New diseases included damping xxx spot caused by *Rhizoctonia solani*, *Sclerotium rolfsii* and xxx top flagging of *Pinus kesiya* and leaf web blight of 23 hardwoods by *R. solani*, xxx hardwoods by *Phytopthora nicotianae*, *P. citrophtora* and *P. palmivora*, leaf blight of *Azadirachta indica* and *Pongamia pinnata by Coletotrichum dematium*, leaf and seedling blight of *Syzygium cumini by Cylndrocladium quinqueseptatum*, leaf blight of *Bombax ceiba* by *Ascochyty* sp.; set rot of *Populus deltoides* by *Phomopsis* sp., an exotic pathogen intercepted at New Forest, wilt of *Cupressus torulosa* by *Fusarium* sp.; root and basal rot of *Paulownia fortunei* by *R. solani* and *Fusarium* sp.; root and collar rot of *Bauhinia purpurea* by *R. solani*, leaf rust of *P. deltoides* (65/27 clone) by *Melampsora larici- populina*. Besides the above new diseases, three known rusts namely *Maravalia achroa, Ravenelia sessilis* and *R. elemensiae* were found highly damaging to seedlings of *Dalbergia sissoo*, *Albizia stipulata* and *A. procera* respectively Root knot nematodes ocurred commonlyy in nurseries and high nematode infestation on roots was recorded on *Pongamia pinnata, Olea glandulifera, O. europea, O. cuspidata* and *Paulownia fortunei*.

Study on the impact of the above diseases showed that damping-off *in H. integrifolia* accounted for 40% loss of seedlings whereas seedling blight by *S. rolfsii* caused 50-80% mortality and Phoma leaf spot damaged more than 50% of leaf tissues resulting in perceptible impairment in growth of plants. Rhizoctonia top flagging of *P. kesiya* wiped out 60-80% of the seedling stock whereas Rhizoctonia leaf web blight was particularly damaging to *Albzia lehhek, Melia azedarch* and *Asdiracta indica* causing 30-90% defoliation and rendering the plants unfit for planting in high humid areas. Though *Phytophthora* leaf blight was recorded on 8 hardwoods it was particularly damaging to *M. azedarach* and *H. integrifolia* causing 65-85% and 30% defoliation respectively. Ascochyta leaf blight of *B. ceiba* accounted for premature defoliation by 72%. Root and basal rot of *P. fortunei* caused 30% mortality of seedlings whereas it accounted for 40-95% death of saplings in experimental plots. Cylindrocladium seedling blight of *S. cumini* caused 83.3% defoliation and wiped out 63.5% of seedlings. Loss in biomass was estimated to be around 772% on comparison of Dithane M-45 + Bavistin treated seedlings with untreated surviving ones. Verticillium and Fusarium wilts resulted in 26% and 23% mortality in *M. indica* and *C. torulosa* respectively whereas Phompsis set rot of poplar resulted in 46% loss of cuttings and Rhizoctonia root and collar rot accounted for 68% loss of seedlings *of B. purpurea*. Maravalia leaf and twig rust of *D. sissoo* impaired considerably the growth of seedling besides causing 20% mortality whereas *R. sessilis* damaged the entire seedling stock of *A. stipulata* and mortality rose to more then 85% *and R. clemensiae* adversely affected plant growth due to heavy infection on foliage. Heavy infestation by root knot nematodes particularly in *P. forunei* and *Acacia catechu* had perceptible adverse impact on plant growth.

Majority of nursery diseases caused by soil borne pathogens were controlled by integrating cultural practices with fungicidal application in order to make disease management effective, economical and less hazardous. However, Cylindrocladium and *Phytophthora* blight, set rot, collar rot and rusts were effectively managed by fungicidal treatment alone. Application of coiled neem cake, an eco-friendly nematicide, not only reduced considerably root knot nematode infestation but also improved appreciably the growth of *P. fortunei* whereas moderate improvement in plant growth was recorded in *A.catechu* over control.

Alders Selection for Polluted Areas

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In the Europe only two alders, namely the European black alder (*Alnus glutinosa*) and speckled alder (*Alnus incana*) are of importance for reforestation purposes in strongly polluted areas by emissions from copper industry, where air contains not only many toxic fumes, primarily SO2 , but also large quantities of heavy metals Cu, Pb, and Zn are being accumulated in the soil.

Alders are fast growing trees, with nitrogen-fixing root nodules occurring on moist and bogy soil. Between black (Ag) and speckled alder (Ai) there are natural hybrids (Aixg). The result of investigations presented below concern of half-sib progenies collected from 3 provenances of Ag one half-sib family of Aixg and a random common seed sample of 5 trees Ai. The main purpose of the experiment established in a region under the influence of emission from a copper smelter, was to see whether those exist difference between black alder families in their growth reaction to the emission from the copper smelter, and also to see which is more resistant black alder or speckled alder which faster growing and less demanding on site conditions. Evaluation of hybrid progeny is lesser importance for the needs of recultivation in view of the rather rare occurrence of these hybrids in nature. However results obtained for this progeny may perhaps be of indicator value for the utility of artificial interspecies alder hybrids.

It is generally believed that well growing seedlings in the nursery have also a greater resistance to a polluted environment. During the nursery investigations it was decided to test what influence is exerted by covering of the beds wit a polyethylene plastic tent (PT) on the growth of individual progenies. The planting material was obtained in two stages: 1.) seed sowing in PT and tending the first year, 2.) Seedlings after overwintering was divided into two groups, one of which was still cultivated in PT in a single-tree-plot test designated and the second was planted in the open nursery (ON). Both groups received the same soil preparation. With two year seedling (1+1) was established an experiment in the region of emissions from a copper smelter.

RESULTS

1. Cultivation of black alder (1+1) in a PT permits the attainment of much larger seedlings then when after 1 year in PT the plants are kept for second year in ON.

2. For the needs of outplanting in the zone of emission from a copper smelter it is better to produce nursery material in the regime, 1 year under PT and 1 year in the ON.

3. Alders which in the nursery period have developed very large leaves suffer later much more than alders with small leaves when grown in the zone emissions from a copper smelter. Their leaves undergo substantial injuries and the main leader dies at first and later grows much slower than the small-leaved trees. However the best results are obtained with alders having leaves which do not differ substantially from average size in dimensions.

4. Ai has better growth increments in the conditions of the polluted environment than Ag or Aixg.

5. Progeny of natural hybrid Aixg growth better than the parental species in unpolluted environment but in the zone of emissions from a copper smelter they have poorer increments than both parental species.

6. It is possible to make the tentative conclusion that both black and speckled alders are useful

species for planting in the areas polluted by emissions from a copper smelter.

Review Advance in Integrated Control of Larch Sawfly in China

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The results of research about biological and ecological character of larch sawfly *Pristiphora erichsonii* (Hartig): Influence of elevation on the vertical distribution and ecological type, deferring to the even spatial distribution. Life table parameters of experimental population, rm=0.04914, Ro=9.9881, average generation period T=46.7924d. Influence of temperature to sawfly growth and development, the suitable temperature range is 7-24°. Needle stock and timber volume loss intensity of infected larch forest is 10.32-100.00% and 4.625-5.946m3/ha. The control technique is as follows: Control tactics, control threshold value, population dynamics and prediction model sawfly-resistance larch species, chemical control methods and the way of natural enemy utilization.

Keywords: *Pristiphora erichsonii*, larch sawfly, ecology, control.

Importance of Management of Tree Seed Pathogens for Sustainable Forestry

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Successful forest management has to be based on the complimentary principle: multiple use and sustained yield. Expansion of reforestation programmes, more silviculture and better forest protection are its chief components. Although foresters and forest pathologists have been aware of the seed health problems since past several decades, the increasing demand of seed of high quality and genetic potential for germplasm conservation and as reproductive material; development of new cultural systems such as container production and intensively managed nurseries, and the high cost of producing the quality seed and planting material, have made it imperative to manage them. Considerable savings can be accomplished by reducing fungal damages to seeds.

Yields of viable seeds can be increased, thereby increasing the seed: seedling efficiency, reducing the costs and extending the acreage of land to be seeded. Healthy nursery stock will increase the probability of successful reforestation and, will avoid economic losses resulting from the subsequent seedling mortality in the field. This however, requires a better understanding of the characteristics and behaviour of tree seed pathogens, more so for reducing the use of pesticides or replacing them by the biocontrol agents or improved silviculture. Tree Seeds are both suscept and vehicles of pathogens and may carry them as contaminants or infections. The pathogens include bacteria and viruses but predominantly the fungi. Several fungi have been reported on tree seeds world-wide; some even cause considerable reduction in seed germination, decay and loss of viability of seeds during storage, and diseases like damping-off wilt, blight and others of the seedlings in nurseries. Inoculation and establishment of infection of the host depend on conditions favouring pathogen's development, the pathogen that differs from one another in selection of the point of entry and the colonisation of seed, and the anatomy of seed which varies from one host plant genus or species to another. Tree seeds are exposed to many conditions during their collection, handling storage and germination which differ from those for the seeds of agricultural crops, and are conducive for fungal infection.

Management of the fungi therefore, requires integrated approach including timely seed collection from healthy sites, use of proper methods of collection, handling and storage of seeds including seed treatments with physical methods, chemicals and biocontrol agents. The paper is a synthesis of available information. It emphasizes the importance of characterization and management of tree seed pathogens and identifies the researchable issues for sustenance of reforestation programmes.

Disease Management in Eucalyptus Plantations for Solid Timber Production in Tasmania, Australia

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Both on an international and domestic level Australia has a strong commitment to the role of forestry in sustainable development. The forest industry in Australia is therefore increasingly applying more intensive silvicultural regimes to timber production, involving thinning in native forests and establishment of plantations. Of the approximately 200,000 ha of eucalypt plantations established in Australia to date, most are intended for production of pulpwood on short rotations of 15 to 20 years.

Between 1991 and 1996 in Tasmania more than 7000 ha of *Eucalyptus nitens* plantations were established for saw-log or veneer on rotations of 30-plus years. The Tasmanian Regional Forest Agreement signed in November 1997 by the Federal and State Governments has provided further funding for solid wood plantation development to compensate for losses of production forest to reserves. Under it, another 20 000 ha will be planted - with *E. globulus* as well as *E. nitens* - over 5 years.

The major eucalypt species grown in plantations retain rather than shed dead branches which results in severe wood quality problems. Trees develop large knotty cores that make them unsuitable for the production of sawn timber and veneer. The only way to counteract these problems is 'green pruning', the removal of live branches. To minimise the diameter of the knotty core, pruning begins early in a tree's life and must extend as high as possible to maximise the length of good quality log that can be recovered. The high cost of both pruning and thinning operations means the impact of fungal stem degrade or foliar pathogens could be very significant.

Research in Tasmania focuses on developing management strategies to avoid or reduce the impact of fungal pathogens. Surveys have been conducted to identify fungal pathogens present in newly established plantations. Special emphasis has been given to the identification of the different species of *Mycosphaerell*a (leaf blotch), scoring damage and assessing resistance levels.

Pruning of live, especially large diameter, branches carries a higher risk of establishing decay than the pruning of dead branches. Management strategies for controlling branch size and minimizing pruning associated decay are considered essential. Studies, in both *E. nitens* and *E. globulus*, are being carried out to investigate antimicrobial defence and understand factors influencing its effectiveness both in the short and long term. A wide range of parameters involved in xylem defence in both the initial and later stages of wounding and decay infection of *E. nitens* have been examined; water content at the decay interface with NMR imaging and gravimetric sampling techniques, constitutive and novel compounds in the reaction zone, free radicals and mineral concentration. *E. nitens* does not appear to show certain defence responses typical of many other angiosperms. Ongoing research is comparing antimicrobial defence in *E. nitens* and *E. globulus* and the role of kino formation in the latter species.

Population Trends of *Hyblaea puera* Cramer in a Large Teak Plantation at Nilambur, Kerala, India

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Population trends of the teak defoliator *Hyblaea puera* Cramer (Lepidoptera: Hyblaeidae) was studied by sampling in a 1000 ha teak plantation area at Nilambur in Kerala, India. In addition to three permanent study plots containing about 200 trees, moving plots were used to sample shifting populations. Sampling was done at weekly intervals almost continuously during a three-year study period.

The study showed that during each year, while only two to three generations of the insects appeared in each of the study plots, seven to nine generations appeared in the total study area. During the early part of the season, outbreaks were characterised by synchronous development of the insect, with the dominance of one instar throughout the developmental period. However, in the later part of the infestation period almost all stages were present in each of the populations sampled, but the population was small. This was followed by a period of six to seven months months when the population although present, was very small and almost undetectable, until the out-breaks appeared again next year, following the pre-monsoon rains between late February to late May. If there was a shift in the time of arrival of the pre-monsoon rains.

Diseases and Disorders of Bamboos in Asia

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Of the three major regions of bamboo distribution in the world, Asia is the largest with about 18 million ha of bamboo growing lands and having more than 800 species and varieties of bamboos belonging to 45 genera. However, economically important bamboos of Asian region belong to relatively few species of the genera, *Bambusa, Cephalostachyum, Dendrocalamus, Gigantochloa, Melocanna, Ochlandra, Phyllostachys, Schizostachyum* and *Thyrsostachys.* The productive potential of bamboo stands in most of the bamboo growing countries in Asia is affected by various biotic and abiotic factors including pests and diseases.

About 170 species of bamboos belonging to 26 genera in this region are found affected by various diseases and disorders. A total of 440 fungi 3 bacteria 2 viruses, a phytoplasma and a bacteria-like-organism have been reported from India, China, Japan, Thailand, Philippines, Bangladesh, Indonesia, Taiwan, Vietnam, Pakistan, Singapore, Sri Lanka and Malaysia as associated with various diseases and disorders of bamboos .Among the diseases only a few are identified as potentially serious one which affect the culm production as well as stand productivity. These include (i) culm blight caused by Sarocladium oryzae in village groves in Bangladesh and in coastal belts of Orissa State, India (ii) rot of emerging and growing culms of industrially important species in India caused by *Fusarium* spp. (iii) witches' broom incited by *Balansia* spp. in different species of bamboos in Japan, China, Taiwan and India (iv) little leaf of *Dendrocalamus strictus*, an economically important species in India, caused by a phytoplasma (v) culm mosaic caused by bamboo mosaic virus in Taiwan, (vi) culm rust caused by *Stereostratum corticioides* and (vii) top blight of *Phyllostachys* spp. caused by *Ceratosphaerea phyllostachydis* in China. From an economic point of view a disease impact assessment becomes difficult due to lack of sufficient quantitative data on disease damage and rate of spread of the disease.

Bamboo culm blight, culm rust, top blight and culm mosaic are spreading at a very fast pace in bamboo stands in the respective countries and occasional new outbreaks are common which affect the bamboo industry as well as the rural economy as a whole. Disease management measures practised against the diseases in the respective countries have relied mainly on silvicultural measures and to a lesser extent on chemical treatment. Etiology and epidemiology of most of these diseases are little investigated and often control measures adopted are proved inefficient.

Decay and biodeterioration of culms in storage is an important problem confronting the bamboo based industry in modern as well as traditional sectors in most of the countries in Asia. Natural durability of the bamboo culm is very low. A large number of decay and staining fungi have been recorded on bamboos under storage in different countries. The severity of the problem depends on duration of storage, bamboo species, environmental as well as storage conditions. Hence, appropriate storage techniques to minimise the hazards have to be developed. Although effective preservative chemicals and treatment techniques for bamboos are available, more emphasis should be given to develop low cost, locally available preservatives and economically viable as well as environment friendly treatment methods.

A concerted effort to study the potentially serious diseases of bamboos in this region and develop appropriate measures to check further spread of the disease in stands as well as safeguarding against the inadvertent introduction of disease in new areas in the region have to be made. Disease management strategies of both short-term as well as long-term measures including broadening the genetic base of bamboos, development and introduction of disease resistant species/provenances are suggested.

Biological Pesticides for Sustainable Management of Teak Pests

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Insect pests cause severe damage to forest plantations, and lead to considerable economic loss. Teak is one of the very important commercial timber species found in India. Of the various insect pests infesting teak plantations, teak defoliator, *Hyblaea puera*, teak leaf skeletinizer, *Eutectona mechaeralis* and teak trunk borer, *Cossus cadambae* are of major importance. Application of synthetic pesticides has resulted in ecotoxicity, insecticide resistance, pest resurgence and secondary pest out-breaks. Due to these and other concerns there is a need for effective biodegradable pesticides with greater selectivity. Neem, *Azadirachta indica* A.Juss-Meliaceae, is indigenous to India. Neem derivatives comprise a complex array of novel compounds with profound behavioural and physiological effects on insects such as repellence, phagodeterrence, growth distruption etc. Application of neem seed kernel extract (NSKE) mixed with nucleopolyhedro virus (NPV), *Bacillus thuringiensis* (Bt) and fungi, *Beauveria bassiana*, showed promising control measures of *H. puera*, *E. mechaeralis* and *C. cadambae* on five year old teak plantations. Higher population reduction and larval mortality were observed after application of NSKE and Bt toxins on teak plantations. Combination of NSKE, NPV and fungal extracts brought out larval deformities and reduced oviposition of moth in the field. Laboratory experiments also showed significant reduction in feeding and fecundity of the insects. Bioefficacy of plant compounds with potentiating effect on microbial pesticides in relation to practical field management of forest pests have been discussed.

Biodiversity of Ganoderma a Stem Rot Infection in Tamil Nadu South India

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Ganoderma lucidum and allied species are widely occurring polyporous white rot fungi causing the heart rot disease on many angiosperms and gymnosperms. Though these fungi generally cause only decay of dead wood and stumps and also attack aged and declining trees. Severe infection by these have been reported in a variety of trees like Tamarind, *Delonix, Acacia, Casuarina, Prosopis, Citrus*, Silk cotton, Oil palm, Mango, Coconut and teak in Tamil Nadu. Therefore a servey on the incidence of this disease was conducted in the hilly areas of Nilgiri, Anamalai hills and Kodaikanal as well as in the plain of the east coast of Tamil Nadu.. In general the incidence of this disease was more in the plains than in the hilly forest areas. While about 55% of all the diseased trees in and around Chennai have been infected by *G. lucidum*, only about 5-10% had severe infections in Kodaikanal and Nilgiri forests. However, the disease incidence was slightly higher at about 25% in the Anamalai hills. Detailed studies on the isolates of the fungus *G. lucidum* showed that this fungus produces macroscopical aerial basidiocarps and cause extensive delignification, dissolution and Š disintegration of cell walls of tamarind wood by the secretion of the lignolytic enzyme lignin peroxidase, laccase, carboxy methyl cellulase and xylanase were observed. Similarly among the different cell wall components of wood namely lignin, cellulose and hemicellulose, *G. lucidum* showed preferential utilization of lignin for growth. The basal stem rot of *Tamarindus indica* caused by *G. lucidum* is a serious problem in and around Chennai and other areas of Tamil Nadu. The biological control of *G. lucidum* was also studied under *in vivo* and *in vitro* conditions. The details on this study will be presented.

Ganoderma Diseases of Evergreen Forest Trees in Anamalai Hills South India

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An assessment of wood rot fungal infection in evergreen forest carried out periodically from July '97 to October, '98 in Anamalai hills, Western Ghats South India. *Ganoderma lucidum* and other species cause severe root rot and heart rot infection in many of the economically important tree species including *Mesua ferrea, Hopea parviflora, Vataria indica, Palaquium ellipticum, Amoora canarana, Aglaia rouxburghiana* and *Machilus macrantha* etc., Macroscopical survey made in one hactare of 448 trees by observing the disease indicators in Anaikunthi shola showed that 25.67% of trees were infected by *Ganoderma* species. An attempt made on biological control of *Ganoderma lucidum* in nurseries of forest tree species with *Trichoderma viride* and *T. harzianum,* were found to reduce the disease incidence.

Blister Bark of *Casuarina*

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Wilt or blister-bark is a seriuos disease affecting *Casuarina equisetifolia* (Butler, 1905; Narayanan & Sharma, 1996; Mohan, Narayanan & Sharma 1998) and *Casuarina hybrid* (*C. equisetifolia* x *C. junghuhniana* Miq) (Narayanan, Sasidharan & Sampathkumar, 1998). Blister-bark disease particularly affects monoplantations of *Casuarina* and has attained global quarantine significance as it has been recorded from India, Vietnam, Thailand, Mauritius and Ceylon (Narayanan et al., 1996; Narayanan, 1998). The paper discusses findings on epidemiology and management of blister-bark disease. Detailed symptomatological studies in blister-bark affected *Casuarina*s showed that, age of the trees and prevailing environmental factors of the sites, significantly influenced field symptom expression and disease severity. Further studies on various provenances of *C. equisetifolia* showed significant differences with reference to blister-bark disease incidence. Cell free culture filtrate of the pathogen, induced differential phytotoxicity in shoots of *Casuarina equisetifolia*, which can be utilized for preliminary in-vitro screening of numerous genotypes for further disease resistance breeding.

Spatial Distribution of *Lepidoptera* species in the Forest Stands in the Lugar Nuevo State Woodland (Jaén, Spain)

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In the Lugar Nuevo State woodland there are forest stands of *Pinus pinaster*, *P. pinea*, *Quercus ilex*, *Q. faginea*, *Q. suber* and *Arbustus unedo* mixed with *Quercus coccifera*. In each of these stands some plots are chosen, with the aim of collecting examples of Lepidoptera. When the examples are taxonomically identified, a study is carried out of their spatial distribution and behavior in relation to the vegetation species under consideration. 126 *Lepidoptera* species were detected, 34 of which can be considered as potential pests. The highest biodiversity was found in the stand of *A. unedo* mixed with *Q. coccifera*, followed by the *Q. ilex, Q. faginea, Q. suber, P. pinaster* and *P. pinea* stands.

Natural Enemies and Biological Control of Elm Leaf Beetle in Tehran, Iran

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Elm Leaf Beetle (ELB) is the most important pest of elm trees in Tehran and other big cities of Iran. Larvae of this pest cause the main damage by feeding on the leaves of elm trees and skeletonizing them. Investigation for potential natural enemies of this pest was carried out from 1993, and several species of arthropod predators and parasitoids were identified in Tehran. These species include Mantis, Ladybirds, Wasps and Spiders, but the main natural enemies were two species Wasps and one Ladybird as follow: * *Tetrastichus gallerucae* (Fonscolmbe) (Hym. Eulophidae) is an egg parasitoid of ELB and the percentage of its parasitism was 25-45% in different times and places of the city. *T. brevistigma* Gaham (Hym. *Eulophidae*) is larval-pupa parasitoid of ELB. This wasp cased 18-25% parasitation. These two species of wasps were reared in laboratory condition, LD 14:10, 25+_1 Degree C. and RH 65+_5% . Under this condition a single generation of the *T. gallerucae* and *T. brevistigma* were completed in 14-18 days and 13-15 days respectively. *Oenopia conglbata* L. (Col. *Coccinellidae*) is predator of ELB. Both larva and adult of this ladybird feed on eggs and first stage larvae of ELB.

Shoot Borer: *Hypsipyla robusta* Moore (*Lepidoptera; Pyralidae*) Damage to Growth and Survival of Native *Meliaceae* (African Mahogany)

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African mahogany namely *Khaya, Entandrophragma, Guarea* and *Lovoa* species (meliaceae) are considered among the most valuable Tropical timbers worldwide. These species are found naturally throughout the Wet semi-deciduous and Dry forest zones of West and Central Africa Timber trade in Ghana began in the last quarter of the nineteenth century and was initially focused on the mahoganies. Currently, timber from the native mahogany is earning approximately 12% of total timber exports. The percentage stocking of the mahoganies in the forest, using forest inventory data is reported to be 2.6%. The domestic and international markets depend heavily on these species. This has led to excessive exploitation of these species in the natural forest. It is observed that the annual over-exploitation of the mahogany species is approximately 53% and most of the species in the meliaceae family are predicted to go commercial extinction by the year 2004. Continuous over-exploitation has prompted a proposal to list all mahoganies on Cites appendix II. As a result its exploitation will require a permit from the Forestry Department. However legal restrictions and/or depletion of the Reserves will further restrict supply and export revenue. The Government of Ghana in response to the dwindling resource of the mahogan put in place measures to guarantee their sustainable production in the natural forest. The measures include establishment of the mealiaceae in plantations and the reduction in yield allocated to contractors for felling in the natural forest. Most of the plantations that were established failed due to shoot borer *Hypsipyla robusta* Moore attack. *Hypsipyla* has been recorded on Khaya species, Entandrophragma species, Carapa species, *Lovoa* species indigenous to Africa and *Swietenia macrophyla* exotic mahogany, in West Africa.

Recent reviews on the mahogany pest problem emphasize an integrated pest management strategy based on the incorperation of pest tolerant planting stock in silvicultural systems which encourages natural biological control. The search is on for sociologically and economically acceptable, sustainable and environmentally safe integrated pest management (IPM) strategies for these major timber species (African mahogany).

The principal damage consists of borers feeding on and killing the apical shoot. The *Hypsipyla* attack reduces vigour and repeated attack on the leading shoot causes stunted growth. The excessive branching as a result of the death of the death of the terminal shoot affects the quality and quantity of wood that can be recovered. Thus reducing the commercial value of the timber.

There seems to be regional differences in the life cycle of *Hypsipyla*. While four larval instars were recorded in Nigeria, five or six larval instars have been recorded in Ghana. Regional differences in life cycle and probably in the host plant preferences on the species of hypsipyla has prompted the need for intensive local biological investigation which can be incorporated into IPM of *Hypsipyla* in a Coordinated Action Network.

The different species of *Meliaceae* have different mechanisms and different levels of tolerance to *Hypsipyla* attack. A study to identify the extend of seedling growth following *Hypsipyla* attack in three African mahogany species is currently going on at the Forestry Research Institute of Ghana. This study aims at identifying plant characteristics associated to tolerance which will help formulate appropriate IPM strategies for control of the pest of the mahogany.

Tree Defoliation as the Environment Quality Assessment

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It has been clarified that not only different damage agents (fungi, insects, wildlife, snow, wind, etc.) but biological factors (species, crown form, branching habit, tree age, social class, soil humidity, etc.) also determine crown defoliation. For example, defoliation of narrow-crowned trees is slightly more significant than that of wide-crowned trees (28.8±0.6 and 22.2±0.8%, respectively). In comparison to crown defoliation of trees Norway spruce of comb branching (32.7±2.7) or plate (30.5±1.6%) type, that of trees of irregular comb (22.5±0.7%) or brush (23.8±0.5%) branching type is less. Crown defoliation of younger trees is less as compared to that of older trees (up to the age of 20 years crown defoliation of conifers is only 11.1±1.0% and that of trees older than 80 years - 27.3±0.5%). Trees of Kraft class III and IV were defoliated considerably more than these of Kraft class I-II (crown defoliation of conifers of Kraft class I-IV is 21.0±0.8, 23.4±0.3, 27.9±0.6, and 28.4±3.3% respectively). Crown defoliation of trees growing on sites of normal humidity (N) and swamps (P) (in case the index of their fertility is identical) is more significant than that of trees growing on wet sites (U) or these of temporary surplus of moisture (L) (for instance, defoliation of spruces on sites "c" in hydrotopes N and P is 11.2±0.2 and 39.8±3.5%, respectively, while that in hydrotopes L and U is 8.7±0.2 and 6.2±0.9%, respectively. Consequently, it is necessary to standardise data on crown defoliation for assessing the ecological situation (quality of environment) in different districts of the Republic. The standardising of the data has been performed according to defoliation of the upper part of a crown. Trees of Kraft class I and II without visual indication of damage have been selected.

It has been determined that in a certain hydrotope the correlation between age (A) of a tree and defoliation (DF1.3) is best described by the equation DF1.3=aAb. For instance, for pine in hydrotope N DF1.3=10.35 A0.294 (R2=0.88), for spruce in hydrotope L DF1.3=4.51 A0.572 (R2=0.73).

Since crown defoliation depends upon the hydrotope and age while site fertility does not essentially influence it. Crown defoliation of pine in hydrotope N equals 1.0. The coefficients of standardisation have been calculated in other hydrotopes (DFst.=KDF1.3, here Dfst. is standardised defoliation, K - the coefficient of standardisation).

By applying such data the quality of the environment in different administrative districts of the Republic has been assessed. Environmental quality was evaluated as the best in the districts where air pollution is the lowest.

The Forest Damage Documentation and Information System of the Federal Forest Research Centre

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- An Introduction and First Experiences

In 1996 the Institute of Forest Protection started to elaborate a comprehensive Forest damage documentation system for pests and diseases occurring in Austrian forests. The basis data therefore are written expert opinions, which date back up to more than 40 years. The reasons therefor were the preservation of scientific knowledge, support of a comprehensive database, and a more comfortable elaboration of damage diagnosis. The damage documentation and information system consists of two major parts:

- the database: containing a great number of information of the samples send in and about the symptoms found. At the beginning it has been configured as a relational Filemaker database. Now it is transformed into an Oracle-database. The goals were a facilitated data input and improved possibilities for requests as well as the compatibility to the internet.

- The photo documentation: consisting of a large slide database with more then 10.000 slides and an analogue Video documentation system which allows to take images as well as video sequences even at high magnifications. The photo documentation system allows joint analytical and diagnostical work of several scientists as well as the visual documentation of pests/diseases and damage during the analystic and diagnostic work.

Perspectives: In the next future the parts of database will be opened for public use in the Internet. The main goals of the performance in the world wide web are;

- providing a helpful knowledge in form of this database for authorities and private clients and
- the possibility of independent input of environmental and stand data by authorities and other clients.

Study of Performance of Different Attractants for *Ips typographus* (L.)

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In studies regarding pest control the different pheromones for Ips typographus which are commercially available showed very different catching performance. In the course of these tests, beetles were taken from 4 different pheromone agents (Pheroprax, Ipsowit, Pheroplates, and Etokap IT) and used for further investigations in addition to the electrophoresis. In laboratory reproductive tests in sprucelogs, their fertility and fecundity was assessed. Those of the beetles that were analysed by electrophoresis were submitted to a detailed dissection the data of which were also evaluated.

Considering all investigated factors and parameters, there is a basis for the assumption that different pheromones (pheromone formulations) do not only cause different catch quotas but also catch different beetles. A pheromone which is less effective (such as Etokap IT, which was then available on the market) does not only have significantly lower catch quotas; also the reproduction rate in the above-described reproductive tests in spruce and the electrophoretic splitting of isoenzymes distinguish this substance (more or less clearly) from the other products. On the other hand, it was not surprising that the difference between Pheroprax and Ipsowit is minor taking into consideration that, according to informations during a later phase of this project, they differ chemically only by a different degree of purity of the applied substances.

Insect Factors Effecting Seedling Establishment in Second Rotation *Pinus radiata* Forests in New Zealand

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Keywords: *Hylastes ater*; *Pinus radiata*; mortality; sub-lethal attack; sapstain fungi

Background

Hylastes ater (*Coleoptera: Scolytidae*) is a European bark beetle that was first recorded in New Zealand in 1929. It is now well established in all exotic pine plantations. *H. ater* breeds in stumps, roots and logs of *Pinus* spp. The adults attack and can kill young pine seedlings. Despite initial concerns, *H. ater* has been disregarded as a pest in New Zealand until recently. However, unpublished surveys indicate that attacks on *P. radiata* seedlings by *H. ater* are common in second rotation forests.

Objectives

The main objectives of this study were to evaluate the extent of *H. ater* attack and mortality in second rotation *P. radiata* forests and to investigate the effects of sub-lethal feeding on seedlings.

Methods

Sites were chosen to cover a variety of site types and logging histories. One hundred seedlings were sampled along a randomly located transect in each site. Every dead seedling encountered was removed and examined for evidence of *H. ater* attack. In addition, every fifth seedling encountered was removed from the soil and examined. Evidence and severity of *H. ater* attack was recorded as follows, no evidence, evidence of attack, moderate attack and severe attack.

Results and Discussion

Attack by *Hylastes ater* is the dominant cause of seedling mortality in the first year of establishment in second rotation *Pinus radiata* forests. *H. ater* emerges from stumps and attacks surrounding plantings during maturation feeding. Seedling mortality is usually less than 20%, although mortality may reach 50%. Mortality differs with site and is strongly correlated with logging history. Those seedlings planted in sites soon after logging are most at risk from *H. ater* mortality.

Of serious concern is the amount of sub-lethal attacks by *H. ater* seedlings. While mortality may be considered low, the extent of sub-lethal feeding attack is much higher. Two thirds of one-year old plantings showed evidence of 60-90% sub-lethal attack by *H. ater*. The proportion and severity of sub-lethal attack differs between sites and shows a strong relationship to logging history. Sites with the greatest proportion and most severe sub-lethal attacks are those planted soon after harvesting.

While sub-lethal feeding does not effect seedlings growth in the first two years of planting, longer-term effects of sub-lethal attack are not known. The seedlings in this study were examined to determine whether a relationship between *H. ater* attack and the presence of sapstain fungi existed. Preliminary results indicate a highly significant relationship between severe sub-lethal *H. ater* attack and the presence of sapstain fungi.

Integrated Pest Management Approaches in Forest Nurseries: Alternatives to Methyl Bromide

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Afforestation represents a major environmental effort around the world. High quality seedlings supply is a critical issue in the recultivation process. Pests have a negative impact in seedling health in forest nurseries. Among them *Fusarium* diseases cause the main losses in *Eucalyptus* spp. and *Pinus* spp. nurseries. Disease incidence being generally considered to be related to the high population levels of the *Fusarium* species. Methyl bromide is still an important control measure available in forest nurseries in Argentina. Environmental concerns on the use of this chemical continously encourages the development of alternative methods. Integrated pest management (IPM) programmes are powerful and effective tools. As a first step in order to develop an IPM program, suitable IPM approaches were considered for the management of *Fusarium* diseases. Field trials were carried out in order to (i) monitor the *Fusarium* population in the nursery field soils for predicting the expected damage to forest seedlings, (ii) evaluate the effect of soil solarization to decrease the population levels of *Fusarium* species and (iii) compare the effects of solarization with the use of methyl bromide, dazomet and fungicides. These studies have shown that nursery field soils in Argentina have few *Fusarium* taxa. Cultural practices such as the incorporation of organic matter amendments increased the diversity of *Fusarium* species as well as the population levels. Solarization effectively reduced the *Fusarium* population levels and this behaviour was related to deceased incidence. Solarization treatment was as effective as the methyl bromide treatment while dazomet was less effective. The use of fungicides decreased the population levels of *Fusarium* species only partially. In conclusion solarization represents an alternative method for the control of *Fusarium* diseases in forest nurseries preventing the risks of the methyl bromide use. Moreover, this treatments should be combined with appropriate cultural practices avoiding the addition of potential pathogens that might increase disease incidence.

Variation in Resistance of *Casuarina* Provenances to the Stem Borer, *Indarbela Quadrinatata* Walker (*Lepidoptera: Metarbelidae*)

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Casuarina equisetifolia is an important tree species used for coastal afforestation in India. It was introduced to the country in nineteenth century.

Because it is a growing short rotation tree, having multiple utility from fuelwood to poles for construction, *C. equisetifolia* has been the farmer's favorite species. Since it is compatible with many agriculture crops, the farmers in Southern India grows, *C. equisetifolia* under agroforestry system, especially in the coastal areas.

Though *C. equisetifolia* is almost free from major pests in its places of origin, it is encountered with many severe problems in countries where the species has been introduced. In India there are about 56 species of insects reported to feed on live Casaurina, among which the stem borers are very serious. The bark feeding borer, Indarbela quadrinotata attacks *C. equisetifolia* plants above two years age. The larva remains inside the borer hole made on the main stem or branches during day time and comes out during night time for feeding on the bark. The borer holes made on the stem not only obstruct the condition of nutrients and foot materials, but also invite invasion of pathogens into the attacked trees, ultimately resulting in die-back. The problem of the stem borer has been very severe in the semi-arid Casaurina growing tracts of the east coast, especially in Tamil Nadu.

In order to find out provenance's resistant to the stem borer, studies were conducted in an International Provenance Trial of *C. equisetifolia* laid out in 1992, at Neyveli area of Tamil Nadu State. The trial contains plants raise from twenty provenance's, in Queensland, Egypt, Kenya, Vietnam, Malaysia and India and a local seed source (control).

The study shows that among the 21 seed sources, one provenance, Kilifi is completely resistant to the borer and another provenance, Watamu is highly resistant. The four provenance's rated as resistant are: Ela Beach, Kenyatta Beach, Pantai Dalit and Tanjung Aru. Eight provenance's viz. Bako Borneo, Pantai Moyog, Darwin *Casuarina*, Montazah Alexandria, Nine Chu, Phl., Wangetti Beach and Non Nuoc are susceptible and seven provenance's, Mamorah Alexandria, Chadipur/Balasore, Peempur/Kujaug, Haingara/Balukhand, Local, Mariana Island and Cua longhi Loc are highly susceptible.

Beta-1,3 Glucanases Confer Resistance to European Chestnut against *Phytophtora cinnamomi*

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European chestnut orchards were drastically reduced as a result of ink disease, caused by *Phytophtora cinnamomi*. All over the world, problems of ink disease were mainly solved by establishement of *C.sativa* x *C.crenata* orchards. This expected good solution now being confronted with problems due to the high susceptibility of these hybrid clones to virus diseases and to the production of fruits and wood with lower quality.

It is urgent to find new approaches to minimise world chestnut disease problems. In an attempt to create new alternatives, for chestnut improvement, a program for molecular identification of selected clones was established. This program aims the correct discrimination between *C. sativa* and hybrids and between resistant and susceptible clones. These resistant clones were obtained following a breeding program, started in the forties, and have been shown, until now, resistance to ink disease after inoculation tests with *P. cinnamomi*.

The analysis by RAPD enabled the molecular separation between *C. sativa* and *C.sativa* x *C.crenata* hybrids, and proved to be adequate for the molecular characterisation of the ink disease resistant clones.

Sequencing of the ITS regions was also performed, in order to compare the results with those obtained by RAPD analysis and to establish molecular tools which can be used for the large-scale screening of genetic diversity of *Castanea* populations.

It is commonly accepted that resistance against fungi can be the result of expression of ß-1,3 glucanase and chitinase genes. Following the studies on resistant chestnuts, it was verified that they present much higher levels of ß-1,3 glucanases in leaves than the susceptible *C. sativa* clones. These levels are comparable or even higher (in some cases) to those observed for mycorrhizal plant leaves. Otherwise, the leaves from mycorrhizal plants present much higher ß-1,3 glucanases activities than those from non-mycorrhizal plants. These results have been cross-linked with those from studies on resistance to *Phytophthora* of susceptible plants mycorrhized with different mycorrhizal fungi. The results obtained revealed that susceptibility of chestnut plants is reduced at least by 40%, depending on the mycorrhizal fungi species used.

Insect Outbreaks in North West of Russia

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Forestry is a major economic sector in north-western Russia, including Murmansk and Arkhangelsk districts, Komi Republic, and northern part of Karelia Republic. Forest pests were generally considered to have low importance in these regions. However, comparison with respective areas of Finland and Sweden, for which the information on pest outbreaks is readily available, suggests that damage from pests and pathogens may well affect economy of Northern regions.

The information on forest damage was classified in the former USSR, and there was a common tendency not to report any loss or damage. Therefore we assumed that the official data of the Russian Federal Forest Service are unrealistic, and should be used with discretion.

The goals of our study were (1) to locate primary information on forest pests and pathogens, which is generally stored in archives of local forest enterprises and forest protection organizations, (2) to evaluate its reliability by cross- check of different sources, including interview of local people, (3) to summarize the reliable data in a form suitable for statistical analysis, and (4) to reveal spatial and temporal patterns which may be related to environmental changes during the past decades.

By searching over 1,000 sources and interweaving of ca xx forest pathologists in the region under study, we discovered an information on outbreaks of 38 insect species between 1950 and 1998. The total area of the outbreaks during this period was about 1 mln ha. Total losses of timber or other forest products (for instants seeds) for the same period were about 18,5 mln USD. Since a number of outbreaks had surely not been recorded (or reported) for this sparsely populated territory, we believe that forests in >2 mln ha was damaged during insect outbreaks, resulting in losses of >20 mln USD. We concluded that forest pests have caused much more problems in northern forests of Russian part of the Europe than it was yet believed.

We detected an increase in frequency and severity of outbreaks between 1955 and 1998, and proved that this increase was not due to changes in intensity or quality of forest health monitoring. We suggest that this pattern may have resulted from either industrial development of the region (due to increases in pollution etc.) or climate change.

The Loss of Pine Stand Stability in the Northwest of Russia

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The loss of pine stands stability in the National Park "Sebezhskij" (Pskov region) is a particular example of the great problem of pine stands degradation in the series of regions in the Northwest Russia.

The National Park was organised some years ago on the territory of the industrial (intensive) forestry. Mature and maturing pine stands prevail in the National Park now. The part of the stands were tapping for 10-15 years ago. The great disturbances of tapping rules have been placed at that time.

The expansion of disease caused *Heterobasidion annosum* (Fr.) Bref. in pine stands produces a large amount of declining trees which infect by pine shoot beetles.

Some years ago there happened unfavourable weather conditions (drought and snow-fall). They caused snowbreak in young-growth stands. As a result pine shoot beetles (*Blastophagus piniperda* L. and *Blastophagus minor* Hart.) outbreak took place there. This species are the most aggressive ones for pine stands in this region. Numbers of another aggressive pests, such as *Ips acuminatus* Gyll. and *Pissodes pini* L., is not significant. *Tetropium* spp. are typical for declining trees. As a result, pine shoot beetles outbreak expanded in the surrounding woods (tapped and virgin ones). The pest outbreak developed at the background of *Heterobasidion annosum* (Fr.) Bref. infection. The disease caused by fungus *Peridermium pini* is also widely spread.

The pine shoot beetles harmful activity, which lasted for some years, caused the loss of pine stands stability in the National Park. The data obtained showed that the average health category of the stands is now about 2-3 (by the six-number scale that is usual in Russia for describing pathology conditions of individual trees or whole stands). In other words, the stands, investigated are "depressed" and "high grade depressed". It is necessary to carry out the clear sanitary felling in the woods, which have a great portion of died trees (16-53%), because the selective cutting leads to the formation of sparse stands. Besides, the selective cutting changes the light regimen and the next outbreak of pine shoot beetles will be provoked. It is necessary to leave the seed trees, but the harmful activity of pests leads to the decrease of their seed productivity. The combination of the fungi *H. annosum* and pine shoot beetles creates the great hazard of a new pests outbreak in the future.

It is very useful to realise the long-term pathology monitoring for prognostication of the convertibility of pathological processes in the injured stands. The regeneration of the lost pine stands requires to develop special forestry measures and new recreation regimen. Though, the expansion of disease caused by *H. annosum* in pine stands doesn't make it possible to look forward to full regeneration. Probably birch stands will replace lost pine stands.

Pro-ecological model of forest ecosystems protection in Poland

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The need of a new model of managed forest protection, based on ecological principles, raised recently due to the condition of forests in Poland, existing threats as well as society's expectations.

Forests in Poland cover the area of 8800 thousands of hectares, what makes the country forestage of about 28%. Stands are characterized by the simplified age and species structure (with the domination of coniferous – 77,3%, mainly Scots pine – about 70% of total forested area) as well as severe endangerment of biotic, abiotic and anthropogenic stressing factors.

The most important threats are insect pests and pathogenic fungi. It was demonstrated in the period of 1970-1998 by the mass occurrence of over 60 species of pests, among which 46 were controlled on the area of about 9 million of hectares. In 1982 the nun moth (*Lymantria monacha* L.), most danger species of pine and spruce stands was chemically treated on the area of 2,3 million of hectares. Additionally, forests in Poland on over 1 million of hectares are potentially threaten by the pathogenic fungi, mostly *Heterobasidion annosum* root rot. The damages associated with the occurrence of all kinds of fungi caused infectious diseases are reported on the area of 0,55 million of hectares each year.

Intense management practices that had been applied in the forestry since the second half of the 19th century have essential impact on the health condition and sustainability of forests in the present. This is the reason of forest ecosystem transformation from natural communities towards the artificial, plantation-like forms with the timber production as a most important goal of cultivation. As a result, the lasting changes of the soil properties, site degradation as well as simplification of species composition and age structure had occurred. The plantations of low biological variability and decreased sustainability replaced the natural forests, adjusted to the site and local climate condition.

The health status of forests in Poland is also determined by such factors like country geographic location in the zone of interaction of two major climate types in Europe: continental and Atlantic or fragmentation of forest site types resulted from the influences of 3 glacial ages. In addition, industrial air, soil and water pollution, radioactive contamination and global climate change affect the forest condition. That is why it is so important to limit the destructive impacts on forest ecosystems and to increase their biological resilience and stability.

Pro-ecological model of forest resources protection is based, first of all, on prevention. It may be expressed by the holistic approach towards the forest management manifested by the merged forest sylviculture, protection and exploitation practices to minimize harmful human impacts on natural processes.

The basic features and goals of pro-ecological forest ecosystem protection may be listed as follows:

Complex approach towards the forest ecosystem protection.

Spreading protection on large spatial units such as ecosystems, physiocenosis or mezzo-regions and on all living natural resources.

Early detection and recognition of potential threats and their limitation by the application of the biological, bio-technical and hylo-technical methods of forest protection.

application of methods and technologies safe to the environment

evaluation of the forest ecosystem disturbances by use of biological indicators such as average specimen biomass of *Carabidae*, primary insect outbreak sites or coefficients of phytopathological monitoring

The fundamentals of the pro-ecological model of forest protection are sustainability and multi-function forest management, what oblique foresters to comply such rules as follows:

Protection and extend of diversity of forest ecosystems by preservation of most valuable stands and endangered species of fauna and flora

Preservation of vitality and health condition of forest ecosystems by preference of silvicultural an protection treatments encouraging forest sustainability (promotion of genetic and species diversity, native and resistant ecotypes, species-site concordance etc.)

Turning back the degraded forest elements to its primeval state and protection of their further existence in the forest environment in spite of anthropopressure and threats.

Plant Derivatives from Oil Yielding Forest Species: Their Utility in Pest Control

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In recent years environmental pollution has been increasing at an alarming rate due to indiscriminate use of synthetic pesticides. High levels of pesticidal residue in foodstuffs which is neither within permissible limits nor conforms to international standards, have directed studies towards use of environmentally safe, biodegradable phytochemicals. Oil seeds are a major source of biologically active compounds. There are about 93 such species available in India. These, however, remain badly under-utilised, only 7% of the total potential being tapped. In the present study, the bio-efficacy of natural products from non edible oil yielding seeds of some forest species viz. *Azadirachta indica, Jatropha curcas, Madhuca indica* and *Pongamia pinnata* have been studied for assessing their potential against some key insect pests of tropical forests.

Terpenoidal fractions isolated from *A.indica* kernels were screened for their feeding deterrancy against 3rd instar larvae of *Ailanthus excelsa* webworm, *Atteva fabriciella*, at different concentrations. Chloroform and aqueous isolates exhibited promising feeding deterrancy of 37.4% even at a low concentration of 0.03%. Five chromatographic fractions (FA-FE) and phorbol derivatives from *J.curcas* were screened in the laboratory and field against 3rd instar larvae of *Hyblaea puera* (teak defoliator), *Eutectona machaeralis* (teak skeletoniser) and *Plecoptera reflexa* (sissoo defoliator). Seed oil constituents showed significant deterrancy which varied between 43.37-100% at concentrations from 0.01-2%. Two component fractions FD and FE showed larvicidal activity (76.66-100% mortality) at the tested concentrations. Phorbol derivatives showed 60-80% antifeedancy at 1-5% under field conditons. Test solution of 1% concentration showed 100% feeding inhibition on seed insects of Bambusa arundinaceae and *Acacia nilotica*. Seeds from *M .indica* were collected from ten different localities and their bio active saponin glycosides estimated gravimetrically, giving a yield of 3.4 to 10%. Their biological activities were evaluated against insect pests of *Tectona grandis, Dalbergia sissoo, Dendrocalamus strictus* and phytonematodes *Meloidogyne incognita* and *Rotylenchus reniformis*. Emulsifiable concentrates of these concentrates showed antifeedancy in the range 20-80%, insecticidal (100% mortality at 1% concentration) and nematicidal properties (17.65-100% at 0.01 to 1% concentration) under laboratory conditions. Karanjin, 3-methoxyflavone-7,8-furan, separated from seed oil of *P.pinnata* was tested against teak defoliator *Hyblaea puera* and *Dalbergia sissoo* defoliator, *Plecoptera reflexa*. It was found to be effective in affording leaf protection against larvae, over the control. 1% and 2% concentration provided a leaf area protection of 67.5 and 92%. The e/g masses of phytonematode, *Meloidogyne incognita* treated with different dilutions of karanjin (2%, 1%, 0.5% and 0.1%) exhibited promising effects on larval emergence and mortality, 85.54%, 64.5%, 55.86% and 45.44% as compared with the control. Thus it may be postulated that the pesticidal potential of these oil constituents, which is technically and economically feasible, but still under utilised can be exploited for the preparation of eco-friendly protection chemicals.

Cono- and Spermatophagous Insects of Norway Spruce *Picea abies*/L./Karst.

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In Poland, Norway spruce *Picea abies* /L./Karst. is an important forest tree species in the mountains. Cono- and spermatophagous insects of *P. abies* have been studied in Poland for almost 25 years. The objectives of these studies were:
/l/ to evaluate qualitatively and quantitatively, the cono- and spermatophagous insects of *P. abies*;
/2/ to assess the impact of these insect species on seed production, and
/3/ to identify the parasitoids of these pests.

As a result of these studies, the following conophagous insects were obtained:

Cydia strobilella L./Lep., Tortricidae, *Dioryctria abietella*/ Den. et Schiff./Lep., Pyralidae, *Eupithecia pini* Retz. Lep., Geometridae, *Kaltenbachiola strobi*/Winn./Dipt., Cecidomyiidae, *Strobilomyia anthracina*/Czerny/Dipt., Anthomyiidae/ and two spermatophagous insects *Megastigmus strobilobius* /Ratz./Hym., Torymidae/

and *Plemeliella abietina* Seitn. /Dipt., Cecidomyiidae/. The major pest, *C. strobilella*, destroyed 20-96% /average 25.4%/ of the Norway spruce seeds. *P. abietina* infested 2-13% /av. 8%/ seeds, while attacks by *M. strobilobius* were rare. Losses to other insects were less than 2%.

During investigations parasitoids of these insects were noted. Hymenopterous parasitoids of *C. strobilella* included: *Elachertus .geniculatus* /Hart./, *E. nigritulus* /Zett./, *Tetrastichus strobilanae* /Ratz.//Eulophidae/, *Liotryphon strobilella* L., *Nemeritis transf* /Grav./, *Scambus calobatus* /Grav.//Ichneumonidae/. Parasitism reached almost 60% with 35% caused by *L. strobilellae*. These parasitoids should be evaluated as biological control for *C. strobilella*.

I. typographus f. *japonicus* Niijima (Col., Scolytidae): A Genetic Analysis by Allozymes and Mitochondrial Sequence Data

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Ips japonicus was first described by Niijima (1909) on Yezo spruce, *Picea jezoensis* and Sachalin spruce, *Picea glehnii* in Japan. Kono & Tamanuki (1939) described *I. japonicus* as a form *of I. typographus*, *I. typographus* f. *japonicus*. Wood (1992) stated that even the status as subspecies is doubtful. However, studies of associated antagonists like mites and like the associated blue stain fungi revealed differences between the *European I. typographus* and the Japanese *I. typographus f. japonicus*. This study was designed to analyse the phylogenetic relationship of *I. typographus f. japonicus* in relation to other European Ips species, particularly *Ips typographus*.

I. typographus f. japonicus was collected from Hokkaido (Japan) and Changbai County (China), infesting *P. jezoensis*. Two regions of the mitochondrial genome and several isozyme loci were screened. A nucleotide divergence of 1.71% estimated by the gamma distance following the Tamura & Nei (1993) model was detected. All the substitutional sites were on the third codon position and transitions, thus not changing the amino acids. Further a species specific non coding region between COI and tRNA-LEU showed no difference between *I. typographus* and *I. typographus f. japonicus*. The European *I. typographus* populations, and the two Asiatic populations formed two significant monophyletic clusters.

Ecosystem Management of Forests In Russia: Strategy Of Forest Protection

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The analysis of interaction humans-forest ecosystems in Russia over of the 20th century does not reveal an essential evolution of forest protection strategy. Its development has not left frameworks of improvement of fire fighting measures and of controlling pests and diseases. We can state that - in force of diverse reasons - an inertia of political, instead of ecological priorities continues to exist in forest policy as concerns forest fires, outbreaks of insects pest and forest diseases, and their consequences for forest ecosystems, when justifying and developing active measures. The fire protection of forests and the control of pests and diseases are traditionally considered as a subsystem of forest management that should carry out organisational, sanitary and active (destroying) measures in order to protect forests and other forest economic objects from harmful organisms and negative man-made and natural influences and thus to maintain and increase the efficiency of forest biogeocoenoses. So, the definition of this subsystem highlights its understanding as a service of emergency reply on already happened events in forest ecosystems. Continuing of such understanding of forest protection leads to preserving paradigm (that became obsolete) of interrelations between humans and with forest ecosystems as antagonistic: all that deprives humans to use forest resources, first of all, wood, refers to as negative factors (fires, outbreaks of insects, diseases, etc.). This stereotype in public consciousness has proved to be tenacious enough in life and its conception at each new generation successfully begins in schools and universities, then proceeds through professional dialogue, textbooks, normative documentation and mass media. A dismal view of forest fires and burnt, nidi of outbreaks of forest insects and diseases of damaged leaves, branches, wood, etc. firmly secures this stereotype.

The transition to the ecosystem-minded forest management in Russia demands a differentiated approach to economic and ecological assessments of role and functions of forest fires, pests and diseases in various landscapes' elements.

The strategy of forest protection for an ecosystem-minded forest management demands to recognise that the laws of Nature have priority over those of economic development. The humans should be considered within the framework of forest ecosystems, and not as their supreme manager.

The said strategy proceeds from principles of adaptational ecology and adaptational management, that predetermines differentiated approach to organisation of the inventory and planning works, forest protection, use, restoration and forest area arrangement. It means that there is necessity to restructure enterprises and institutions, delimiting different patterns of ownership for various specialised kinds of activity, reducing at the same time the number of forest management units and increasing their equipment.

Recently Appeared Fungal Diseases on Forest Trees in Hungary

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In Hungary situated in the Carpathian-basin, Central Europe, the rate of forest covered areas amount to 18%. The Hungarian forests are dominated by stands of broad-leaved tree species: oaks *(Quercus cerris, Q. petraea, Q. robur*), black locust (*Robinia pseudoacacia*), beech (*Fagus sylvatica*), poplars (*Populus* x *euramericana, P. alba, P. canescens*). Conifers are represented mostly by Scots and Austrian pine (*Pinus silvestris* and *P. nigra*). During the 1990s the appearance of some dangerous diseases, new for Hungary have been observed on most frequent cultivated forest tree species. Since the ratio of forests and the assortment of tree species are limited by climatic and topographical conditions, these diseases caused by fungi have a major significance for the forest practice in Hungary.

On *Quercus cerris*, especially in young stands of thinning age an abnormal swelling and cancer deformation of the collar region of the trees is frequent. The bark becomes abnormally thick, cracked and decays on some portions of the stem circumference. In the bark cracking the black stromata of the *Ascomycete Botryosphaeria stewensii* can be seen. At first the pycnidia develop that produce one celled and hyaline conidia becoming dark and two celled after their evacuation from the pycnidial cavities. The other factors can occasionally contribute to the disease syndrome, especially the frost and the attack of honey fungus (*Armillaria* species, most frequent *A. gallica*).

On *Robinia pseudoacacia* some bark canker and necrotic diseases have been recently investigated. In the summer 1998 the total death of the above ground parts of young trees was observable in 1-3 year old plantations. In other cases and on the somewhat older trees the lens shaped bark necroses were frequent mostly at the basis of lateral branches. The causal agent was the fungus Diaporthe oncostoma, anamorphe Phomopsis oncostoma. Further fungi as *Cucurbitaria elongata, Massaria anomia* were found frequent on the diseased twigs and branches as secondary colonizers.

Another symptom also has been frequent on young tress as well as on older ones at the bifurcation of the branches: swelling, deformation and fissures. This kind of canker proves to be caused by *Fusarium* species, namely *F. lateritium* and *F. avenaceum*. Their ocher colored sporodochia often can be observed on the swelled deformations. They infect the trees through injuries of different origin, in most cases caused by frost.

On hybrid poplars (*Populus* x *euramericana*) bark necroses caused by *Fusarium* species have been observed in relation to attack of poplar borers. In a stand of clone I 214 the bark decay has started from the larval galleries of *Agrilus populneus* and extended on large bark areas causing the death of the trees. In this case *F. solani* was isolated. At another clone the galleries of *Melanophila picta* were the starting-points. The margins of the necroses were healed in this case.

The *Phytophthora* root and collar rot of alder reported for the first time from southern Britain in 1993 has been recently observed in Hungary on *Alnus glutinosa*. The mass death of the trees became conspicuous in 1999, but the annual ring analysis of the stem basis of decaying trees shows that the epidemic has started three to four years earlier. The pathogen is close related to *Phytophthora cambivora*. It is morphologically variable, our isolates form smooth oogonia and two-celled amphigynous antheridia.

A Survey for *Bursaphelenchus* spp. in Conifers in Austria and Implications to Austrian Forests

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Wood samples from more than 400 coniferous trees (*Abies alba* Mill., *Larix decidua* Mill., *Picea abies* L., *Pinus sylvestris* L., *Pinus nigra* ARN., *Pinus cembra* L. and *Pseudotsuga menziesii* FRANCO), showing decline symptmos, taken from 200 different sites all over Austria, were investigated concerning the occurrence of *Bursaphelenchus* spp.. 62% of wood samples contained sapwood nematodes out of which 27% belonged to *Bursaphelenchu*s. The most abundant species was *B. mucronatus*. *B. hofmanni*, *B. sexdentati*, *B-leoni*, *B. eggersi* and *B. new* spec. were observd less frequently. So far, the pine wood nematode (*B.xylophilus*) could not be found in Austrian forest.

Pathogenicity test with *B. mucranotus* and *B. sexdentati* on 3 yr. Old seedlings (*P. sylvestris* L., *Abies alba* Mill., *Picea abies* L. and *Larix decidua* Mill.) in climatic chambers (250C) and under outdoor conditions caused at least 30% mortality. Mortality increased in climatic chambers when additional water stress was induced (200ml per pot and week). The results indicate that *Bursaphelenchus* nematodes seem to be involved in the decline of coniferous forest in Austria, especially after drought periods.

Assessment on The Distribution of Wood-Inhabiting Macrofungi in Peninsular Malaysia

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A total of 327 samples of wood-inhabiting macrofungi were studied with regard to their distribution from forest reserves at Kepong, Pasoh and Jeram Lenang and from plantation forests at Kemasual, Mata Ayer and Ulu Sedili. The highest number of species was collected form Pasoh forest reserve and the smallest number came from Mata Ayer plantation forest. Altogether, 52 species were identified. Common species found were *Earliella scabrosa* (Pers.) Gilb. & Ryv., *Trametes feei* (Fr.) Pat., *Lentinus sajor-caju* (Fr.) Fr. *Lenzites elegans* (Fr.), Kuntze, *Pycnoporus sanguineus* (Fr.), Murr. and *Schizophyllum commune* Fr. Similarity indices (Jaccard and Menhinick) showed the highest species diversity occurred at Pasoh forest reserve. Comparison between forest reserves and plantation forest showed that there is greater species diversity in forest reserves and lowest in plantation forests.

Termite Damage and its Management in Tropical Forests

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In the tropics, subterranean termites cause serious damage to saplings and young trees of some species and often pose a threat to afforestation programmes. In general, exotic tree species are more prone to termite attack than the native species. In addition, dampwood termites of the genera, Kalotermes and Neotermes, cause damage to older living trees of some species.

In all the tropical countries, the exotic eucalypts are seriously damaged by several species of subterranean termites during the first year of establishment, and in some cases, during subsequent years also. Most common are species of the genera, *Macrotermes*, *Microtermes* and *Odontotermes* in Africa and Asia, and Nasutitermes in South America, all belonging to the family, Termitidae. The economic damage caused by termites to eucalypt plantations is substantial. If prophylactic measures are not adopted, over 80% of the transplants are liable to be killed by termites. In the past, control measures were generally based on soil treatment with organochlorine insecticides. Prophylactic spot treatment with aldrin, heptachlor or chlordane proved very effective and was practiced widely for establishment of eucalypt plantations. However, the use of the highly persistent organochlorine insecticides has now been phased out, on environmental considerations. Therefore research on the use of less persistent insecticides and other alternatives has become necessary. The organophosphate, Chlorpyrifos and some pyrethroids have shown promise and are currently being used. Controlled-release formulations of carbosulfan, carbofuran and chlorpyrifos have also been found effective, but are not being used widely as they are costlier. Although a number of non-chemical alternatives have been tested, none have proved operationally successful yet. However, this is a field which requires serious investigations and evaluation.

Three species of the genus *Neotermes* (Kalotermitidae) attack living trees of the exotic mahogany (*Swietenia macrophylla*) in Fiji, causing serious damage, and *N. tectonae* causes economic damage to plantations of the exotic teak (*Tectona grandis*) in Indonesia. There are no practically effective control methods against them.

Estimation of Conifer Resistance against Pests and Fungal Diseases

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The current ecological situation conditions the priority of working out methods for forest protection against pests and diseases. In this context the problem of early diagnostics of woody plant resistance loss becomes pressing, since decrease of resistance is one of the reasons of outbreaks of pest insects and fungal diseases transmitted by these insects, that cause widespread mortality of forest stands or significant reduction of their economical value.

Inoculation of pathogenous fungi, associated with xylophagous insects is known to promote hypersensitive reaction in infected tissues of conifer stem phloem. This reaction is characterised by prompt development of necrosis in infected and adjacent cells and activation of terpenoid and phenolic metabolism (Reid et al., 1967, Paine et al., 1977).

A number of researches, devoted to defensive response in conifers to inoculation with pathogenic fungi, are concerned with study of resinosis, induced by pathogen effect (Reid et al., 1967; Wong, Berrymann, 1977; Cook, Hain,1987). The role of various phenolic compounds in induced defence response of conifers is studied insufficiently, while this group of substances is widespread in woody plants and is well known for its antimicrobic activity. Therefore it is necessary to extend investigations of physiolo gical and biochemical parameters of defensive response to fungal pathogens as well as simultaneous anatomical studies of tissues, involved in defensive response. This very approach will make it possible to devise methods of early diagnostics of resistance loss, when exterior symptoms of decline don't make its appearance.

In this paper the data on biochemical and anatomical parameters of stem phloem defence reaction, induced by fungi or their mycelium extracts are presented. The study was carried out in natural stands of some main siberian forest conifers, where trees of *Abies sibirica*, *Picea sibirica* and *Larix sibirica* were influenced by some biotic and abiotic environmental factors of different intensity. A number of experiments were conducted to establish defensive response parameters suitable for the characteristics of conifer resistance to pathogenous fungi and pest insects.

Our results show that trees, irresistable to fir sawyer beetle (*Monochamus urussovi* Fisch.) colonization, are very sensitive to the fungi, transmitted by this beetle. The level of fir tree resistance to the fir sawyer beetle and associated fungi was found to be characterized by the rate of lignin and proanthocyanidins accumulation in stem phloem reaction zone.

Decrease of spruce trees resistance under flooding of their root systems may also be estimated by the dynamics of lignin and proanthocyanidin concentrations in stem phloem after inoculation.

Strong correlation was shown between degree of fir tree defoliation by Siberian *moth (Dendrolimus superance sibiricus* Tschetvr.) and resistance of these trees to fungal invasion. The resistance of trees was evaluated by dimensions of necrotic lesion and other anatomical features of defence reaction zone.

In casebearer (*Coleophora laricella* Flkv.) damaged larch trees a defensive response to fungal infection involves an increase of necrotic lesion in stem phloem and decrease of infested phloem mass in comparison with non-damaged intact trees. From biochemical point of view the stem phloem response was shown to be systemic and non-specific. The systemic pattern of the response was indicated by tannin accumulation in stem phloem in reply to casebearer damage of needles. The non-specific character is suggested by the same tannin accumulation in response to insect damage of needles and fungal inoculation of stem phloem.

The method of single inoculation of stem phloem with pathogenous fungi usually vectored by xylofagous insects is shown to be simple and convenient technique for defensive response study and in the end for determination of mechanism of woody plant resistance to pathogens.

The risk of occasional spread of infection in forest stand during experimental inoculation may be avoided by substitution of fungal preparation by their mycelium extracts. The induced alterations in defensive response after these extracts application were found to be the same as after fungal inoculation. The advantages of diagnostics of conifer tree resistance by single inoculation method are its sensitivity and multi-utility. The method sensitivity results from capability to evaluate the resistance decre ase when no exterior signs of decline appear yet. The multy-utility is concerned with possibility to estimate effect of any unfavourable environmental factor, bringing tree resistance down. So, anatomical and biochemical parameters of conifer stem phloem defensive response induced by pathogenous fungi invasion are related with the level of resistance to pathogenous fungi and pest insects and may be used for characteristics of conifer resistance to these pathogens.

Insects as Indicators of Forest Health in Ponderosa Pine Forest in Northern Arizona

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Forest health in northern Arizona ponderosa pine forests has declined since European settlement. Reintroduction of fire and thinning are the main practices suggested to return forest to healthy conditions. However, a major gap exists in understanding how broad landscape-level management practices may affect forest health (i.e. biodiversity, NPP, tree growth efficiency). We are examining ground beetles (Carabidae), bark beetles (Scolytidae), and wood borers (Cerambycidae) as potential indicators of forest health in relatively large stands (20-40 ha) subjected to different management regimes in Northern Arizona. Although rarely referred to as ecological indicators, these insect guilds have most of the desirable attributes such as high sensitivity to environmental change and stressing factors. We hypothesize that the composition and community structure of these insects is linked to specific stand structural and functional attributes.

Four stand conditions with four replicates are being evaluated: 1) thinned plus prescribed burned, 2) thinned, 3) unmanaged, and 4) wildfire burned stands. Standard trapping techniques are being used to sample insects on each guild. The study will include two growing seasons to determine insect guild abundance. Insects are being identified to the species level when possible. Predictive indexes based on selection of functional groups will be used to characterize the differences in stand conditions.

Preliminary results on the ground beetle guild indicate that species richness and evenness differed significantly among treatments. Unmanaged and thinned sites had lower Shannon diversity index than wildfire burned stands and thinned plus prescribed burned stands. Also, the number of species was consistently higher on wildfire burned sites. Differences on species assemblage were found among treatments. Unmanaged and thinned stands were consistently dominated by one species of the genus *Synichus*. Although this species was recorded on wildfire burned stands, the abundance of two species of genus *Calathus* was more characteristic on these stands. Several species of genus *Amara* were abundant on wildfire burned stands but rare on thinned stands and prescribed burned stands.

There were differences in bark beetle and wood-borer diversity among treatments. Wood borer diversity was consistently higher than bark beetle diversity in stands other than wildfire burned stands. Bark beetle diversity was higher than wood borer in wildfire stands. There were stand specific beetle species as well. The red turpentine beetle (*Dendroctonus valens*) was present in all the four stand types; however, other Dendroctonus species were found in wildfire burned stands only. The Cerambycidae *Acanthocinus obliquus* was found in wildfire burned stands and unmanaged stands, whereas Arthopalus rusticus was found in unmanaged stands only.

These findings are encouraging because they suggest that selected insect guilds can be used to characterize stand condition. The presence and relative abundance of specific insect species could be used to indicate healthy or unhealthy conditions of ponderosa pine forests, based on documented insect behavior.

Integrated Pest Management to Sustain Iroko Production in Ghana, West Africa.

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Milicia spp. (*M. regia* and *M. excelsa*), referred to as Iroko in West and Central Africa, are valued commercial timber species because of their natural durability and good working properties. Because of this high value, Iroko exploitation has exceeded regeneration throughout much of its range. Regeneration of the species is poor because of several factors including attack by a gall-forming psyllid *Phytolyma lata*, low incidence of overstory trees, high seedling mortality, limited dispersal of fruits, and narrow environmental conditions that are suitable for seedling survival. *Phytolyma* attack is followed by dieback of the foliage down to the woody tissue, which disrupts physiological processes, causes growth reduction, and in many cases kills seedlings. Repeated attacks by *Phytolyma* are common, resulting in decimation of seedlings in plantations. All attempts to grow this species in West African plantations have failed. For the past 8 years an integrated team of ecologists, geneticists, and entomologists have developed a comprehensive integrated pest management (IPM) system to manage this insect. Components of the IPM system include:

1) Identification and clonal trials of genotypes of Iroko that tolerate *Phytolyma lata* attack resulting in a number of clones of Iroko that show considerable potential as insect resistant stock.

2) Development of improved cultural practices such as vegetative propagation, seed collection and storage procedures, nursery production, and improved planting techniques. Experimental trials of Iroko in mixed species plantations with both native and exotic species has demonstrated the potential of some significant pest impact reduction in mixtures when compared with pure stands. Thechoice of companion species may be important as may be the sequence of planting various species

3) Enhanced understanding of regeneration of Iroko and the role played by the psyllid in natural forests: including determining the light conditions suitable for regeneration, seedling survival relative to the parent tree and the influence of gap size on seedling survival and *Phytolyma* attack.

4) Identification of factors influencing natural enemy regulation of *Phytolyma lata*. Four parasitoids from two families were identified: *Psyllaephagus phytolymae* (Encyrtidae), *Aprostocetus salebrosus*, *A. roseveari*, *and A. trichionotus* (all Eulophidae) were identified. Percent parasitism was low, between 4 and 16% with higher rates in drier months (November through February). A negative relationship was discovered between parasitism and the size of the galls. *Psyllaephagus phytolymae* did not occur on seedling galls, even though it has been cited in the literature as one of the primary parasites on *Phytolyma lata*. The absence of this important parasite from the seedling galls may explain why the worst cases of *Phytolym*a damage occur in nurseries and young plantations.

This IPM program has the potential to resurrect Iroko as a major West African timber species if effectively implemented in suitable growing sites.

Study on the Relationship between Morphological and Dissection Characters of Bark and Its Resistance to Longhorn Beetles (*Anoplophora nobilis* Ganglbauer and *Anoplophora glabripennis* Motch)

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Bark is the only reproduction place of longhorn beetles, and is very important for their population cycle. The different species and clones of tree resistance to longhorn beetles are highly correlated with the physics, chemical and morphological characters of bark. In this paper, olefin sections of 49 species and clones of bark were made, and 19 indexes of micro-characters of cortex, periderm, primary phloem and secondary phloem were observed and described in quantity and quality. The rough degree and thickness of bark were measured. The quality indexes were quantified by Quantity Theory I, and all 57 variables and 1 constant (population density of longhorn beetles (Y)) were analyzed by Stepwise Regression. Finally, 7 factors, namely, rough bark (x1), light rough bark (x2), sclereid in cortex (x3), small cubic crystal in primary phloem (x4), fibre surrounded crystalloid in secondary phloem (x5), organic compound in periderm (x6), distribution way of fibre in secondary phloem (x7) were proved to be related to the tree resistance to longhorn beetles. The regression equation was Y=-2.559+13.531x1+4.676x2+3.654x3+1.992x4+.293x5+3.050x7-1.499x6 , r=0.713, and the difference was significant. Among 7 factors, 2 concerned bark morphological characters, 3 concerned the chemistry characters, 2 concerned the structure characters. These above indicated that tree resistance to longhorn beetles depends on the synthetic element.

Antioxidant Enzyme Activities to Air Pollution of *Alnus firma* in Yochon Industrial Complex, Republic of Korea

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This study measured the seasonal changes of physiological characteristics and antioxidants of Alnus firma to compare several enzyme activities (Rubisco, Superoxide dismutase (SOD) and Glutathione Reductase(GR)) between resistant and sensitive Alnus firma trees in Republic of Korea. Resistant and sensitive Alnus firma individuals near Yochon industrial complex were selected to conduct this study.

Photosynthetic capacity, stomatal conductance, transpiration, Rubisco, SOD and GR activities of resistant trees which had no visible damages to air pollution were higher than those of sensitive trees in same area. All physiological results supported that biochemical process to be one of the important key features to understand resistance to air pollution. Increases of photosynthetic capacity and antioxidant enzyme activity in resistant trees in response to air pollution were the results of biological compensation to stress.

Relationship Between Fungal Spread and Defensive Responses in Japanese Cedar Sapwood Inoculated with *Guignardia* Dieback Fungus

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Keywords: *Cryptomeria japonica*; *Guignardia cryptomeriae*; sapwood; wood discoloration; defensive response; phytoalexin

To determine the relationship between fungal spread and defensive responses in the sapwood of Japanese cedar, *Cryptomeria japonica*, a canker and dieback fungus, *Guignardia cryptomeriae*, was inoculated into excised stem lengths and standing trees of *C. japonica*. Then, spreads of wood discoloration and fungal hyphae were measured, and defense responses were analyzed chemically and anatomically.

Fungal hyphae spread quickly in autoclaved stem lengths and freeze-treated stem lengths. In spring inoculation test, fungi spread longitudinally in the excised stems as fast as on potato dextrose agar. Therefore, constituents of sound sapwood prior to the infection are thought not to inhibit fungal spread in the wood. Fresh excised stem lengths, in which intensity of the defense response was weakened, interfered with fungal spread except in the case of spring inoculation with virulent isolates. Fungal spread was most retarded in living trees. Sapwood of fresh excised stems responded more intensively to avirulent isolates than to virulent isolates, and the rate of retardation of fungal spread was higher in avirulent isolates than in virulent isolates. These results indicate that active defense responses play an important and definitive role in the inhibition of fungal spread in the sapwood of *C. japonica*. Axial-tangential ratio of fungal colonization was higher in living trees and fresh excised stems than in both autoclaved stems and freeze-treated stems. This suggests that active defense mechanisms are also involved in the determination of the shape of wood discoloration.

Wood discoloration and fungal hyphae spread quickly during the first 2 weeks of inoculation in the standing trees. The spread of both virulent and avirulent isolates was inhibited between 2 weeks and one month postinoculation, though the size of wood discoloration and fungal colonization varied depending on the virulence of inoculated fungal isolates.

Within one week postinoculation, oil droplet-like deposits containing norlignans (e.g. hinokiresinol, agatharesinol and sequirin-C) and terpenes began to be secreted. Extractives content increased between 2 weeks and one month postinoculation. Antifungal compounds, hinokiresinol and a few unidentified compounds, accumulated quickly as phytoalexins. Agatharesinol, sequirin-C and several terpenes, which had little antifungal activity, accumulated slowly in the reaction zone barrier. These results suggest that accumulation of inhibitory substances contribute to the retardation of fungal spread within 2 weeks after the infection and the complete prevention thereafter.

Intensity of the defense response, evaluated from the concentration of phytoalexins and secretion of oil droplet-like deposits, did not differ between standing trees inoculated with isolates of different virulence. Concentration of phytoalexins accumulated in the reaction zone barrier, however, were higher in inoculated trees than in wounded trees, suggesting the enhanced induction of defense responses by the existence of pathogenic fungi. Concentration of phytoalexins in the reaction zone barrier was higher in fresh excised stems inoculated with avirulent isolates than ones inoculated with virulent isolates. This fact suggests lower induction level of the defense response against virulent isolates under stress.

The Land Leech, *Haemadipsa zeylanica japonica* (Gnathobdellida: Haemadissidae), Study of Biology to Control its Biohazard.

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Key word: land leech, biology, biohazard, population increase, change of forest management, shika deer

The land leech, *Haemadipsa zeylanica japonica*, is a common blood sucking land leech, and distributes widely from subtropical to warm-temperate zones of Japan, but each distribution area is usually localized, and its density is usually low. However its range and density have increased since 1985 in the southern Boso Peninsula, Chiba Prefecture in Japan. Now it often causes biohazard by attacking forest worker, hiker. resident, as well as companion animals not only in the forest but at the home garden in rural village. It is not dangerous among the animals inhabiting in the forest, because it does not transmit any harmful pathogen, but it is thought to be one of the most uncomfortable ones which causing bleed of human being unconsciously during working, hiking, and walking. This causes some undesirable impact on tourist industry by decrease of visitors there. To establish safety control measures against it, studies on biology and environmental factors affecting population increase of the land leech have been made.

Based on laboratory observation, the life span is about 9 to 19 months, and after sucking blood 4 or 5 times it becomes mature enough to deposit cocoon of which average number of eggs was about 6, maximum was 13. Deposition of cocoon and hatching from cocoon occurred at the temperature above 15°. Sucking and mating were observed above the temperature of 10°, that means the activities during winter stopped, but even in winter when it was warm enough it may become active in sucking blood. The amount of blood sucked by a land leech from host human being was six times as much as its body weight . During blood -sucking it exhausted excessive water from its body surface of which weight was about twice as much as the body weight. Total amount of blood sucked was about eight times and grand total of bleeding from host including loss of blood after it left was about nine times as much as its body weight.

The reasons why expansion of distribution and population increase have occurred were considered to be due to the population increase of the shika deer, and change of forest management in which the ever-green broadleaf trees have not been harvested for production of charcoal and fuel wood for long time resulting in overcrowded forest and providing suitable environmental conditions such as rich in litters and wet on forest floor for the land leech. At present the most convenient way to avoid attack by the leech is use of effective repellents available commercially.

Diseases and Disorders of *Azadirachta excelsa* in Peninsular Malaysia

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Keywords: *Azadirachta excelsa*; Diseases; Nursery; Plantation

During the last decade, the rapid establishments of forest plantations in Peninsular Malaysia are based on fast growing exotic species. However in recent years, the trend has shifted to indigenous species. One of the species chosen is *Azadirachta excelsa* locally known as sentang. Since this species has never been planted in large scale, its introduction as monoculture provides opportunity for the emergence of new disease problems. There has therefore, been an increase in demand in recent years for information regarding this problems.

Disease surveys conducted at forest nurseries and plantations in all the states in Peninsular Malaysia revealed that seedlings of *A. excelsa* are resistant to disease, since there are very few diseases occurring at the nursery stage compared to the plantation. The only nursery disease outbreak observed was wilting of *A. excelsa* cuttings due to *Sclerotiu*m sp. In the plantation root disease and multiple leader phenomena are the two most common occurrences. Apart from this, foliage and stem diseases are also observed but they are less common.

Root diseases such as root rot and collar rot occurred in most of the areas surveyed. The associated pathogens are Basidiomycetes, namely *Phellinus* sp. and *Rigidoporus* sp. At the moment they are the most important threat to young *A. excelsa* in plantations. There are also occurrences stem diseases such as canker, shoot lesion and dieback but incidence are generally low. The occurrences of foliage disease such as leaf spots and lesions, curled leaves and yellowing of leaves are very minor that it did not cause any significant damage to the trees. The fungal pathogens most commonly associated with these diseases are *Lasiodiplodia theobromae, Fusarium* spp., and *Colletotrichum gloeosporioides*.

Multiple branching phenomena have been observed occasionally at several sites in Peninsular Malaysia. It was observed to occur on one a half to two year old trees planted on poor lateritic soil, where no tending is done. Until now no specific fungus has been found associated with this symptom.

Apart from fungal problems *A. excelsa* is also susceptible to a number of known abiotic factors and conditions. The abiotic factors include water-logging, drought, nutrient poor sites and hard pans. In addition, factors such as site preparation and site history also play an important role in increasing disease incidence especially root diseases.

Incidence du complexe des ennemis naturels intervenant à la fin du cycle de larvaire de *Thaumetopoea pityocampa* Denis et Schiffermüller (Lep., Thaumetopoeideae) dans une région subsaharienne (Djelfa-Algérie)

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La processionnaire du pin, *Thaumetopoea pityocampa* (Lep., Thaumetopoeidae), défoliateur des essences résineuses à travers le bassin méditerranéen est en phase de culmination permanente, depuis plus d'une décennie dans les reboisements à *Pinus halepensis* Mill. du "barrage vert" en Algérie. Les attaques massives de ce ravageur sont apparues dès 1970, après les grands efforts entrepris dans le cadre du projet intitulé "barrage vert" qui a pour objectif la reconstitution des formations forestières à travers toute l'Algérie et plus particulièrement celles localisées le long de l'Atlas Saharien. Une monoculture exclusive, celle du pin d'Alep, a engendré une explosion démographique des populations de *T. pityocampa* qui, par ses défoliations répétées, mettait en péril ces reboisements qui évoluaient déjà dans les conditions contraignantes d'une région semi aride. Cette dernière est connue pour ses déficits hydriques (moins de 400 millimètres d'eau par an) et par la pauvreté de ses potentiels édaphiques.

L'étude a été menée durant les cycles de développement 1993/1994 et 1994/1995 dans la région subsaharienne de Djelfa dans des peuplements artificiels non encore fermés avec des arbres ne dépassant pas trois mètres de hauteur. Ces reboisements font partie du "barrage vert" et correspondent à la limite sud de l'aire de distribution de *T. pityocampa.* Cette étude a permis d'inventorier et d'évaluer l'aptitude parasitaire des ennemis naturels de ce ravageur, notamment les parasitoides intervenant à la fin du larvaire.

Parmi les traits d'adaptation phénologique qui ont été observés dans la nature, nous avons les rythmes des dépôts et ceux des processions de nymphose, qui marquent la fin du cycle larvaire. A Djelfa, il apparaît que les pontes ont lieu avec 30 jours de retard par rapport à des biotopes similaires du point de vue altitude comme Chréa (nord de l'Algérie) et le Mont-Ventoux (sud de la France) alors que les processions de nymphose interviennent à des époques similaires à celles des deux autres biotopes cités.

Les résultats obtenus montrent que les espèces clefs du complexe des parasitoides ont été retrouvées à Djelfa mais la diversité spécifique de ce complexe est faible par rapport à celle observée dans le littoral algérien et le sud de l'Europe. Il ressort des résultats de l'inventaire que se sont les parasitoides polyphages qui n'ont pas été rencontrés dans les stations d'étude. Cela est vraisemblablement liée à l'artificialisation abusive du milieu découlant de la monoculture pratiquée dans le projet du "barrage vert".

L'efficacité des différents parasitoides intervenant à la fin du cycle larvaire a varié d'une station et d'une année à l'autre et s'est montrée dépendance de la densité de l'hôte et des possibilités de coincidence phénologique avec ce dernier. Des élevages des parasitoides des chenilles dans les conditions semi-naturelles et l'observation des rythmes de dépôts de pontes et des processions de nymphose dans la nature ont permis de constater dans certains cas, un désynchronisme entre la présence de l'hôte avec celui des parasitoides qui se développent dans des microclimats différents.

Concernant les parasitoides larvo-nymhphaux, *Erigorgus femorator* (Hym., Ichneumonidae), peu abondant en règle générale dans l'aire de réparition du ravageur, a été constamment observé. Son action a été dans certains cas plus importante que celle du parasitoide spécifique *Phryxe candata* (Dipt., Tachinidae)

Les résultats ont permis d'apporter des éléments biologiques sur le déterminisme des gradations et d'asseoir une stratégie de lutte intégrée pour contrôler, autant que possible, les populations de cet insecte dans les conditions du "barrage vert".

The DCPV Virus Used for Long-lasting Control *of Dendrolimus punctatus* (Lepidoptera: Lasiocampidae) in China

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Satisfactory results were obtained by using the compound formulation of *Dendrolimus cytoplasmic* polyhedrosis virus (DCPV) with *Bacillus thuringiensis* Berliner (Bt) to control *Dendrolimus punctatus* Walker (D.p.) (Lepidoptera: Lasiocampidae)in Masson pine forests in south China. At the condition of 27°, the compound of DCPV (1-105CPB/ml) with Bt (2-107spores/ml) against 4-instar larvae made 70% mortality, and infected 50% the survivors as well. Within the compound of the two biocontrol agents, Bt could quickly reduce populations D.p. larvae and DCPV could spread and preserved in the colony of the defoliator generation by generation. Meanwhile, the dosages of the DCPV and Bt were reduced to 20% and 40% respectively, compared with being used alone. There were still 78.5% individuals containing DCPV (determined by ELISA), and thus, the pest was maintained at a low population, since its spraying in 1983 in certain forests.

Ecological Pest Management and its Practices of Forest Pest Management in China

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There are only 134 million ha. of forest with the coverage rate of 13.92%. To solve the problem, Chinese government has made effort to develop plantations in recent years. With the increase of the plantation area the damaged area increased year by year from 1 million ha. in 1950s to 11 million ha..

Because of the limitation of existing IPM strategy and the limited application of biological control, the occurrence area of forest pests is still increasing and the situation will last at list for a period of time. To solve the problem sustainable pest management must be taken as a guideline. To meet the need of Sustainable Development and Sustainable Pest Management, ecological pest management “EPM”¸ is proposed to replace IPM in future.

EPM uses many elements of integrated pest management “IPM”¸but it is based on keeping and supporting the natural stability of the ecosystem and suppressing pest outbreaks at the very beginning when the population density is still low. With a special system of collection and processing of information, the frequent detection and estimation of pest, predator and parasite population density, biological control decision making is made according to the threshold when pest is slipping away from the control of the natural enemies. EPM can be cheaper than IPM because both costly uses of chemical pesticides and mass inundation by artificially reared parasites or predators are rejected.

There are some successful practices in forest pest management of EPM technology in China. For example, suppress the pine caterpillars through mountain closure, control the longhorn beetles by diversification of forest structure, use pine caterpillar CPV (*Dendrolimus punctatus*) and the inoculative release of Beaureria bassiana to control of pine caterpillars. However, at the present level of knowledge and technology, EPM cannot be elaborated thoroughly. More efforts should be made in researches of the ecology of ecosystem and the relevant techniques.

Population Crash Threshold of *Paulownia* Bagworm *Clania variegata* Snellen (Lepidoptera: Psychidae)

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Keywords: Population crash threshold; *Cryptothelea variegata*; Spread rate; Parasitism

Data of paulownia bagworm [*Cryptothelea variegata* Snellen (Lepidoptera: Psychidae)] population development, management, and parasitism from 1985 to 1995 in Lankao county, Henan province, P. R. China were analyzed. The hypothesis of population crash threshold was therefore put forward and the index of the threshold was calculated based upon the analysis. The result could theoretically explain the sudden breakdown of bagworm population in large area of pure paulownia plantation.

The development of bagworm population, on account of the attacked area, could be divided into spreading stage (1985-1990) with average spread rate of 115% annually, peak stage (1991-1992) with spread rate of nearly zero and breakdown stage (1993-1995) during which the pest population crashed sharply.

Control operations of *C. variegata* were effective for foliage protection but they could not prevent the pest from dispersing due to incomplete control of trees with living larvae, it was not the means to lead the population to crash either. Reliable data also showed that *C. variegate* cycles were more likely to be the result of interaction with parasitoids. Furthermore, parasitoid is one of the facilitation factors to promote the breakdown of bagworm population but not the key element.

Population of *C. variegata* will extinct under condition of population crash threshold Tcr=355 larvae per hundred leaves of insect density or above, and spread rate should be or near zero. The intensive high density caused severely interspecies competition and under such condition the environmental carrying capacity was shortage to support the whole population.

Mass Rearing of *Chouioia cunea* (*Hymenoptera: Eulophidae*) and Applying for Biocontrol of Fall Webworm in China

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The effective endopupal parasitoid, *Chouioia cunea* Yang (Hymenoptera, Eulophidae: Tetrastichinae), of *Hyphantria cunea* (Drury) was studied on its starting development and effective accumulated temperatures, as well as mass rearing technique. By experiment of different defoliators selected for substitute hosts, 12 of them showed good result, and especially substitute host I and II were the best hosts for mass rearing the parasitoid for the number 5270 and 468 reared from one host respectively). After releasing for biological control of fall webworm in three Provinces and one city in China, the pest was significantly controlled. The parasitic ratio usually reached over 80% by the wasp itself, plus other parasitic natural enemies, the total parasitic ratio of the pest was over 90%. It was indicated that the biocontrol technique has a bright prospect to supression the pest under control.

Impact of Pine Wood Nematode on Pine Forest Sustainability in Taiwan

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Keywords: Pine wood nematode; Pine sawyer; Taiwan red pine; ecosystem

Pine wood nematode (PWN), *Bursaphelenchus xylophilus*, has caused severe damage to pine forest in Taiwan since its first occurrence at a small tree farm of 0.3ha at Shimen village in 1982. It is recognized that the pine wilting disease at Shimen village was the starting point for PWN disaster in Taiwan. Pine sawyer (PS), *Monochamus alternatus*, was discovered to be the most important insect vector of PWN. From 1985 to 1990, outbreak of severe pine damage spread rapidly from northeast to north and then southward to Taoyuen pref., and the disease became epidemic. During this period, two pine species, i.e., *Pinus luchuensis* and *P. thunbergii*, were severely attacked and destroyed.

Since 1991, the disease spread through north to central part of Taiwan. Although Taiwan red pine (*P. taiwanensis*) was claimed as resistant species, PWN damage has spread to the main stands of Taiwan red pine in central Taiwan. It was discovered that the PWN recovered from the diseased Taiwan red pine coincided morphologically with *B. mucronatus*, which can mate with *B. xylophilus*.

Recently, the disease was discovered in Taiwan red pine plantations in southern Taiwan. The infested areas have been increased to more than 3,500 ha.

Fortunately, up to the present, PWN damage does not occur in plantations of five-needle pines, such as Taiwan armand pine (*P. armandii*) and Taiwan white pine (*P. morrisonicola*). Control measures such as felling of diseased trees, burning, chemical spray and fumigation treatment, and biological control, as well as attractants application were conducted to eradicate PS and PWN. Quarantine regulation has been set up to prevent disease expansion. Reforestation with PWN resistant tree species, salvage cutting, thinning, breeding for resistance, and establishment of multi-story forest, as well as forest ecosystem management strategy are adopted to ensure sustainability of pine forest in Taiwan.

The Background of Insects - Defoliators Outbreaks Prediction in Ukrainian Forests

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Pest prediction must answer the questions - what pest, when and where can form the outbreak, what will be the influence to the stands. This will allow to make the decision about necessity of control measures planning. The foliage-eating insects cause the main injury in the considerable part of Ukrainian forests, especially located in the forest-steppe and steppe zones. The main defoliators of deciduous trees are *Tortrix viridana* L., *Lymantria dispar* L., *Euproctis chrysorrhoea* L., *Operophtera brumata* L., *Erannis defoliaria* L. The main needle-eating insects are *Diprion pini* L., *Neodiprion sertifer* Geoffr., *Dendrolimus pini* L., *Bupalus piniarius* L., *Panolis flammea* Schiff. Population parameters, site and stand characteristics in the foci and out of them as well as weather indices during outbreaks, before and after them in different regions of Ukraine for more than 50 years were collected in computer databases. There are also databases with ecological and population indices of the main defoliators, critical population density in different conditions, phenological data for pests and their hosts in the different regions of Ukraine. All these data were processed using statistic methods, multivariate, principal component, discriminant and GIS-analysis to obtain some quantitative characteristics of conditions in which pest outbreaks occur.

Investigations of outbreaks history show that pest-defoliators outbreaks are cyclic and have high correlation with sun - spot activity. Special attention was paid to development of meteorological factors analysis methods, which allow to determine the zones of different outbreak frequency and injury, to predict the weather conditions unsuitable for stands resistance and suitable for pests, to systematize the information about critical periods for pests and to plan in time protecting measures using phenologic indicators. Statistic analysis allows to conclude that duration, intensity and spreading of outbreaks vary in the different foci and depend on site conditions, initial forest state. The state of stands may be both the cause and the result of this process. To predict the probability of outbreak realization in the given site conditions we tried to take into account the totality of relief, soil, stand indices and state, water availability in analysis of the pest history for different forest enterprises. The mean characteristics of above said parameters and their statistics were calculated for the stands with outbreaks and without them. Simultaneously damage history was analyzed. It was stated that equal pest density can cause different damage in different region, site, stand, weather conditions. Thus foliage consumption by pest depends on foliage quality and weather. Weather influence both on the foliage quality and feeding rhythm of the larvae. Pest damage influence to tree vitality also depends on numerous factors which characterize site conditions, weather, previous damage and stands state, as well as stand composition, biological peculiarities, number and population state of insects. The spring damage is more dangerous than the autumn one because shoots do not develop and reserve substances do not accumulate. The middle-aged trees are more resistant to damage than young and old ones. Oppressed and desiccated trees decline more quickly than healthy ones. Healthy trees foliage is less favorable for insect development because of large contents of protective substances in the leaves or needles. The trees in the favorable site conditions recover more quick after damage. At dry weather more trees die than in the wet seasons. Sudden frost in autumn can cause the pest mortality or shoot mortality if they are not yet woody.

The Effects of Simulated C2H4 Alone and Synergic Stress with SO2 and NO2 on Several Woody Plants

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Ten species of woody plants: *Pinus tabulaeformis*, *Platycladus orientaliscl*.Franco, *Sabin*a, *Populus tomentosa, Salix capitata* carr., *Sophora japonica* L., *Robinia pseudoacacia* L., *Amorpha fruticosa* L., *Fraxinus sogdiana* Bunge, *Ailanthus altissima* Swingle, were exposed to simulated C_2H_4 alone and combination of it and SO_2, and NO_2 by using open-top chamber. The responses of their some physiological metabolism as chlorophyl content, K^+ leaching concentration, free amino acid, ascorbic acid, to these gaseous pollutants, were investigated in this paper. Based on the responses, the evaluation of resistance for the experimental plants through cluster analysis method were made in this paper as well. The results showed that the resistance of several species such as *Platycladus orientalis* cl. *Franco, Sabina, Fraxinus sogdiana*

Bunge, and *Amorpha fruticosa* L. were stronger among all of experimental tree species, whereas *Ailanthus altissima* Swingle was weaker.

Threats to Armenia's Forest Biodiversity

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Armenia is a landlocked mountainous country situated in the north-eastern part of the Armenian Highland and bordered from the North by Georgia, on the East by Azerbaijan, on the South by Iran, and on the West by Turkey. It covers an area of 29.8 thousand square kilometres and has a population of 3.7 million. The capital of Armenia is Yerevan. Armenia is a typical mountainous country, 90% of the territory of which is situated on 1000 m above the sea level, including 40% at 2000 m above the sea level. The average altitude of the territory is 1830 m, the highest point is 4090 m high and the lowest is 390 m high.

The geographical situation of the country and complex mountain terrain as well as its vertical zonality have created conditions for a unique biodiversity of resources and natural conditions. The forest area of Armenia is 4,599 km^2, including 3,341 km^2 forest cover (or 11.2% of Armenia's territory). The forest cover area per capita is 0.1 ha. More than 200 species of trees and bushes are grown in trees. The main tree species of oak, beech and hornbeam. The forests of Armenia are characterized by rich biodiversity, the great number of endemic flora and fauna species. In the mentioned forests there are 24 species of endemic plants registered, most of which are wild relatives of cultivated plants, for example Armenian pear tree, Meghri plume, etc. Among invertebrate animals, beetles are particularly well studied whose total quantity in the forest zone reaches almost 2,300 species, including 30 endemic species. The species of vertebrate animals in forest zones is also rich in biodiversity. Here 2 5 species of mammals, 90 species of birds, 11 species of reptiles and 1 specie of amphibians are registered. Rare and threatened species are the Caucasian endemic, for example Caucasian birth mouse, Black sea mole. In the mentioned forest zones a rare population of Syrian bear exists.

In Armenian forests such organisms are widespread (insects, diseases, etc.), which during their mass reproduction period defoliate trees and bushes in vast areas and cause desiccation. Before the breakdown of the USSR prophylactic aviation combat measures were implemented against these problems, yearly on 15,000-25,000 ha. These measures prevent the current damage as well as further spread of the damage. After the collapse of the Soviet Union, the mass cut down of trees because of the energy crisis created favorable conditions for the mass reproduction and expansion of these diseases. In recent years 9,000 to 15,000 forest cover areas are being defolia ted. For 1999-2003 a projection of the expansion of those areas has been done using computer models. According to this projection if no measures are taken until 2003 the infected area will reach 62,000 ha, and lost of yearly growth will be 179800 cbm. At present in the situation of economic crisis, the volume of implemented measures d o not exceed 10% of the necessary measures. For this reason the infected areas increase each year and a great number of desiccated trees can already be noticed, namely 3-10%. If a tree defoliates for three years in a row, consequently it is desiccated. Thus, there is an urgent need tor developing and implementing modern methods of pest control in the forests of Armenia.

Study on Fermentation Engineering of *Bacillus Thuringiensis*

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This paper was dealing with research on the fermentation engineering of *Bacillus thuringiensis* (Bt.). The main subjects of the research were about the highly toxic Bt strain isolation and characterization, genetically engineered Br construction, medium optimization, fermentation metabolism, downstream technology, high cell density cultivation and application.

Highly toxic Br strain, MP-342, was isolated from naturally died insect. It was more than toxic to *Pluttella xylostella* and *Helioverpa armigera* than the production strains of main Bt preparations of European and American, such as Xentari©, Dipel©, Agree©, Cutlass©, Delfin©, 1S057A and Javelin©. MP-342 strain belonged to *B. thuringiensis sups. kurstaki*, and had flagella serotype H3a3b3c. It carried six genes of insecticide crystal proteins, which were crylAc, crylAc-3, crylla, crylAa, cry2Aa and cry2Ab; and owned 7 plasmids with molecular weight of 152Md, 45 Md, Md, 7.2Md, 5.5Md, and 5.2Md respectively. The cryl genes located on plasmids with molecular weight of 152Md and (or) 48 Md., while the cry2A and cryl Ia genes located on 152Md plasmid. MP-342 strain produced 133kD and 71 kD proteins. It differed from Bt HD-l strain, which was the production strain of Dipel in plasmid profiles, insecticidal crystal proteins, gene types and gene locations. The main proteins expressed by MP-342 strain were CrylAc, CrylAc-3 and Cry2Aa, and lacked CrylAb, to which resistance had been developed by some insects. CrylAc-3 was also highly toxic to *Spodoptera exigua*.

MP-342 produced water-soluble potentiator in the supernatant of fermentation broth, which showed low toxicity to neonate of *H. armigera* (LC50 was about 20ug/ml), could increase the toxicity of spore and crystal complex about 3 fold. Potentiator in supernatant was stable during pH2-10, and good thermostability. There was no significant effect on potentiation activity when supernatant was boiled for 15min. But the activity of supernatant lost when autoclaved at 121°C for 20min. And this supernatant had no lethal and teratological activity against larvae and adult of housefly. It demonstrated that this potentiator was not á-exotoxin and also different from protein toxin, which was not thermostable. And it was similar to Zwittermicin A and Ia. This water-soluble potentiator made MP-342 strain more toxic than HD-l. Efficacy of fermentation beer of MP-342 was over 4000lU/ul. The technical powder of MP-342 was obtained through spray-drying process. The average efficacy and toxin content were 55744lU/mg and 10.4% respectively. Technical powder of MP-342 was very stable during storage. When treated at 54°C for 7 days and 14 days, the activity decreased 7.1% and 15.1% respectively. But liquid formulation was unstable during storage, of which the efficacy decreased 60-70% after 6 months storage.

The water-soluble poteniator in the discard supernatant from technical powder production process was recovered through vacuum evaporation and spray-drying process. The maximum solid content in concentrated supernatant could reach 45%. The proper spray-drying condition was 300°C at entrance, and 80°C at exit. The vacuum evaporation and spray-drying process showed no significant effects on the activity of potentiator. 700kg potentiating powder could be obtained out of the production of 1000 kg technical powder. The potentiator powder composed of 10.58% carbohydrate, 5.82% total nitrogen, 1.15% fatty acids and plenty of amino acids and inorganic salts.

Liquid formulation with efficacy of 8000lU/ul and 16000lU/ul was made by mixing concentrated supernatant with fermentation beer and sludge. Efficacy of the mixture was highly correlated with crystal concentration and index of supernatant concentration. The correlation formula was: Y (efficacy, lU/mg) =-1582.9+1500.4X1 (crystal concentration) +1435.2X2 (index of supernatant concentration). r=0,983. The toxicity to Spodoprera exigua could increase 11.14 fold when mixed MP-342 technical powder with potentiator powder at the ratio of 1:10. 32000lU/mg and 64000lU/mg powder preparations were obtained at the mixing ratio of 1:2-4. Powder potentiator was more stable than liquid potentiator. The powder potentiator was relatively stable, it maintained 70% of original activity after 3 days' treatment at 54øC, and no decrease any more. The potentiation activity of supernatant in liquid formulation decreased 48.2% after 13 months storage at room temperature.

MP-342 strain was transformed with plasmid pHT3lOl carried crylCa gene by electroporation, and 41 transformants were obtained in erythromycin selected plate. MP-342 lC-15, one of the transformants, was proved to carry crylCa gene, recombinant plasmid and express Cryl Ca protein. The percentage of CrylCa protein in this recombinant was 35% of Cryl proteins and 29% of total crystal proteins.

Recombinant plasmid showed a rather good genetic stability. Reservation rate of recombinant plasmids was 94.6% after 22 generations of propagation. LC50 of MP-342 IC-15 to neonate of *S. exigua* was 21.65ul/ml which was one fold lower than that of parent strain, MP-342. Toxicity of MP-342 IC-15 to *P. xylostella* was similar to that of parent strain. Potentiator produced by MP342 IC could increase the activity 2 to 3 fold against *S. exigua* and DBM in some extent.

A new model was set up to optimize Bt fermentation media. This model included four selection procedures. Single factor selection test was used for the selection of suitable single carbon and nitrogen ingredients. Combination test was adopted to select factors with combination effect. Steepest ascent method was used to determine optimizing region. The response surface method was used to wok out mathematics equation which was used to predict optimization medium recipe. This model could be used to treat various ingredients, and experiment factors could be controlled with easily handle number, through step by step selection, optimum recipe could be got at the last experiment. By using bioassay toxicity as parameter, the model above was adopted to optimize MP-342 medium. An optimized medium YM-2S was achieved. The toxicity of fermentation beer reached 5016.5lU/mg (*H. armigera* as testing insect). LC50 to *P. xylostella* was 85.3ppm. It was

5.16 fold (*H. armigera* as testing insect) and 4.38fold (*P. xylolstella* as resting insect) higher in toxicity compared with that of HD-l strain in its production medium and continuous cultures (μ_{max} = 0.69 l/hr, Ks = 0.5mg/ml, Yx/s = 0.75g dry cell weight/g glucose). The middle of log growth phase was determined as appropriate feed time. pH value was a good parameter to predict the log growth phase. By using constant fed-batch culture strategy, the fermentation level was correlated with substrate Consumption rate when the total glucose concentration was lower than 76.6g/l. Higher feeding concentration of glucose would cause the accumulation of substrate and limit of oxygen supply. By using the variable feeding speed fed-batch culture, the residual glucose was easily controlled within 10.0g/l and higher biomass and spore count could he got. Medium with low C/N ratio in growth stage was helpful for spore formation. Of fed-batch 19#, maximum biomass, crystal concentration, bioassay efficacy and spore count were 65.2g/l, 10.11 mg/,l, 0.28ug/ml diet and 1.29 X 1010/ml respectively. In fed-batch culture of 19#, low C/N ratio medium was fed at earlier growth stage while high C/N ratio medium was fed at later growth stage. Compared with batch culture 3#, its glucose Consumption was 2.76 times higher, whereas maximum biomass, crystall concentration, bioassay efficacy and spore count were 3.08, 3.25, 2.79, and 3.39 times higher respectively. Feeding at spore and crystal formation inhibited spore formation, caused the variation of morphology of crystals and expression of crystal protein with abnormal molecular weight.

Niche of Bark Beetles within *Pinus armandi* Ecosystem in Inner Qinling Mountains

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The bark beetles of damaged *Pinus armandi* Fr. and their niche were investigated in middle areas in Quinling Mountains. The result showed tat 19 species of bark beetles infected and damaged Pinus armandi in pine ecosystem of Quinling Mountain, but only 11 species of bark beetles were obviously competitive for the spatial and trophic niches. *Dendroctonus armandi* Tsai et Li was a precursor of bark beetles to attack the healthy host, which brought through blue stain fungi to infect host trees, and their symbiotic fungi prior to *Dendroctonus armandi* ward overcame the resistance system of host trees. In the Quinling Mountains bark beetles are depentaed on different times to infect host trees. Competition of bark beetles for the spatial and trophic niches can competitively coexist, and thus the ecosystem could be steadily maintained.

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8.00.00 Forest and environment

Ökologischer Wandel als Grundlage und Triebkraft einer zukunftsorientierten Waldbewirtschaftung

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Eine zukunftsorientierte Waldbewirtschaftung begreift den Waldel der ökologischen Bedin-gungen aufgrund von Umweltveränderungen sowie sich ändernden gesellschaftlichen Anforde-rungen an einen mehrfunktionalen Wald als Herausforderung.

Voraussetzung für Nachhaltigkeit in Ressourcennutzung und Landschaftsschutz, für die Bewertung der umweltrelevanten Leistungen der Wälder ist die Bündelung und Strukturierung vorhandenen Wissens und die Einordnung neuer Erkenntnisse über Waldökosysteme in be-herrschbare, ökologisch begründete Elementarheiten des Waldes, die wir als Wald- bzw. Forstökosystemtypen bezeichnen. Diese werden über Wirkungszusammenhänge von Bio- und Geosystem in Raum und Zeit durch ökologisch bzw. ökologisch-ökonomisch determinierte "Fahrrinnen" geführt.

Bei einer im Rahmen der Waldformation einmaligen Merkmalskonfiguration sind sie (über Schlüsselfaktoren quantifizierbar) in sich weitgehend homogen in wesentlichen strukturellen Merkmalen, wie Zusammensetzung und Mengenanteile der Baumarten, Schichtung und Schichtenaufbau, Arten- bzw.Artengruppenzusammensetzung der Bodenvegetation und deren Mengenentfaltung, durchschnittliche Anzahl der in den jeweiligen Entwicklungsstadien beteiligten Pflanzenarten, in Qualität und Quantität wuchsbestimmender ökologischer Faktoren, wie Bodennährkraft, Luft- und Bodenfeuchte, Strahlengewinn und Wärme, in wesentlichen Prozeßabläufen, wie geochemischen Stoffflüssen (C, N, H2O u.a.), Nettoprimärproduktion, inter- und intraspezifische Konkurrenz, Regeneration. Sie grenzen sich von anderen Wald- bzw. Forstökosystemen durch qualitative und quantitative Unterschiede im Zustand und in der Ausprägung o.g. Merkmale ab. Daraus resultiert für die Einheiten eine definierbare waldgeographische Stellung, eine in sich ähnliche genetische Ausstattung, eine gleiche Entstehungsgeschichte (natürlich=Wald, halbnatürlich=Halbforst, künstlich=Forst).

Forstpraktisch sind Wald- und Forstökosystemtypen flächenkonkrete Informationsträger zu ökologischen, biologischen, ökonomischen sowie sozialen Leistungen und Funktionen der Wälder und Forsten. Wald- und Forstökosystemtypen in der Einheit von Standort und Betand sind in der Forschung anhand relativ weniger, sorgfältig ausgewählter und hinsichtlich Struktur, Ökologie und Prozeß intensiv untersuchter Ökosysteme (Fallstudien) zu determinieren und zu parametrisieren. Die dabei erkannten Beziehungen zwischen (nur aufwendig quantifizierbaren) wuchsbestimmenden ökologischen Faktoren sowie Prozeßabläufen auf der einen und (vergleichsweise einfach erhebbaren) Strukturmerkmalen auf der anderen Seite erlauben eine flächenhafte Verallgemeinerung von Forschungsergebnissen. Dies wird beispielhaft dargestellt, indem verschiedene Wald- und Forstökosystemtypen hin-sichtlich ihrer wasserwirtschaftlichen Leistungen (pflanzenverfügbare Bodenfeuchte, Tiefenver-sickerung, Grundwasserneubildung), ihrer Produktivität (Kohlenstoffbindung und -speiche-rung) sowie ihrer Naturnähe (biologische Vielfalt) verglichen werden.

Ziel dieser Vergleiche ist, über die Bereitstellung fundierten Wissens die Zukunftsfähigkeit naturnaher Wälder zu sichern. Über das Konzept einer dem natürlichen Standortswandel fol-genden potentiell-natürlichen Vegetation wird dabei der Grenzbereich bestimmt, bis zu dem eine differenzierte Naturabweichung im Sinne eines ökologisch-ökonomischen Kompromisses zugelassen werden und jenseits dessen nicht mehr toleriert werden kann, weil sie zum Schaden wird.

Spatial aspects of forest management-landscape ecological perspective

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Keywords: landscape ecology; forest management; sustainability; environment; ecological function.

As long as (or wherever) timber production has been considered the only or at least the principal forest function, the spatial considerations of forest management have been limited primarily to the percentage of forest complexes, proximity to the market or at least to the means of transportations (from rivers to railways). Considerations of site productivity were of secondary importance - particularly in cultural landscapes where forest lost in this regard invariably to just about any other land use.

Thus, timber grows everywhere if only given a chance and this forest function (so important in itself) rarely, if ever, influences the forest distribution patterns in cultural landscapes.

Sustainability is said to have three components: ecological, social and economic one. The same could be said about the role of forest in modern cultural landscapes. As a landscape component forests perform three major groups of functions: the ecological/environmental, social/culturally conditioned and economic/production ones.

Managing forests for the said three groups of functions from a spatial point of view clearly requires different approaches. Production functions by and large require only sufficient forest area of reasonable site quality and proximity to the market is only of secondary importance. Social functions (e.g. recreation, aesthetic) are much more dependent on the proximity of the beneficiaries (visitors). As such they are subject to changes in the growth of cities and industrial areas. Losses of forests within such »catchment areas« can be only replaced in a given radius - depending on the willingness of the people to accept certain costs in terms of time and/or money.

Contrary to the above, majority of the ecological forest functions (e.g. antierosion, climate, water, habitat etc.) are not as flexible in the time and space. Largely they are natural givens - depending on natural conditions cannot be shifted around at will - they require a thorough knowledge of landscape ecology in the broadest sense of meaning.

Conserving biodiversity has recently become one of the most important (hopefully not just fashionable) forest functions. In many parts of the world forest is, indeed, some kind of Noah’s ark, conserving and saving many forms of life and natural processes.

In order to conserve such biodiversity not only large areas of diverse forest habitats are required. Conserving biodiversity on gene, species, ecosystem, landscape and higher levels of ecological integration requires quite clearly different principles of modern forest management for other forest functions; it is only that managing for biodiversity stresses that forests in space (landscape, region, even continent perhaps) need to be managed as a connected, functioning ecological system, considering of archipelagoes of forest complexes (patches) that are in distances that render possible functioning communications and are in addition connected with corridor systems (networks).

Application of this view of forests in management for all the other (particularly ecological) forest functions may bring a novel view of forest into the classical forest management. New questions will be asked and new solutions sought - particularly if we consider such (new?) forest management in the context of the three imperatives of modern forestry - i.e. of multiple use, close to nature and sustainable forest management.

Flora vegetation and conservation of forest gene resources of the National Park Conguillio, IX Region Chile

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Keywords: forest gene resource; abundance and importance of species; phytogeographic origin; life form.

The flora, vegetation and conservation to the millenarian forest resources of the National Park "Conguillío", located east of Temuco IX Región, Chile was studied.

Using the methods of the Zürich-Montpellier school of phytosociology, 59 vegetation samples were analyzed. Size and distribution of the samples were defined according to criteria of floristic, physiognomic and ecological homogeneity, and minimal area requirements. A floristic list was first obtained from the vegetation samples and then from herbaria collections, 248 vascular species. From the obtained vegetation table the frequency, abundance and an importance value of each species were determined. The phytogeographic origin and their life forms were obtained from other authors, associate with the descriptions of theirs, and were also determined.

It was concluded that the low homogeneity of the phytosociological table confirmed the presence of an alto diversity floristic among the sample analyses. Most important plant taxa include families Compositae and Papilionaceae. In the biological spectrum, Phanerophytes and Hemicriptophytes are abundant, indicating with it that the phytoclimate of the park is Hemicriptophyties. Principal components analysis revealed that dampness and temperature were the likely main factors in the distribution of the species in a park studied.

A most detail about to structure of the vegetable associations was studied, give these multivariate statistical analysis. The first, appears like if it to be a strong influence on the dynamic of vegetable analysed.

In the park and "Cordillera de los Andes" there is a scheme of retrograde succession from community climax of *Araucaria araucana* (Mol.) Koch.-*Nothofagus pumilio* (P et E) Krasser., to the condition of the continued steppe in zone ecotonal of *Araucaria*, Steppe and *Nothofagus pumilio* in the most humid conditions. At the same that other research, was determined the following process of secondary succession for the park.

Harvest and Fire

Gramineae

Pernettya Sp - *Escallonia Sp*

Chusquea Sp - *Berberis Sp* - *Escallonia Sp*

Araucaria araucana - *Poa tristigmatica or*

Araucaria araucana - *Nothofagus antarctica or*

Araucaria araucana - Nothofagus dombeyi or

Araucaria araucana - *Nothofagus pumilio*

In this way was observed that *Araucaria araucana* takes part in many kinds of communities in agreement with the kinds of soil, height and humid available in the zones was studied. Nevertheless the general standard shows a defined relation between the composition of different stand and the humid and height over at sea level. *Araucaria araucana* begins to grow at 1050 m.s.n.m., mixed with *Nothofagus antarctica* (G Forster.) Oerst., *Nothofagus alpina* (P. et E.) Oerst and *Nothofagus dombeyi* (Mirb.) Oerst. At the 1.230 m.s.n.m, only with *Nothofagus dombeyi*, at the 1.350 m.s.n.m., the forest is compound for *Araucaria araucana and Nothofagus pumilio* and at the 1.600 m.s.n.m., *Araucaria araucana* to disappear.

Through the phytosociological study, the following wooded associations *Araucarietum araucanae*, *Araucario-Nothofagetum pumiliae*, *Araucaria araucana-Poa tristigmatica*, *Araucario-Nothofagetum dombeyosum*, *Nothofagetum pumillionis and Chrysosplenio-Nothofagetum dombeyosum and Austrocedrus chilensis-Nothofagetum dombeyosum*.

Jointly, to these wooded masses, in the forest was founded bioindicators species with which was determined among others. The conditions of richness or poverty of nutrients, humid, degradation of soil. Finally, the forest resources, the flora and the ecosystems of the park are real banks of genetic pool, since into them are preserve species with problems of conservation, in addition they have a millenarian species in which the forest science don't still to dedicate it a real importance.

Climate change: some evidence from a tropical forest experimental watershed in the Philippines

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Keywords: global warming; climate change; evidence; monitoring; tropical forest; the Philippines.

Global warming, or climate change in general, and its consequences are among the pressing issues today. For example, the global average surface temperature has increased by 0.3-0.6°C over the last century (Lasco and Pulhin, 1998). The changes have been attributed to the rise in concentration of greenhouse gases (GHGs) in the earth's atmosphere. GHGs like carbon dioxide, methane, nitrous oxides and chlorofluorocarbons absorb thermal radiation emitted by the earth's surface. Hence, rising concentration of GHGs in the atmosphere could lead to a change in energy balance and consequently the world's climate.

To monitor the climate changes, data from an experimental catchment in the Philippines was made. Analysis was made for the daily rainfall (1970-1997) and air temperature (1974-1997) records at the dipterocarp forest catchment of the Angat watersheds in San Lorenzo,Norzagaray, Balkan, Philippines. The area is considered a representative of the evaluation of dipterocarp forests in the country and belongs to Climatic Type I based on the Coronas'(1920) system of classification.

Data shows that there is an increasing trend in temperature, an evidence of warming during the recent years. The mean annual temperature during the intervening years (70s, 80s, 90s) is 26.9°C, 27.1°C and 27.5°C with 1997 being the hottest with an annual mean temperature of 28.2°C. The 1997 value is 1.0°C higher than the 1974-97 mean annual temperature and 0.7 ohigher than the mean annual temperature in the 90s.

Annual rainfall varies from year to year with an annual average of 3,198.0mm. The 1997 rainfall is about 32% below the annual average. During the study period, there were twice as many El Nino years than La Nina.

Relationship of soil nutrients to occurrence of *Shorea curtisii* in two hill dipterocarp forests in Peninsular Malaysia

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Keywords: dipterocarp forest; soil nutrient; species occurrence; regeneration; soil acidity; Malaysia.

Shorea curtisii (Seraya) is the most important timber species in the hill dipterocarp forest (HDF) of Peninsular Malaysia. A study was conducted to gauge the influence of soil nutrients on Seraya's occurrence in two contrasting virgin HDF ecosystems; an isolated hill on the western coastal plain with clinal species distribution pattern (Selandar Forest Reserve, Melaka State) and a foothill of an inland mountain range with patchy or mosaic pattern (Senaling Inas F.R. in Negri Sembilan State). Seraya, a normative HDF species was compared with *S. leprosula* (Meranti Tembaga), a normative timber species of the lowland dipterocarp forest with which it overlaps in its lower altitudinal limits of distribution. Plots measuring 10x10 m were laid out using stratified random and systematic designs respectively in Selandar (n=40) and Senaling Inas (n=70). As species abundance measures all trees (dbh >10cm) were identified, enumerated and dbh measured and regeneration (1.5m height to dbh <10cm) similarly identified and enumerated. Soil samples were augured (0-30cm depth) at five points per plot, bulked, processed and analysed for total nitrogen, phosphorous, potassium, magnesium and CEC, available phosphorous and pH. Data was analysed using Canonical Correspondence Analysis with strong canonical correlation between species and environmental axes taken as $r^2>0.70$. Results indicate overall strong influence of soil nutrient factors on species occurrence in both study sites. Total phosphorous, potassium and soil pH were strongly influential on species with variation between sites, vegetation type and abundance measures. In Selandar, tree frequency was affected by soil acidity alone and regeneration by acidity and potassium. In Senaling Inas, tree frequency and basal area were influenced by both acidity and potassium while regeneration by acidity and total phosphorous. Tree vegetation appear more responsive to soil nutrients in the more complex Senaling Inas stand. But regeneration appears uniformly sensitive in both sites. Biplot analyses showed greater Seraya tolerance for lower fertility and more acidic soils compared with Tembaga. The tolerance was however more marked among regeneration in Selandar but less so in Senaling Inas. The possible influence of soil nutrients on Seraya occurrence and distribution pattern in the HDF was discussed with implication on its post-harvest regeneration.

Estimation of biomass and nutrient extraction through forestry interventions in natural *Nothofagus pumilio* forests in Magallanes, Chile

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Keywords: forest; biomass; nutrient; *Nothofagus pumilio;* forest management; productivity; Chile

The use of a forest ecosystem under sustainable assumptions implies the need of evaluating the distribution and total amount of existing products feasible of being extracted from a forest with each forestry intervention. The productive capacity of a forest site may be determined through quantification of existing biomass (dry weight unit/surface unit). This information may be supplemented with the study of nutrient accumulation in trees to optimize forest resource use.

In order to estimate the effects of natural *Nothofagus pumilio* forest management on biomass and nutrient extraction, two stands - one pure, uneveraged of the species, and another one mixed, uneveraged with *Nothofagus betuloides* - were studied, both located in the Province of Magallanes, Chile.

In order to estimate existing biomass in each stand, allometric equations providing the dry weight of the different tree components were adjusted using BHD and their total height as predictive variables. Nutrient accumulation was estimated by weighing biomass amount with nutrient concentrations determined in tissue subsamples. Forestry intervention in each stand was simulated using extraction rates accepted under Chilean legislation, estimating biomass and nutrient amounts extracted, to remain standing, and to remain as waste on the forest floor, comparing two treatments: one with and the other without barking.

Total accumulated biomass in the pure stand was 421.8 t/ha (85.1% boles and 14.9% crowns). Total estimated aerial mineralomass reached 5,572 kg/ha (96% accumulated in woody tissues and 4% in leaves), with percentage distributions of 55.2, 29.2, 6.7, 4.4, 2.2, 1.6, 0.3, 0.4, 0.7, and 0.03 in Ca, N, K, Mg, P, Mn, Fe, Zn, B, and Cu, respectively.

The mixed stand exhibited a total accumulated biomass of 322.2 t/ha (81% boles and 18.6% crowns). Total estimated aerial mineralomass was 3,480.2 kg/ha distributed on a percentage basis in 52.9, 27.2, 9.7, 4.5, 3.6, and 1.1 of Ca, N, Mg, K, P, and Mn, respectively. The remaining 1% corresponds to Cu, Fe, Zn, and B.

When simulating application of a protective felling (shelterwood system) on the pure stand with a 49.6% reduction in the basal area and a protective canopy of 161 trees to remain standing, 129 t/ha of biomass would be extracted and 79 t/ha would remain as harvesting waste. An amount of 521 kg/ha of mineralomass (97.9% macro-nutrients and 2.1% micro-nutrients) would be removed. A figure of 1,935 kg/ha of nutrients in the waste would remain on the forest floor. If extracted boles were barked on site, extracted biomass would descend 7.2% and the removed mineralomass amount would be 422.5 kg/ha.

When simulating application of a protective felling on the mixed stand, with a 45.2% reduction in the basal area and a protective canopy of 176 trees to remain standing, 146.2 t/ha of biomass would be extracted and 30.4 t/ha would remain as harvesting waste. Development would remove 1,125 kg/ha of mineralomass (98.2% macro-nutrients and 1.8% micro-nutrients). A figure of 564 kg/ha of nutrients in the waste would remain on the forest floor. If barking is considered, extracted biomass diminishes 9.6% and exported mineralomass amounts to 462 kg/ha.

Certification of forest reproductive material

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Keywords: forest reproductive material; national and international standards; plant varieties; labelling system; material source identification.

Several national and international standards for Forest Reproductive Material (FRM) have been developed, for example by the Organisation of Economic Cooperation and Development (OCSE, 1974) and the European Economic Commission (CEE, 1967). Their objective is to ensure that anyone establishing a plantation for forestry purposes is supplied with healthy planting stock, genuinely of the provenance or origin chosen by the customer; in addition, certification maintains and makes available to customers high quality FRM of superior crop plant varieties and enable the forest industry to export FRM around the world.

Over recent years, considerable changes have occurred in the forest nursery stock demand, the more important of these being summarised as follows:
1. a growing request of a wide variety of species, for a wide range of uses (multi-purpose forestry);
2. an increasing demand for plants and seeds of native species, broadleaves rather than conifers, and local provenances in forest practice;
3. an increasing performance potential requirements for planting stock.

Because of these changes, the OCSE and EEC schemes are inadequate, as confirmed by the fact that the demand for certification of FRM under these schemes has dramatically decreased. In particular, for the EEC scheme, it depends on the fact that it covers only few species (mostly conifers) and considers appearance and size for evaluating plant quality. Today, such parameters are considered inadequate indicators of survival and growth, while the main determinant of tree seedling capacity to perform well after outplanting is their physiological condition.

As far as the contents of FRM standards, there are three main set of issues that should be considered: inherent genetic quality (i), material attributes (ii) and performance attributes (iii).

(i) Nurserymen must keep accurate records that explain in detail the history of the FRM, taking into consideration that use of local provenances, varieties or ecotypes is preferred and encouraged by national and international resolutions.

(ii) Material attributes, that can be measured directly. They include both morphological attributes, such as height, collar diameter, dry weight, volume; and physiological attributes, such as bud dormancy, water status, mineral nutrition, carbohydrate status, levels of growth regulators and enzymes.

(iii) Performance attributes, which are measures of the performance of the whole seedlings when subjected to specified test conditions. They include a wide array of tests, such as root growth capacity, vigour test, frost hardiness, infrared thermometry, chlorophyll fluorescence, ethanol analysis.

Moreover, for an effective guarantee of the FRM, not only good standards are requested, but also a third-party independent system of certification based on international well established rules. This is the only way certification can guarantee that FRM has been collected, handled and produced according to a known set of standards. Process and product certification should be associated to a labelling system to be used to mark FRM traded in the international market.

The introduction of certification programme in forest nurseries is very likely to improve plantation establishment, preventing the use of not source identified seeds or the planting of poor quality seedlings. In addition, it can be beneficial to nursery personnel in developing new stock types or nursery cultural regimes; enhance confidence between nurserymen and customers, field foresters and reforestation scientists.

Towards priorities of biodiversity research

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Keywords: biodiversity research; policy and management focus; management objective**.**

In 1996 the Tropenbos Foundation published the policy document ‘Towards Priorities of Biodiversity Research’ (Biodiversity Policy Document: BPD). The BPD proposes:
1. A procedure to identify research priorities for biological diversity, and
2. A preliminary and partial application of this procedure.

Starting point of the procedures are main policy and management objectives of the Tropenbos programme:
1) Land-use planning for conservation and sustainable forest land use
2) Designation and management of totally protected natural forest areas
3) Protection and reintroduction of endangered species
4) Documentation and adoption of indigenous management of tropical rain forests
5) Use and valuation of non-timber forest products
6) Sustainable timber production
7) Rehabilitation and productive use of secondary forests

The information needs related to the different policy and management objectives have been listed and categorised into site specific information needs and generic information needs.

Also considered are the three dimensions of biodiversity research:
1) spatial patterns
2) temporal patterns(short-, medium- and long term)
3) functional relationships

Based on the seven objectives, the information needs and the three dimensions of biodiversity research, information was gathered as to the availability of research methods that would produce the results necessary to fulfil these objectives. This process resulted in an ‘information matrix’, which can be used in various ways, as a basis for selecting the most urgently needed research:
1. The matrix facilitates the identification of repeated needs for similar types of generic information.
2. The matrix shows research areas where methodological improvements are most needed.
3. The matrix provides a means for a critical review of the relevance for policy and management of ongoing or planned biodiversity research.

Tropenbos will follow the procedure outlined in this paper to further develop the biodiversity component in its own research programme. The policy and management focus of each site will be matched with the policy and management objectives described in this paper. Research proposals will be assessed on the basis of a comparison with the information matrix.

A preliminary ranking of research priorities lists:
1. Indicators for monitoring biodiversity
2. Criteria to identify forest land suitability
3. Criteria to evaluate the results of biodiversity monitoring/land suitability rating
4. Distribution of forest types/species
5. Taxonomic studies Taxonomic studies

The transfer of timber line to higher altitudes in the conditions of Kopaonik

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Keywords: timber line; spatial distribution; forest; anthropogenic factor; national park; Yugoslavia.

The National Park Kopaonik extends over the highest parts of the mountain Kopaonik which is situated in the central part of the Balkan Peninsula, at the altitude of 2017 m. The flora of Kopaonik consists of 1350 taxa, and alpine flora in the National Park includes 825 species and subspecies, of which 91 are endemic, 82 subendemic and 3 stenoendemic plants. The region of the National Park Kopaonik influenced by biotic, abiotic and especially by anthropogenic factors in the past, suffered numerous transformations which affected the composition, abundance and distribution of wildlife. Unfortunately, many plant and animal species are extinct in this area. A significant, often decisive influence on the flora and fauna was exerted by the anthropogenic factor reflected in daily mining by which this mountain was named, forest clearing, pasturing and, more recently, the expansion of tourism with all the accompanying activities (traffic, water engineering, visitors' circulation, etc.).

This paper analyses the issues of timberline translocation. It proves that the upper tree line gradually changes to higher altitudes, "occupying" the previous communities of juniper and blueberry (*Vaccinio-Juniperetum*). This phenomenon is proved in three ways:

By comparing the photographs made 40-50 years ago with modern photographs of the same sites.

By comparing actual forest maps with old forest maps.

By observation and records at several sites where the gradual disappearing of juniper and other vegetation is evident, due to invasion and gradual formation of spruce forest canopy at higher altitudes.

Field observation is accompanied by measurements and attempts to assess the velocity of spruce-forest upper tree line change. The explanation of this phenomenon should be sought in the three significant reasons:

1) small-scale but still present artificial afforestation of the area, 2) drastic reduction of livestock which used the grazing land in this area, and probably the most significant reason: 3) global, as well as local climate changes, especially the process of mean annual temperature increase.

Impact of silvicultural treatments on monospecific stands of *Aucoumea klaineana* Pierre

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Monospecific (or monodominant) forests dominated by long-living pioneer species are a frequent stage of secondary successions in tropical areas. These long-living pioneer species (*Terminalia superba, Triplochyton scleroxylon, Aucoumea klaineana*, etc.) are often of great economic value and forest logging operations have heavily relied on them in Congo, Gabon since the turn of the century. However, nowadays other values of these species and of the associated vegetation are more and more taken into consideration: biodiversity, carbon sinks, non timber forest products, etc. Secondary forests in the coastal forest-savanna mosaic of Gabon are mainly even-aged monospecific *A. klaineana* stands developed on areas abandoned after shifting cultivation. *A. klaineana*, a typical long-living pioneer tree, represents about 80% of the logged volume and is, therefore, of tremendous importance for the Gabonese forest sector.

Sustainable management of such monospecific forests should not only improve growth and yield of the dominant timber species but also ensure its regeneration while delaying or stopping the natural evolution of this secondary vegetation towards a possible climacic or more mature forest devoid of the interesting long-living pioneers.

The continuous monitoring since 1987 of 34 permanant plots of natural pure *A. klaineana* stands, ranging from 5-10 to over 60 year-old, in the coastal forest-savanna mosaic of Gabon is a precious tool to quantify the impact of silvicultural operations including commercial logging on growth, regeneration and mortality. In 1989, 13 plots (from 7 to 45 years old) were selectively thinned in order to promote the growth of dominant *A. klaineana* designed as plus trees. In 1995, two 50 year-old plots were commercially logged to assess logging damages and post-logging regeneration.

Natural mortality of *A. klaineana* did not substantially increase after the silvicultural operations. Recruitement between 1987 and 1997 (individuals with a diameter at breast height reaching 10 cm) was favourable to *A. klaineana* if the stands were thinned before reaching 35 years old : the species accounted respectively for 57 and 49% of the recruited trees in the thinned and control plots. Three years after logging, *A. klaineana* is the most abundant species (11%) of the natural regeneration (individuals higher than 30 cm with dbh < 30 cm) in the most intensively harvested plots. In spite of large open areas due to a considerable harvesting intensity (more than 15 stems/ha), the density, higher than in treefall gaps (1%), is much lower than in fire-protected savannas (31,5%). Interspecific competition appeared favourable to the establishment of *A. klaineana* seedlings in situations where both early pioneer and shade-tolerant species were excluded: moderately damaged areas (lightly open canopy and damaged soil) or large open areas temporarily flooded. The relevance of the silvicultural treatments in order to delay the disappearance of *A. klaineana* is discussed.

Efecto de la tala en la estructura de un bosque autóctono del Uruguay (Sudamérica).

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En el Uruguay existe muy poca información sobre la dinámica de las comunidades leñosas, a pesar de lo cual han sido explotadas fundamentalmente para la obtención de energía (evidentemente sin los planes de manejo silvícolas adecuados). Gran parte de las mismas se han regenerado, aunque no hay datos que establezcan si han habido cambios importantes en su estructura.

Con el objetivo de determinar el comportamiento de un "bosque de quebradas" (formación vegetal caracterizada como selva subtropical empobrecida) luego de la tala, se determinó la estructura fitosociológica de dos sectores contiguos del mismo en las nacientes del Río Lunarejo, Uruguay, (Originalmente toda la zona tenía las mismas características, sin embargo en el año 1982 un sector fue talado (tala selectiva de especies maderables) para la obtención de madera de aserrío. Posteriormente no hubieron talas lo que posibilitó la regeneración del bosque. Esto permite comparar la estructura fitosociológica actual con la original y por lo tanto establecer los efectos de la intervención.

En este caso se entiende por estructura fitosociológica la composición florística, la cantidad de individuos por superficie, la distribución horizontal y cobertura de cada especie presente, resumido en un índice jerárquico de las especies que componen la comunidad.

Se establecieron cinco parcelas de 500 m^2 en sitios considerados característicos de cada sector, se censaron los ejemplares arbóreos, calculándose para cada especie los parámetros: Abundancia (Ab), Frecuencia (Fr), Dominancia (D) y Regeneración Natural (RN). A su vez con estos parámetros se calcularon el Indice de Valor de Importancia (IVI) e Valor de Importancia Ampliado (IVIA) con los cuales se caracteriza la estructura de cada comunidad.

No se encontraron diferencias florísticas ni fitosociológicas importantes entre las comunidades. En cada caso cinco especies representaron alrededor del 60% del IVIA, siendo tres de ellas comunes a ambas. Esto quiere decir que luego de la regeneración se mantienen como más importantes las mismas especies que en la situación original. Sin embargo si se consideran los valores absolutos de los parámetros se observa que la comunidad intervenida presentó aproximadamente el doble de ejemplares por unidad de superficie, y la mitad de Dominancia que la situación original (tanto para el total de la comunidad como para cada una de las especies más importantes), es decir se trata de una comunidad con el doble de individuos pero estos son de mucho menor tamaño, lo cual demuestra que la regeneración se debió al rebrote de cepas cortadas (como en otras situaciones) sino por nacimiento de nuevos individuos.

Site quality estimation of *Pinus roxburghii* Sargent stands in India

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Forests of chirpine (*Pinus roxburghii* Sargent) account for 8.3% of the total forests area in India and occur gregariously as pure crops in outer Himalaya and Shiwalik ranges at elevations ranging from 600 to 2100 m, otherwise it is found in a continuous belt belt between latitudes 27^o to 35^o N and longitudes 70^o to 92^o E. The present study was conducted in Solan Forest Division of Himachal Pradesh in India with the aim to classify sites under chirpine due to its differential growth pattern on different sites. The direct method of site quality estimation viz., height intercept method was followed, since it is a time saving method, after selecting all the 19 years old plantations and natural stands under Solan forest division. In all there were seven such sites viz., Dharampur natural stand, Kandaghat plantation, Sabathu natural stand, Bauhli natural stand, Barog natural stand, Sultanpur plantation and Oachghat natural stand. Total tree height and height intercept viz., mean internodal lengths of 3, 4, 5, 6 and 7 internodes from breast height were recorded for the selected trees in each site. Linear, log linear and curvilinear models were tested for different height intercepts in order to find out the best mean internodal length (height intercept). Six years mean internodal length was found as the best indicator of site quality. The 5 years height intercept was also found to be quite significant but its significance was less than 6 years height intercept. The model finally developed by 6 years height intercept was:

Height19 = 3.0493 + 0.1419 HI - 0.0007 HI2 (adjusted R^2 = 0.54) (0.0223) (0.0002)

HI = Height intercept (6 years mean internodal length)

Figures in parentheses are respective standard errors.

On the basis of 6 years height intercept classification of different sites was done as : the site with less than 30cm height intercept was graded as poor site (Dharampur natural stand), sites with height intercept between 30-50cm were considered as average sites (Kandaghat plantation, Sabathu natural stand and Bauhli natural stand), sites with height intercept between 50-70cm were called as fair sites (Barog natural stand, Sultanpur plantation) and the site with height intercept more than 70cm was rated as good site (Oachghat natural stand).

The present calssification was then compared with the standard site quality classification given by Forest Research Institute (FRI), India for chirpine stands. The good site quality site was equivalent to site quality I/II given by FRI and poor site quality sites was equivalent to site quality III. Thus, the findings suggested that the height intercept method can be reliably used for estimating growth of young chirpine stands and can be taken as an indicator for their future management.

Regional forest monitoring in Latvia

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Keywords: forest health; ecological monitoring; Scotch pine; Norway spruce; common birch.

Regional forest monitoring in Latvia was started at 1990 according to International co-operation programm methodic ICP Forests (International Co – operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests 1 st Level). The objective on the ICP Forests Programme is to ensure a long – term and systematic observation, assessment and forecasts health condition in Latvia.

The main tasks are:

- to carry out a general assessmsnt of forest condition;
- to determine the changes and trends in forest health;
- to detect the main factors influencing forest health.

The annually observed national grid in Latvia is 8 x 8 km and comprises 379 observation plots with 9005 trees in 1997. Most the assessed trees are conifers – Scots pine (47,1%) and Norway spruce (26,3%); the most represented broadleaf species is common birch (20,9%). In general about 90% of broadleaves and 80% of conifers observed are considered to be none or slightly damaged.

The mean defoliation of Scots pine in 1997 reaches 22,8% and shows a statistically significant inprovement since 1996. About 74% of trees observed are none or slightly damaged; moderately damaged – about 25% of trees. Regarding forest monitoring data in 1997, insect attacks on Scots pine have diminished, associated with total population dynamics of insect species. The main factors influencing Scots pine health in 1997 are diseases (mainly *Cronartium flaccidum*) and bark insects (*Tomicus* spp., *Pissodes* spp., etc). The hard winter of 1996/1997 has also caused widespread snowbreaks, as well as different indirect effects.

The mean defolation of Norway spruce is 17,2%, being very close to the value in 1996 (17,1%). About 85% of Norway spruce observed are supposed to be undamaged or slightly dameged; only 14,4% are moderately and 0,5% severely damaged. In comparison with 1996 the changes in defoliation classes are slight. The main direct factors influencing Norway spruce in 1997 are game and insect attacks (*Ips typographus*). Changes in water availability (destroyed amelioration canal system, activities of beaver – *Castor fiber*) have also negative impact of sprucee health.

Regarding broadleaves the most widespread tree species is Common birch with the mean defoliation 16,7%, showing crown condition deterioration since 1995. Also crown condition of other broadleave species (aspen, Common alder, etc.) has become worse. The deterioration of tree condition of broadleaves is possibly associated with warm and dry summer of 1997.

Tree crown defoliation is significantly affected by phytopathological, entomological as well as mechanical damages, however, they explain only a part of crown damage. It is supposed that also meteorological conditions, air pollution and other factors directly and (or) indirectly influence forest health. The obvious impact of air pollution on tree condition is local and observed near stationary sources. In order to assess the effect of air pollution, meteorological and other factors, it is necessary to start a complex analysis of the forest condition, estimating the share of each of these factors in forest damage in Latvia.

Assessment of forest technologies and their impact

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Keywords: deforestation; ecological equilibrium; assessment of forest technology; forest development.

Growing population competition for poorly controlled forest resources is intensifying huge pressure and accelerating deforestation. The proportion of forest to the total geographical area in India is not sufficient to maintain ecological equilibrium though several forest policies were formulated since 1894. In India, studies have shown that dense forest cover (crown density 40% and above) is only 11.71% even though a country should ideally have 33% of its areas under forest. The country also loses 1.3 million ha of forest area every year and soil loss due to degradation which is equivalent to the loss of 30-50 million tonnes of food grains. This had called for a major shift in the policies and approaches and ultimately new forest policy was introduced in the year 1988, which envisages people involvement and their movement in the development, protection, management, maintenance of forest and augmentation of the raw material production. This means dissemination of forest technologies among the people. The dissemination of forest technology is a complex process as exemplified by the research studies conducted in India. It is probably universally recognized that behavioral change among people and those in hierarchy of systems for promoting it-is one of the requisite component of forest development, in addition to the technological, physical, social economical, political and cultural factors. One of the research studies entitled "Diffusion of forest tree species among the farmers of Karnataka" (1998) revealed that adoption of simple technology like growing of *Eucalyptus*, *Casuarina* and Silver oak trees by all farmers of Bangalore district has taken over 52 years. The researchers also evaluated the technologies against the identified various dimensions. It has been revealed that people felt that growing of tree species on their farm lands either on boundaries or as block plantations is relatively advantageous, compatible to soil, temperature and rainfall, less complex, less trialable and the results and observable. Further, farmers indicated that the initial cost and the operational cost required for growing tree species is high and low respectively. The profile of farmers revealed that majority of them studied up to primary level, having small land holdings, poor economic condition, less innovative and less cosmopolite. Further, they have occasionally participated in the forest extension education activities. thus, the characteristics of forest technology coupled with socio-economic, cultural traits factors are the reason for the slow diffusion process. Another study conducted during (1998) in Karnatka also revealed that the involvement of the people right from the planning, implementing and evaluation of the forest improvement and protection, will able to bring consciousness and awakening about the ecology and environment. Therefore, the strategies like Joint-Forest Management should be implemented in right spirit. Research assessment on tree co-operative societies indicated that the member people are aware of the importance of forest, for meeting fuel fodder and timber requirement through the established community forest. Wherever there is wasteland, such lands can be used to establish community forest by involving people themselves.

Introduction d'espèces ligneuses dans la jachère en zone soudanienne du Cameroun: effets sur le cycle de l'azote et la séquestration du carbone dans le sol

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En Afrique tropicale, la jachère, faisant suite à une période de culture, peut être considérée du point de vue agro-écologique comme une phase de stockage de carbone et d’éléments minéraux pour l’agrosystème. A la remise en culture, ces ressources sont plus ou moins mobilisables selon les modalités de la défriche (brûlage ou exportation des parties aériennes, dessouchage ou non).

En raison des besoins croissants en terres agricoles et de la lenteur des processus de remontée biologique, surtout en situation de surexploitation des ressources de la jachère, il est judicieux de trouver des systèmes accélérant la reconstitution des propriétés physiques, chimiques et biologiques du sol. Dans ce cadre, la jachère agroforestière qui permettrait d’accélérer la restauration de la fertilité du sol en agissant sur l’ensemble des cycles biogéochimiques et d’assurer une production végétale (bois, gomme arabique) apparaît comme une alternative intéressante.

L'objectif de la présente étude est de comparer à une jachère naturelle herbacée protégée contre le feu et le pâturage, des jachères plantées en *Acacia polyacantha*, *Eucalyptus camaldulensis* et *Cassia siamea*. La comparaison porte sur la production de biomasse, le cycle de l'azote et la fixation du carbone dans le sol. Quelques éléments sont donnés sur le comportement des cultures après jachère.

Dans la jachère à *A. polyacantha*, la fixation symbiotique de l'azote (de l'ordre de 630 kg/ha en 7 ans) et le fort recyclage qui l'accompagne, entraînent un stockage de l'azote plus important que dans les autres systèmes, à la fois dans la végétation et dans le sol.

L'important recyclage de l'azote par le sol est caractérisé par la grande quantité d'azote apportée par la litière, par la forte minéralisation de l'azote du sol et par le développement considérable en surface du système racinaire absorbant l'azote minéralisé. Le recyclage de l'azote est lié aux processus de minéralisation et fragmentation de la litière aérienne et racinaire qui donnent lieu à une incorporation de matière organique (MO) au sol sous forme de débris végétaux. Cette incorporation est responsable de l'augmentation significative en 6 ans des stocks de carbone du compartiment matière organique du sol sous *A. polyacantha* (MOS de taille < 2mm). Dans les autres types de jachère on n'observe pas de variation significative des stocks de C du sol pour la même durée. Chez *E. camaldulensis*, on observe à 6 ans une assez forte immobilisation de l'azote dans la biomasse aérienne et la litière au sol et pas d'incorporation de MO au sol sous forme de débris végétaux. *C. siamea* est une espèce exigeante en azote dont l'immobilisation rapide dans la phytomasse est suivie d'un fort ralentissement du cycle de l'azote caractérisé par une faible minéralisation de l'azote du sol, un arrêt de croissance et une baisse de production de litière à 4 ans. Cela correspond à une maturité précoce de l'arbre dont l'alimentation en azote est assurée par le recyclage par la litière. Néanmoins la faiblesse des flux d'azote correspond à une faible incorporation de MO au sol qui reste comparable à celle effectuée par la jachère naturelle herbacée.

La plus grande capacité d'*A. polyacantha* à stocker de l'azote facilement minéralisable, explique son effet supérieur sur le comportement des cultures suivantes après 5 ans de jachère.

Lorsqu'elle existe, l'augmentation du stock de carbone du compartiment MOS au cours de la période de jachère (+3,5 t/ha dans l'horizon 0-40 cm sous *A. polyacantha* de 6 ans) reste faible par rapport à la fixation du carbone dans les systèmes racinaires. Pour les systèmes *A. polyacantha, C. siamea, E. camaldulensis*, jachère herbacée et culture continue, cette dernière est respectivement de 9,8 t/ha, 6 t/ha, 5,7 t/ha, 1,3 t/ha et 0,5 t/ha si on exclut les souches. Cependant les systèmes racinaires se décomposent très rapidement après remise en culture, sous l'action de la macrofaune du sol en particulier les termites, et ce compartiment « racines » se montre très fugace par rapport au compartiment MOS qui demeure quantitativement stable après deux ans de remise en culture.

Age-related changes in forest communties of Lithuania

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Keywords: forest types; community composition; biodiversity; Norway spruce; Scotch pine; broadleaved stands.

In the forests of Lithuania (its territory is in the zone of mixed forests of Europe) Scotch pine (37%), Norway spruce (23%) and various broadleaved (birches, asps, oaks, ashes, black alders etc.) stands prevail. Clear cutting frequently shifts the species composition from conifers to soft deciduous species and later vice versa. Age-related changes in the species composition of vegetation of lower storeys occur in pure stands. Their clarifying is necessary for accurate assessment of the changes induced by human activity.

With increasing age spruce communities are typical of the most intensive shift of the species composition. In spruce stands (depending upon their age) five stages of the development of communities have been singled out: stand restoration (cutovers), stand closing (forming), thicket (pole stand), self-thinning and stabilization (subclimax). At the stage of stand restoration the communities are characteristic of the greatest species diversity and abundance (projection cover) of vegetation. The species typical of cutovers appear and spread. At the stage of stabilization species diversity of vegetation is slightly less. The least species diversity and even complete decline of forest ground cover vegetation are observed at stage of thicket of spruce stands. With increasing age of stands grass cover changes most considerably, while moss cover less. Besides, its nature of a change largely depends upon the forest type. The most insignificant changes in the species composition occur in glade, although the tendencies of changes in abundance are the same.

Forest ground cover vegetation diversity has been assessed according to the Shannon's index. The lowest values have been determined in the communities at the stage of thicket whilst the highest ones at the stages of stabilization and stand restoration (in some forest types the place of maximum is different).

In accordance with the T. Sorensen (1948) coefficient (when projection cover of different species is used for calculation) assessment of the similarity of different development stages of forest communities has shown that the communities at different stages of age in the same forest type are less similar as compared to these of the same stage in adjacent forest types. Phyto-indication method by H. Ellenberg (1991) - indices of ecological demand of plants and that by L. Ramenskij (1956) - ecological tables of plants have been applied. It has been determined that with increasing age of stands changes occur in the ecological conditions. The index of light varies most considerably. Its highest value is at the stage of stand restoration, slightly lower at stabilization stage and the lowest value is at the stage of thicket. The index of moisture is also highest at the stage of stand restoration. It is an indication of bogging up. At later stages with increasing age of stand the value of index diminishes. However, in different forest types its decrease is different. The tendencies of changes in other ecological indices are not distinct. It implies that these communities belong to one type of ecological conditions. Also it proves that similarity indices (Sorensen) applied in geobotany formally do not express ecological similarity of the communities. Consequently, determination of plant indicators is of great significance. Since there are very few indicators typical of a concrete forest type, which remain at all stages of stand development, determinants have been assessed. They permit us to identify forest communities of different types by distinguishing them from ecologically close types.

In pine stands as well as in spruce stands the communities of young stand being formed are typical of the greatest plant diversity. The most scanty vegetation is found in the communities of thicket (pole stand). However, the differences between various stages in pine stands are by far less as compared to spruce stands. In cutovers destroyed moss cover is restored at the thicket stage of young stands. In comparison to spruce stands, on dry sites of pine stands assessment of ecological conditions by the method of phytoindication has demonstrated slightly different results. It has been noticed that the needs of the communities of young stands in light are somewhat higher. It holds for pine stands at other stages. In cutovers no increase in moisture has been detected.

The process of underwood development and its species composition enables pine stands to be divided into two groups - stands which develop devoid of changes in tree species and these where the species composition shifts from pine to spruce.

Age-related changes in broadleaved stands one by far less. The communities of young stands are also characteristic of the most significant plant diversity. However, with increasing stand age the species composition of vegetation in formed stands changes negligibly; it can be partially explained by the fact that during self-thinning of broadleaved stands underwood density increases. In these stands significant fluctuation of the species composition of vegetation has been observed. It causes new problems in delineating protected territories and in assessing changes in vegetation.

Root biomass and symbioses in a first rotation of an *Acacia mangium* plantation - the role of soil disturbance and burning

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Fine root biomass, A-mycorrhizal infection and root nodulation was studied in *Acacia mangium* plantations in Sabah, Malaysia. Samplings were made at 1 and 9.5 years after planting within a paired catchment study on environmental effects and production from plantation establishment at conversion from dipterocarp forest. The treatments covered were 1) minimised soil disturbance and no burning before planting, 2a) crawler tractor log extraction and burning before planting - outside tractor disturbance and 2b) like 2a but - on soil disturbed by tractors. Tree production in the less disturbed and unburned catchment was double compared to the normal practice including soil disturbance and burning. This difference have been ascribed the tractor soil disturbance which covered 25% of the area, but tree production differences were also clear between unburned and burned undisturbed soils.

Initially fine root biomass in disturbed soils above 45 cm depth was only 25% of that of undisturbed soils, but in the end of the rotation the differences were non significant. The only exception to this was clay top soils (opposed to sand top soils and the areal mean) where root biomass was still only 42% of that of undisturbed soils. Total fine root biomass developed from 1.8 and 2.0 t ha^{-1} after 1 year to 3.6 and 4.4 t ha^{-1} at 9.5 years for "minimum disturbance" and "normal practise" respectively in comparison with 4.0 for the previous rain forest (0-50 cm). Initially A-mycorrhizal infection was higher after "minimum disturbance" (84% of root length) compared to burned but undisturbed soil (71%) and disturbed soils (60%). In the end of the rotation all treatment had reached up to between 77-84% of root length infected. However, at 9.5 years chitin analysis of the roots revealed possible differences in quality (better developed mycelium) with 0.93 mg chitin per g of dry roots in "minimum disturbance" and 0.74 and 0.49 mg g^{-1} for "normal practise" with burned soil and disturbed soil respectively.

Root nodulation was recorded at the first investigation. No nodules were found in samples from disturbed soils and in 35% and 31% of samples from "minimum disturbance" and burned but undisturbed soils respectively. Nitrogen fixation could not be calculated according to the natural abundance method, due to lack of suitable reference species. However, ratios between nitrogen and other nutrients in leaves from *Acacia mangium* and other species indicate that nitrogen fixation have been apparent.

These results fit well with investigations on the natural rehabilitation of disturbed soils on tractor tracks. Within a time span of a decade the top soil organic content slowly increases and bulk density decreases. However, the development of soil structure and favourable porosity have been shown to take longer. That could explain that at the end of the rotation there were possibly less developed mycelia in disturbed soils and still lower fine root biomass in disturbed soils with more compact clay top soils. It should also be noted that initially the development of A-mycorrhizal infection was lower by 16% in burned but nondisturbed soils compared with the unburned soils. This difference may well be one of the keys to the doubled nutrient uptake by trees in the initial years. Avoidance of burning did not only stretch out nutrient release from residues (decomposition) in time, but also gave better circumstances for retention of nutrients in the site biomass.

Ecological and productivity characteristics of mixed endemic-relic pine forests in Yugoslavia

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Key words: mixed endemic-relic pine forests; enviroment conditions; stand characteristics; productivity; tree development

The research was carried out in the mixed forest of autochthonous pines: Macedonian pine (*Pinus peuce* Gris.) and Scotch pine (*Pinus silvestris* L.) with white-bark pine (*Pinus heldreichi* Christ.), beech (*Fagus moesiaca* Domin, Maly/Czeczott) and other species, in the National park ‘Sarplanina’in Serbia (Yugoslavia).

This intresting plant community of high mountain forest eco-systems is situated in the nature reservation "Jazinacko jezero". It is phytocoenologically classified as *Pinetum peucis-silvestris* prov. Macedonian pine and white-bark pine are nature rarities - Tertiary relics and subendemics of the Balkan Peninsula and this part of Europe. Their distribution is microdisjunctive, confined by the subalpine zone. Endemic character of these species and their representation in alpine forest ecosystems indicate the characteristic ecological requirements and biological features and the specific flora of the Balkan Peninsula.

The researched stand is situated in specific enviroment conditions: altitude 1,600-1,700 m, exposure southwest, and slope 25 degrees. It is over silicate parent rock and shallow acid brown soil. The mountain masiff of Sarplanina is the natural border with Macedonia and its geographic position conditions the specific climate characteristics - it is situated at the meeting point of Aegean, Adriatic and continental climate, which are modified by alpine relief, and can be characterised as submediterranean-continental mountain climate. Climatic conditions at this altitude (1,700 m) are characterised by mean annual air temperature about 5.4^{o}C, in the growth season (May-September) 12.4^{o}C and average annual rainfall 1,380 mm (in the growth season 45%). According to Thornthwaite's classification, the climate is perhumid; according to Koppen's classification, its group is Dfb.

The stand is even-aged, with complete canopy, aged 80-100 years. The number of trees is 1380 per ha, with diameter variation of 7.5-87.5cm. The percentage of tree number is: Macedonian pine 33%, Scotch pine 37%, white-bark pine 18%, and other species 12% (beech and sycamore). Mean diameter of Macedonian pine is 18cm, Scotch pine 27, white-bark pine 28.5cm, and beech 19cm. Tree number distribution in diameter classes is not typical for even-aged stands because of a greater representation of Macedonian pine, but also beech and maple in lower diameter classes, which may indicate a gradual invasion of these species in the forests of heliophilous pines. Macedonian pine and beech mean height is 14cm, Scotch pine 16.5m, white-bark pine 15m. Dominant trees attain the height of : Macedonian pine 22 m, white-bark pine 18 m and Scotch pine 24 m. Stand productivity is characterised by total volume 474 m^3ha: Macedonian pine 22%, Scotch pine 48%, white-bark pine 25%, and other species 5%. Mean of dominant trees (20% largest dbh trees) aged 80 attain the dbh of: Macedonian pine 31 cm, white-bark pine 28 cm and Scotch pine 37 cm. Current diameter increment of Macedonian pine culminates between the ages of 20 and 25 (6.8mm), white-bark pine between 30-40 (5.6mm), and Scotch pine about the age of 20 (9.4mm). Macedonian pine and white-bark pine diameters, about 50-70cm at the age of 80-100, and volume 474 m^3/ha, show that these (rare) forests may be regarded as highly productive in their natural site (high mountain habitats).

The structure development and maintenance of this intresting plant community of high mountain ecosystems should be supported by active protection. Natural regeneration of these autochthonous pines should be initiated and directed selectively, by the correspodending strictly controlled silvicultural treatments in the aim of extending the distribution and enabling the more abundant progeny of these species.

Nutrient budget of an agrosilvopastoral system - a case study from Kerala, India

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Homesteads of Kerala present an excellent example of a tropical agrosilvopastoral system. However, quantitative information on the nutrient budget of the system are lacking. A field investigation was undertaken to assess the nutrient addition, biomass production and nutrient removal in a typical agrosilvopastoral system of Kerala, India. The study, which formed part of an ad hoc project of the Indian Council of Agricultural Research, was carried out in a homestead of 0.50 ha in southern Kerala, India for a period of two years extending from October 1994 to September 1996. The topography of the study site was undulating and the soil type sandy. The homestead was typically a coconut-based agrosilvopastoral system. The tree components in the system, besides 100 coconut palms, included four mango, six jack, one wild jack, one sapota, two cinnamon, three drumstick, six teak, one tamarind and one cashew. Annual crops cultivated in the interspaces were amaranths in the first year and banana in the second year. The system also consisted of three cows (2+1) in the first year, while in the second year it was four (2+2). The admixture of trees/crops resulted in a cropping intensity of 106.51 (I year) and 111.51% (II year). The amount of litterfall, stemflow and throughfall was quantified by means of suitable traps of known dimension placed below the canopy of trees. The N, P and K contents of collected samples were estimated by standard analytical methods. The nutrients added into the system through organic manure, recycling crop residues, and inorganic fertilizers were also quantified. The harvested biomass from the crops and trees were weighed and their nutrient contents estimated to work out the nutrient removal. The annual nutrient addition by way of litterfall amounted to 4.48, 0.85, 1.92 kg N, P and K (I year) and 3.76, 0.33, 1.51 kg N, P and K (II year) respectively. The addition of nutrients by stemflow was 0.03, 0.001, 0.08 kg N, P and K and 0.04, 0.001, 0.15 kg N, P and K in the first and second years respectively. Throughfall from trees resulted in a nutrient input of 0.53, 0.04, 2.40 kg N, P and K (I year) and 0.81, 0.04, 4.05 kg N, P and K (II year). The total nutrient addition through organic manure, obtained from the livestock component of the system was 28.28, 23.92 and 30.72 kg N, P and K (I year) and 21.42, 19.00 and 27.48 kg N, P and K (II year). Inorganic fertilizer mixtures of coconut resulted in an addition of 38.00, 19.00, 76.00 (I year) and 42.00, 21.00 and 84.00 kg N, P and K respectively. The pseudostem of banana was recycled during the second year resulting in a nutrient contribution of 3.04, 0.64 and 10.40 kg N, P and K respectively. The study further revealed that certain quantity of nutrients were permanently lost from the system by way of harvested biomass. The total biomass production from the system was 9484 kg dry weight (DW) and 9676 kg DW in the first and second years respectively. The corresponding N, P and K removal during the first and second years were 62.70, 11.83, 93.84 kg and 68.17, 11.40, 99.33 respectively. The nutrient balance sheet revealed that the nutrient loss from the system through harvested produce was counterbalanced by nutrient addition through various sources. The tree-crop-livestock integration was a special feature of the system. Plant nutrients were involved in a constant cycling within the soil and plant compartments of the system. Though various nutrient cycling processes tend to replenish the nutrient pool, pool, permanent losses occurring through harvest may need to be compensated through external input. Hence, in agrosilvopastoral systems dominated by annuals and bearing coconut palms judicious application of manure is necessary to sustain its productivity.

Effect of *Pinus roxburghii* Sargent on the nutrient contents of grasses in mid-hills of western Himalaya.

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Keywords: pine; grassland; nutrient content; nitrogen; phosphorus; potassium; Himalaya**.**

The study was carried out in Solan district of Himachal Pradesh in India located between latitudes 30°&31°N and longitudes 76°&77° during the growing season (July to October) to determine the effect of chirpine (*Pinus roxburghii* Sargent) growing at different aspects on nutrient status (N, P & K) of grasses and soil. Two adjacent grassland sites each of 0.1 ha area, one having chirpine overstorey and other without chirpine (open grassland), were selected at three aspects namely: northwestern, northern and southwestern. All the sites were situated at the same locality. Chirpine trees in these sites had crown height ranging from 10.5-12.5m, crown diameter 7.7-8.7 m, crown surface area from 46.57-59.45 m^2. Density of trees at three aspects varied from 270 to 300 trees/ha. Relative solar influx under the trees ranged from 51.9-60%. Plant samples were collected by harvesting 12 quadrats each of size 50x50 cm from each site at monthly interval starting from 15th July. The plant samples were segregated specieswise and analysed for N, P and K. Composite soil samples from 0-30cm depth were collected from each site on each sampling date.

The important grasses recorded in these sites were : *Themeda anathera*, *Chrysopogon montanus*, *Heteropogon contortus* and *Panicum maximum*. Nitrogen concentration in aboveground and belowground ranged from 0.59-1.22% and 0.42-0.91% respectively. Phosphorus concentration ranged from 0.08-0.25% and from 0.04-0.16% in aboveand belowground biomass respectively. Potassium concentration was found to vary from 0.34-0.68% and 0.23-0.49% in above and belowground biomass respectively. Thus, the nutrient concentration was higher in aboveground biomass as compared to belowground biomass at all the sites. There was no significant effect of chirpine as well as aspect on the nutrient status of the grasses.

Soil pH varied from 6.8-6.98 and 6.92-7.20 under chirpine and open grasslands respectively. Organic carbon under chirpine was more (1.6, 1.47 and 1.37%) as compared to open grasslands (1.55, 1.45 and 1.15%). Available N ranged from 0.014-0.043 and 0.012-0.028% under chirpine and open grasslands respectively. Available P ranged from 15-31 ppm under chirpine and 19-30 ppm in open grasslands. Whereas, available K varied from 103-195 ppm and 115-330 ppm under chirpine and open grasslands respectively. Thus it was concluded that chirpine increased the Nitrogen contents of the soil but decreased the P and K contents.

Morphological indices of tree sustainablility

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Keywords: morphology; defoliation; increment; tree sustainability.

Sustainability of a tree can be defined as an its ability to transform one form of energy into another (for instance, to transform the solar energy into chemical etc.) despite any external disturbance.

Two levels of relative sustainability exist. That corroborated by:
- variation of tree growth in the process of dendrocoenosis (forest ecosystem) forming;
- the character of growth and morphological variation during the transition into the lower part of the storey;
- non-specific morphological responses, i.e. active and passive phases;
- threshold variation in the radial increment of a tree with increasing crown defoliation.

The first stable level is observed in limits of crown defoliation 0-35% while the second - in limits 60-85%. For each level of stability, specific morphological characteristics and changes in the inner morphological correlation have been clarified. Transition from the first to the second level is, by far, more rapid than “the moving” within a relatively stable state, i.e. decreasing of stem increment suddenly accelerates. The existence of the second unstable level is based on the fact that within increasing defoliation, approximately 85 to 100% of the increment of the tree does not decrease gradually - at a certain point it drops suddenly to zero and the tree dies.

Each stable level is characterised by three morphological states. In the first level, three morphological levels have been singled out: 1) the stable tree (the most complicated morphological structure - the highest rate of branching etc.; the morphological correlation is weaker than that of a relatively balanced tree; the largest foliage mass, defoliation 0-10% etc. in terms of coenosis they are open-grown trees or trees of Kraft class I); 2) the relatively “balanced” tree (more simple morphological structure, strong correlation of inner morphology, defoliation 10-15% etc.; in terms of coenosis they are trees of classes I-II), and 3) the “effective” tree (a tree “works” most productively; less foliage “creates” a similar stem increment, defoliation 15-20% etc.; in terms of coenosis they are trees of class II).

Transition from the first level to the second one is characterised as the state of high lability (crown defoliation ranges from 40-60%, trees are “sensitive” to the environmental impact; the trees are of class III).

The second stable level is also typical of three morphological states. At the first state is a tree of reduced liability (even sufficiently strong affirmative effect cannot transfer a tree to the first state of stability; for instance, trees of the lowest Kraft classes do not “recover” even after very intensive thinnings). The second state - a tree with disturbed morphological correlation (the size of different organs is independent of their position in a crown); and the third state - absolute collapse of morphological homeostasis of a tree.

An assessment of sustainable forest on environmental conservation in China

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Keywords: forest conservation; sustainability; environment; ecological function of forest; China.

With the rapid economic development, much more international attentions have been paid to environmental problems. Forest plays an important part of ecology system, especially, in activities of environmental conservation. In china, natural forest conservation projects have been executed for three forest districts of northeast, northwest and southeast. The purpose of this study is to describe the expansion and decrease of forest distribution in the three forest district, and discuss factors causing such expansion and decrease from several points of view. This study reviewed land surface, site and contour of the different forest district and evaluated the environmental conservation functions of the forest. First we have build the forest resources environment database by geographic information system (GIS), and assumed that forests have three functions as follows: forest land conservation, sustentation of ecology system and landscape preservation, Then we evaluated quantitatively these functions of forests using GIS, Data from forest record, vegetation maps soil distribution maps and the results of analyses of GIS were used as factors of valuation, Each factor is divided into five categories, and each category is given a quantitative score, The results showed that natural forest plays a great part of the environmental conservation functions for China forest resources and environmental conservation.

Changes in forest ecosystem on drained areas

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The large scale forest drainage in the vicinity of the Baltic Sea after the fifties has essentially improved fertility of forest soils, intensified growth of trees and increased percentage of forested lands. Probably that has leveled climate conditions as in Estonia (57030'-59049'N; 21046'-28013'E) during the last decade has been characterized the climate with relatively short cold periods with little snow in winters and generally cooler summers. Climate warming has caused distribution of till rarely presented tree species, wild animals and birds in the region.

Estonia is situated in the region of intensified paludification. Paludification decreases soil fertility and leads to the declination of the biodiversity of ground vegetation. Today, drainage of one forth of the forest lands has sufficiently bounded transgression of peat to the mineral lands and due to that the drainage is stopped. Ecological changes that become evident after the drainage should be taken into consideration in managing of stands.

Evolution of forest site types in the drainage areas develops towards more fertile types. Middle quality class (stand height degree in defined age) of stands has been arisen in State forests during 25 year analyze period in the all drainage stands, in spite of the dominate tree species: pine, spruce, birch or aspen. It also remarks intensified nutrient cycling, bigger biomass and oxygen production. More intensively change the plant communities in fens with thin peat layer. In alder fens and alder-birch fens mostly meadowsweet *(Filipendula ulmaria*) starts to dominate and after couple of decades it will substitute with goutweed (*Aegopodium padagraria*), if the soil parent rock is carbonate sandy loam. Domination of goutweed has become evident also in the drainage of palutified forests. Areas with deep peat deposition will be transformed into decayed swamps with different fertility where herbaceous plants, bilberry (*Vaccinium myrtillus*) or wood sorrel (*Oxalis acetosella*) will dominate.

Evolution of the new plant communities diversifies remarkably our forests and environment generally. Depending on botanical composition of peat deposit and on filtration of mineral horizon below peat layer, after drainage the thickness of the peat layer decreases 0,6-1,5mm per year.

A part of the nutrient elements that leaves during decomposition process will be used by plants and trees, the other part will be evaporated or leached to runoff waters. If the peat will disappear too quickly and the process of the soil genesis in mineral horizon is slow, the growth of trees may be stunted. For that reason the investigation of regeneration possibilities of the soil genesis using ground water regulation and other measures needs quick solution and implementation in practice.

Weakening cultural traditions and struggle of sacred groves for survival.

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Keywords: sacred groves; religion; vegetation and forest preservation; biodiversity.

This paper traces the history of sacred groves in India and examines the conservation status of the groves in the Pondicherry bioregion.

Sacred groves are patches of vegetations or forests preserved on religious grounds. They were established in ancient days by ecosystem people inhabiting the hilly terrains when they attempted agriculture/cultivation as vocation. As clearing of forests became inevitable, such people adopted ecologically prudent ways to preserve environment. One was to leave patches of original vegetation totally undisturbed and the other was shifting cultivation. Expanding population and its inextricable dependance on natural resources for survival justified large scale deforestation. Hence it became necessary to retain at least the semblance of local biodiversity, as man, out of greed or need might wipe out the wood stands.

In order to deter people from desecrating the vegetational resource, the ancient people sanctified natural elements as sacred trees, sacred animals, sacred habitats etc. Sacred groves, dedicated to the local deity, are the most prominent of them. Unflinching faith in supernaturality and the fear of god are two vital elements that contributed to their survival. Slowly, the ecosystem people migrated to the plains and the society got fragmented. Yet the identification with nature and concern for conservation of natural elements were so deep that they revered and respected them, even as they disturbed, slashed, killed or consumed them. This was more acute in the plains in the face of large scale convertion of land for agriculture.

For the castes /communities for whom the respect for nature was the unifying force, the methodology /practices adumbrated in course of time was guided by cultural tenets and sustained by religious beliefs. As a result such conservational practices became woven intricately into the fabric of traditional cultures of those societies.

The advent of hinduism increasingly shifted the primacy from the forests to the deities, While in most of the interior/rural groves the idols of ancient gods lie in the open , construction of temples and erection of huge imagines of animals are strikingly evident in many groves in the urban and semi-urban settings. Infuence of western culture has also contributed to the decline of the groves by promoting the extention of temples structures and by adding colour and glamour to the worship patterns. Spread of literacy and modernism have further slackened the strangle hold of religions and the belief-systems which had been the guiding force in conservation.

Another factor that has accentuated the decline is the alienation of people from the conservational model as evident from the protected area networks. Wherever people are involved in the maintenance of the grove, and reciprocally drew tangible benefits, the groves survived. Nevertheless, the spread of modernism, absence of any tangible benefit, state control of temples have additively precipitated their decline.

Recent initiatives in Uttara Pradesh and Bihar where people are egged on to develop a kinship with the groves and in Karnataka where religious attributes are channelized through ecologically sustainable synthetic forests for benefits, have provided a glimmer of hope. Their revival, after realizing their ecological values as seen in Mizoram, is further reassuring, With the protected area network failing to deliver the goods, it is imperative that sacred groves, which symbolise the success of conservation through religious traditions and cultural practices, must be rediscovered and restored to their original glory. Their biodiversity is very vast, rich and impeccable.

The groves of India in general and the 15 major groves in and around the Pondicherry region in particular subscribe to most of these generalizations and crave for immediate conservational initiatives.

Contribution of forest research for an ecosystem in extinction: forest: the case of the Atlantic forest of the northeast of Brazil

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Keywords: Atlantic forest; genetic biodiversity; degradation; historical process; Brazil.

The Atlantic Forest is constituted, with certainty, in the threatened of Brazil bioma and, probably, of South America. As a result of its geographical location and with distribution along the Brazilian coast, the area was the first to be explored in the Country. The Atlantic Forest located in the Northeast of Brazil, has been desolated by man's action that already destroyed great part of the genetic biodiversity of that ecosystem, along the five hundred years of colonization of Brazil. The work had for objective to accomplish a rising of the contributions made for the best knowledge of the problems and potentials of the Atlantic Forest and with this to offer subsidies for best to become aware the Brazilian and world society on the prevalent processes of degradation of the remainders of the Atlantic Forest and its negative effects on the quality of the life of man of that area. The work presents an evolution of the historical process of the degradation of the Atlantic Forest since the beginning of the colonization of Brazil to the current days. They are suitable the desolated species of the primary Forest, and its substitution for agricultural cultures and agricultural exploration without there was any concern with the replacement of the desolated forest resources, with the conservation of the soil and with the environment. They are also suitable the consequence of the deforestation of the forest in this area on several environmental aspects (modification in the microclimate; disappearance of the rivers and ciliary forests and loss of the genetic biodiversity). The study indicates a group of actions of scientific and institutional character, that they should be developed, with extreme urgency, in way to avoid to such a pillaging of that important ecosystem and to lessen its impacts on the atmosphere and the populations that live in the areas preserved.

The vanishing palms of the forest ecosystems of India and their sustainable management

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The family *Palmae* (Arecaceae) is one of the most useful groups of flowering plants confined to the tropics. Their versatile use make them a preferable crop for wide cultivation even in the arid and semi-arid zones of the tropical regions. Palms are an important forest resource from ecological, social and economic viewpoints. In India 21 genera and about 106 species of palms occur in three major geographical regions; Peninsular India, Eastern and Northeastern India and Andaman and Nicobar Islands. A small number of palm species occur in the Gangetic plains and in the lower hill valleys of Northern India also. Apart from coconut (*Cocos nucifera*) and arecanut (*Areca catechu*), the major economic palms, cultivated as commercial crops, all other palms are seen in the wild or in semiwild condition. However, despite their frequent occurrence in forests, and the vast array of products derived from them, foresters have so far, dedicated little attention to palms when designing and implementing management plans. In India many palms are endangered. Natural populations of *Arenga*, *Pinanga* and *Bentinckia* have been severely affected due to habitat destruction. A combination of over exploitation and habitat destruction appears to have led many species of rattans to the endangered condition. *Corypha talifera*, an endemic species to West Bengal is reported to be extinct in the wild conditions. *Arenga, Borassus* and *Phoenix* are all multipurpose genera and over exploitation is adversely affecting their population size. In addition, some inherent botanic characteristics of certain palms also have contributed to retard their natural regeneration. In the absence of concrete efforts towards their replenishment, some of these wild palms are likely to face the threat of extinction. For ecologically sensitive palms like *Arenga, Pinanga, Calamus* and *Bentinckia* in situ conservation along with enrichment planting is needed. Plantations of presently over-exploited species and potentially useful species should be established on a large scale to boost their population for sustainable exploitation. In India, at present, the only palm included in the forest management plan under nonwood forest products is rattans. It is worthwhile to note that a number of wild palms have high potential for domestication and there is ample scope to improve upon the product range and commercial exploitation. Further, protection of wild palm genetic resources has practical application in genetic improvement of both wild as well as cultivated palm varieties.

Endemic plants of peninsular Malaysia: their conservation status and future prospects

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Keywords: endemic plants; conservation; endangered species; scoring system; Malaysia.

Most of endemic trees species and palms in the Malay Peninsula (Peninsular Malaysia, Singapore and South Thailand) have been scored for their conservation status using the IUCN 1994 Red List Categories. Of the 814 endemic taxa scored, 348 species (42.75%) species are in the threatened categories while the remaining 466 species are in the lower risk. 52 taxa have been classified as criticallly endangered while 47 others are in the endangered category. No species have been categorised as extinct because there is a lack of information to correctly determine if species had gone extinct. However, most of the species that had only been recorded once are now considered in the critically endangered or endangered categories. In process of scoring the species, it also became evident that there are flaws in IUCN criteria used to assess the conservation status, in relation to endemic Malayan tree and palm species. The present scoring system employed for Malaysia has been modified from the IUCN criteria to suit Malaysian conditions. To ensure the continual existence of the rare, threatened or endangered plants, efforts are currently underway to locate these plants. A large number of these threatened species have narrow phytogeography and their populations are not necessarily protected in totally protected areas such as the National parks and Wildlife Sanctuaries.

The role of flood water control and desert afforestation in environment improvement.

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Keywords: flood water control; afforestation; environment improvement; desert; water saving; Iran.

The meagre amount and uneven distribution of precipitation means that more than 90% Iran is designed as arid and semi-arid. It is estimated that more than 50 billion m^3 surface runoff out of total 413 billion m^3 (mean annual) precipitation drains into Caspian Sea, Persian Gulf and inland lake and swamps. If substantial amount of this flow could be saved, a major portion of our water demands would be satisfied. Flood water spreading is a method that follows numbers of purposes. Some example of these are: to stabilise drifting sand, to control erosion, to develop artificial forestlands, to make changes the environment of the belt zones around desert, to satisfy water requirement, to remove sediment carried by flood-water for changing the bare lands to farm lands, to control ground water quality by preventing the intrusion of saltwater into water bearing aquifer.

Following to a very successful integrated approach and ongoing research project in southern province of Iran that was started in January 1983 and has achieved its main objectives, the national large scale developing program was planed. This plan started in 1995 and consists of 20 stations. The major aims of these stations are; to develop a model for different condition of geology, climate, soils and hydrology, to extend such idea for inviting the people to participate and to develop this project in their own lands, to help the government for large scale planning for water utilisation in Iran. This paper will introduce the basics of this project and its successes since 1995.

Technological exploitation of polysaccharide - polysaccharide interaction

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Keywords: polysaccharide; galactomannan; gum; *Cassia tora; Leucaena leucocephala*; gum industry; India.

Most seeds contain starch as the principal stored food for use by the embryonic plant in its initial growth. Almost all food plants used by humanity produce seeds with starch as the carbohydrate reserve. However, a number of plant food reserve polysaccharides are based on structural polysaccharide from the plant cell wall. The most well known of such reserve polysaccharides, from an industrial view point, are the plant seed galactomannans, which are based on a β-1,4-linked D-mannan backbone which is solubilised by substitution of α-1,6-linked D-galactose residue to the mannan of the backbone. However, other β-1,4-linked structural polysaccharides also forms the basis for groups of plant reserve polysaccharides. Thus the food storage polysaccharides from tubers of the *Amorphophallus* genus are based on a β-1,4-linked D-glucomannan backbone. During the past several years, numerous cultivated crops and forestry species have been investigated for their galactomannan content to give a boost to Indian gum industry which is mainly exploiting guar (*Cyamopsis tetragonolobus*).

In view of the industrial importance of seed galactomannans, the seeds of Leguminosae family have been screened which reveals some genera like *Acacia, Albizzia, Erythrina* are found to be almost devoid of the gum whereas seeds of almost all the species of *Cassia*, *Crotalaria*, and *Indigofera*, occuring in India have been found to be very rich in galactomannan content.The investigations carried out at this institute have shown that seeds of *Leucaena leucocephala*, *Prosopis Cineraria* and *Cassia tora* yield 20-35% of the galactomannan which is invariably present in the endosperm of the seeds and therefore, easily separable by mechanical means. The *Cassia tora* Linn. is a common herbaceous annual occurring as a weed throughout India. A patented technology has been developed to produce the gum from *C. tora* (yield 30-32%) by dry method. The gum has been found to be excellent wet-end additive in paper making. *C. tora* gum on modification act as a flocculant for the treatment of backwater in paper industry and as a settling aid of mud in sugar industry. Non gelling concentration of Xanthan gum and *C. tora* gum interact in solution to give significant increase in viscosity and forms gel which can be exploited in food industry. Paper will be presented to describe the rheological behaviour with respect to their synergistic interaction, of a mixture of Xanthan and *C. tora* gum, the structure of which is different from guar and locust bean (*Ceratonia siliqua*) gums.

High technologies for Russian forestry

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Keywords: forestry; high technology; RS; GIS; GPS; administration management; Russia.

In transition to market economy Russia works on the problem how to make forest administration and management more effective. One of the ways is to design and implement modern and perspective, so-called “high”, technologies in forestry and multiple use of forest resources. To solve these problems it is necessary to change the system of getting information on forest state and dynamics. Most of the forest lands in Russia is difficult to access. There are also a variety of forest lands by designated use. All these make high technologies very effective Among these technologies are remote sensing by use of Russian and foreign satellites, GPS and GIS technologies, modern layers and sensitive materials for air-photography. All this attracts the attention of the country’s research, educational and industrial institutions. The paper deals with analysis of current state of the problem, and especially with it’s theoretical and methodological issues, staff training and practical implementation in forestry.

Utilization of aerobic sludge compost as a soil conditioner and fertilizer for plant growth

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Keywords: aerobic sludge; waste water; water treatment; composting; soil conditioner; plant growth; forestry and agriculture.

Sludge is a byproduct of industrial or municipal waste water treatment. The characteristics of sludge depend on both the initial waste water composition and the subsequent waste water and sludge treatment process used. Increasing volumes of aerobic sludge generated in industrial an municipal waste water treatments plants have resulted in making our solid waste disposal problems worse. It is possible to dispose of aerobic waste water sludge by land filling or incineration, or to reuse this sludge after proper composting. Aerobic waste water treatment sludge generally contains (on dry weight basis) 50-60% organic matter, 4-7% nitrogen,2-3% phosphate (as P2O5), potassium and other minerals.

The most beneficial and appropriate method for sludge resulting from food industry waste water treatment is composing with various kinds of bulking agents. Sludge is typically composted for 21-60 days, during the time pile temperature typically reaches 55^{o}C in a properly run operation. During composting, the organic material in the sludge is degraded to a humus-like material that makes an excellent soil conditioner. The bulking agent is also partially digested. The compost obtained through aerobic treatment can have several beneficial uses in forestry and agriculture.

In this study, sludge from yeast manufactured in Pakmaya-Düzce Plant has been composted with peat moss and corn stalk chips and used as a plant growing media in containers. According to the results obtained from investigation, 2 parts of composted corn stalk chips with sludge + 1 part of sandy loam soil 20% of agricultural prelate mixture gave the best growth for garden flowers (*Tagetes patula* Carolus Linneaeus, *Tagetes erecta* Carolus Linnaeus, *Zinnia elegans* Nicolaus Joseph Jacquin, *Malcolmia maritima* Carolus Linneaeus).

Observations on the mycorrhizal status in decaying and not decaying woodlands in Italy

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Keywords: mycorrhizal status; decaying and healthy trees; mycorrhizal index.

In order to assess the eventual associations that can occurs between the mycorrhizal and the fitosanitary status in decaying and not decaying Italian woodlands, a research was carried out in permanent stands delimited in Sicilian and Tuscanian areas. In some natural and artificial woods of *Pinus halepensis*, *Quercus ilex*, and *Q. suber* the number of mycorrhizal apex and the index of mycorrhizal infection in different plots with decaying or healthy trees were evaluated. For this purpose, samples of soil, roots, and seedlings were collected and observed, using a methodology for making easy the collection of data. In the same plots the presence and the number of mycorrhizal sporophores was detected, too.

The results of these observations, conducted for four years in Sicily and two years in Tuscany, seem to show a strict association between the mycorrhizal status and the health of both the plants and the studied environments. These results evidence that in the stands with healthy trees, the number of mycorrhizal apex, the index of mycorrhizal infection, the variety of mycorrhizal forms, and the number of both the species and the sporophores of mycorrhizal macromycetes are more abundant, in comparison with those observed in decaying ones.

In particular, it was observed that not decaying stands with healthy *P. halepensis* in Sicily, revealed an active mycorrhizal status (high index of mycorrhizal infection, many different mycorrhizal forms, and a lot of species and sporophores of mycorrhizal macromycetes as *Tricholoma terreum, T. scalpturatum*, *Lactarius vinosus*, *Hygrophorus limacinus, Inocybe fastgiata*, etc.). On the contrary, in the decaying stands, where *P. halepensis* showed evident symptoms of chlorosis, redden of needles, and blight of twigs and branches, the index of mycorrhizal infection was very low, as well the variety of mycorrhizal forms, and the presence of mycorrhizal macromycetes. In this stands the sporophores of saprotrophe species were much more represented (*Lyophillum* spp., *Clytocibe* spp., etc.).

The survey conducted in the stands with *Q. ilex* in Tuscany showed that the older woods were characterized by a low mycorrhizal index and few mycorrhizal forms, in comparison of the younger ones. Moreover it was noted that the old woods had a poor underwood and an high percentage of trees fallen down, with evident sporophores of *Phellinus torulosus* at the bottom; on the other hand, in the delimited stands in mature woods, it was found a lower number of species and sporophores of mycorrhizal macromycetes than in the stands with older or senescent trees.

Observations carried out in other Sicilian and Tuscanian environments, confirmed that high index of mycorrhizal infection are always associated with a good fitosanitary status, and permitted the characterization of some specific symbiosis, as the association *Lactarius cimicarius-Quercus suber*, in Sicilian woodlands.

Natural areas as baseline ecosystems for forest monitoring and research: the role of U.S. Forest Service research natural areas

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Keywords: natural resource management; sustainability; biodiversity; indicator; monitoring.

Key to any natural area’s usefulness to natural resource management is its ability to provide information that is not available from more intensively managed landscapes. Effects of management are evaluated not only against the management objectives but also in comparison to a control area that did not receive the same treatment. How can we determine the effect of forest management on stream habitat unless we have an example of a stream in an area not managed for timber harvest? How can we evaluate the recovery of the ground flora after a timber harvest unless we have followed the floristic composition of an unharvested area over time for comparison? How can we study the impacts of silviculture on biodiversity, unless we can inventory biodiversity in unharvested sites? How can we assess the impacts of roads or forestry practices on soil erosion, unless we have areas in which soil erosion is measured in the absence of roads and silviculture?

Research Natural Areas (RNAs) established by the USDA Forest Service are managed to maintain the biological diversity and natural processes within representative national forest ecosystems. Forested RNAs can serve key roles as control or reference areas for monitoring or research that examines the effects of forest management on such ecosystems. A few large RNAs (1,000's to 10,000's of acres) are better able to represent landscape patterns and serve as control areas than many smaller RNAs.

Several examples of research and monitoring in RNAs will highlight the under-utilized potential of RNAs to contribute to the scientific understanding of forest characteristics and functions, and thus to forest ecosystem sustainability.

The Bowl RNA (White Mountain National Forest (NF), New Hampshire) is a relatively unmodified watershed of northern hardwoods. Many studies are using this area as a baseline watershed. One study compared patterns of lichen diversity in forests to show that ‘stubble lichens’can be used as indicators of ecological continuity. At The Bowl, 23 ancient forest indicator lichen species were found, confirming it as an intact old-growth site. Another integrated study of soil nutrients, foliar nutrients, and forest productivity at The Bowl (and a range of other sites that have different land use histories) has helped researchers use remotely sensed data to predict the impacts of forest management alternatives on nutrient cycling and productivity at a site.

Tionesta Scenic and Research Natural Areas on the Allegheny NF (Pennsylvania) have been surveyed for stream habitat, macroinvertebrates, and fish to compare with reaches of the same stream flowing through harvested areas. Bat species diversity at Tionesta (old growth) has been compared with bat species diversity in second-growth forests.

Research conducted at Memorial Grove Hemlocks and Tucker Lake Hemlocks RNAs on the Chequamegon-Nicolet NF (Wisconsin) compared diversity and abundance of birds, small mammals, and amphibians in these old-growth hemlock-hardwood forests to that of second-growth stands.

Monitoring the number of land snail shells (live, empty, and broken) in the leaf litter at Atwood Ridge RNA before and after a prescribed burn has enabled managers on the Shawnee NF (Illinois) to respond to concerns about possible effects of the Forests' prescribed fire program on land snail density and mortality. Results indicate that fire does not affect snail mortality as much as soil moisture.

Floristic inventories at The Cape RNA (Green Mountain NF, Vermont) are part of studies to determine management effects on biodiversity.

RNAs and other natural areas provide critically important baselines for forest resource management. Best management practices can be developed for intensively managed areas based on information obtained in reference areas if land is allocated to both uses within the same landscape.

Soil characteristics in common oak and common hornbeam (Carpino betuli-quercetum roboris Ht. 1938) forests in the Republic of Croatia

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Keywords: soil characteristics; moisturisation; common oak; common hornbeam; Croatia.

In common oak and common hornbeam (Carpino betuli-Quercetum roboris Ht. 1938) forest stands, i.e. the ecological-managerial type (EGT) II-G-10, it has been found that hydromorphic class of soil types are present. Soils in this class are characterised by either periodical or permanent supplementary moisturisation. According to present research, there are ten soil types which belong to the EGT II-G-10: pseudogley on level terrain and pseudogley-gley (Gleyc luvisols), eugley (Gleysol) subtype hipogley and humic fluvisol (Fluvisol). Occasionally, some types from the automorphine soil class are also present: pseudogleyed luvisol (Orthic luvisol) and on some localities pseudogleyed cambisol (Eutric cambisol). The aforementioned soil types and sub-types in common oak and common hornbeam (Carpino betuli -Quercetum roboris Ht. 1938) forest stands in Croatia have a wide range of chemical and physical characteristics. The area or the pedoecological sub-divisions are called pedogeographic areas. According to recent research, the difference between them is the level and the presence of the main soil type or types, their parent soil and other chemical and physical characteristics. On 209 locations and sample plots, one pedological profile and two assisting profiles were excavated. A morphological description of the soil was undertaken on the main pedological profile and samples of their genetic horizons were taken for chemical and physical analysis. After processing the results, the soil type and subtype were determined as well as the main chemical and physical soil characteristics for the ecological-managerial type forest stand. According to the results of the chemical and physical analyses many of the differences were observed between the West Drava watershed and Cesma and Ilova watershed. In a pedological sense these are two extremes. The East Drava watershed and the Pokupsko basin have many common characteristics but differ in the genetic form of the soil profile and mechanical structure. The main difference is in the genetic form of the dominant soil pseudogley on the level terrain. In terms of the percentage share of particular soil types in the II-G-10 ecological-managerial type, these areas can be divided into four pedogeographics sectors. 1. The East Drava watershed with the dominant parent material alluvium of 80% and alluvial terraces of 20%, on which 40% is eugley-hypogley (Gleysol), 40% humic fluvisol (Fluvisol) and 20% pseudogleyed luvisols (Orthic luvisol); 2. The West Drava watershed where dominant parent material is also alluvium (40%) with alluvial terraces and swamp loess 20%. The dominant soil types are humic fluvisols 60% (Fluvisol), eugley-hipogley (gleysol) and pseudogleyed luvisol 10% (Orhtic luvisol); 3. The Cesma and Ilova watershed with part of the Sava watershed in which the dominant parent material is swamp loess which is 90% of the total and alluvial terraces is 10%. In these areas the dominant soil is pseudogley on the level terrain (Gleyc luvisol) with 80% of the share, pseudogley-gley (Gleye luvisol) with 10% and eugley-hipogley (gleysol) with 10%.

In The Pokupsko basin area with part of the Sava watershed, the dominant parent material (60%) is loam and clay in some parts mixed with swamp loess in the upper layer, alluvium 20% and alluvial terraces 20%. The dominant soil types are pseudogley on the level terrain of a primary origin i.e. with a heavier mechanical structure (Gleyc luvisol) taking up 50% of the total, pseudogley-gley (Gleyc luvisol) taking up 25% and eugley-hipogley (Gleysol) taking up 25%.

Comparison of tree composition in primary and logged forest

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Keywords: species composition, primary forest, logged forest, Euphorbiaceae, Dipterocarpaceae

The understanding of variations in species composition of primary and logged tropical rainforests requires detailed and intensive long-term observations. More recent studies conducted in primary forest showed that there were no dominant species in the forest (Kochummen et al. 1990; Manokaran and La Frankie 1990; Kamarudin 1986).

The most common families were Euphorbiaceae, Myrtaceae and Lauraceae. Members of the Dipterocarpaceae are the most abundant of the emergent and tall upper canopy trees (Anderson 1957; Ashton 1964; Wyatt-Smith 1952). This paper describes in detail the differences in species composition of primary and one-year-old logged forest in the Ulu Segama Forest Concession area in Sabah and considers the effects of logging on the recovery of tropical lowland rainforests.

The study was conducted at two sites, each representing a primary and one-year-old logged lowland dipterocarp forest. The primary forest study site is situated within the Danum Valley Conservation Area. The one-year-old logged forest study site is situated adjacent to the primary forest study site. Both study areas had a size of about 40,000 m² (20m x 2000m) or equivalent to about 4 ha each.

The study showed that the primary forest study site was very rich in Euphorbiaceae. This represented 15.3% of the total number of trees recorded. The second highest group was members of the family Dipterocarpaceae, represented 14.4% of the total. The four largest families - *Euphorbiaceac, Dipterocarpaceae, Meliaceae* and *Lauraceae* - were predominant in the study area. Their numbers add up to 1089 trees out of a total 2195 trees (49.6%). Altogether 49 Families were recorded in the primary forest study site. Of these, seven were represented by a single specimen. In addition, 23 families were represented by less than 10 individuals each. These accounted for less than 80 individuals, or 3.7% of the total.

In the logged forest study site the Family Dipterocarpaceae was marginally the family with the largest representation. It accounted for 14.8% of the total. The eurphorbs were a close second with 13.7% of the total number of individuals. As with the primary forest study site, the top four families (Dipterocarpaceae, Euphorbiaceae, Meliaceae, and Lauraceae) accounted for 727 individuals, or 45.5% of a total of 1599 trees. Altogether there were 44 families in the logged forest plot. Twenty of these were represented by less than 10 individuals each, and four were represented by a single individual.

Tree family composition between primary and logged forests showed that although the forest had been logged, 13 families had many more representatives in logged than in primary forest. This was especially true in the family Polygalaceae, with 51 individuals more in logged forest than in primary forest. However, the data clearly showed that many more families had higher numbers of representatives in primary than in logged forests. Marked differences in numbers of representatives were evident in the family Euphorbiaceae and Meliaceae.

There is a strong correlation in the ranking of plant Families between the two study site (Spearman's Rank Correlation; rs=0.89, n=43, p<0.01) suggesting that the ranking positions of each family in the two forest types were very similar. Also the tree composition in both forests was almost the same. However, there was a very highly significant difference in the number of individuals present in both forests (F=19.21, df=51, n1=2195, n2=1599, p<0.001). In primary forest there were 548.5 trees (i.e. trees bigger than 15cm dbh)/ha, while in logged forest there were only 399.8 trees/ha.

The result from species-area relationship clearly indicated that species richness in primary forest is much higher than in logged forest. Results from cumulative number of taxa encountered against increasing number of trees sampled also demonstrated similar patterns. A greater number of trees from the 4-ha area sampled in logged forest were missing particularly at the species level. This shows that selective logging has reduced the number of species due to the reduction in the number of trees left standing after logging. Poore (1968) suggested that even if a 20-ha area of logged forest were sampled, it would not necessarily include all the species in its vicinity.

Although it has been shown that logging affects all species at random, the most important difference between primary and logged forests was the lower number of families, genera and species in logged forests. There were 5, 3 and 17 lesser number of Families, Genera and Species respectively in logged than in primary forests. Many of the trees lost during logging were not only timber trees but also non-timber and important fruit-trees from the families Euphorbiaceae, Meliaceae and Lauraceae.

Forest grazing for sustainable forest management: a case study of China

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Forest grazing has been a tradition for thousands of years in China. In recent decades, however, overgrazing in forests have caused many forest to be degraded, especially in forestry-rangeland ecotones. At present the forestry/pastoralism issue has become a focus of public awareness, and has been treated as one of the priorities in sustainable forestry in China.

Based on case studies throughout China, it is recognized that forest grazing, which is often being considered as a silvicultural measure for plantations for controlling undergrowth and improving nutrient cycling, is one of the most serious factors inhabiting forest natural regeneration in dry zones, and usually induces water and soil erosion in humid zones, although its influence depends on the pressure and duration of grazing.

The paper consists of three major parts. Firstly, the practices of forest grazing were reviewed for typical ecozones, mainly for the arid and semi-arid zones, temperate humid zone, subtropical and tropical humid zones, and sub-alpine zone, with special reference to the resource conflict management. Secondly, strategies and measures were presented for better management of forest grazing for each ecozone, including capacity building, joint management of stakeholders, legislation, communication, training, extension systems, et al. Thirdly, the priorities of researches were listed. The role and its utilization of traditional knowledge were discussed.

It is concluded that, i) forest grazing is a vital part of sustainable forestry; ii) the balance between forest grazing and the limited restoration capacity of forests is possible, but it is a long-term task which requires improvements on related policy and institution, public participatory, forest management technology, investment, and etc; iii) it is crucial to satisfy all stakeholders' demands, otherwise, any attempts to protect and develop forests will not be practical, therefore, the first step to deal with the forestry/pastoralism conflict is to define scientifically their relationships in an integrated system of social, economic and cultural background in stead of in pure forestry or animal husbandry; iv) further researches are needed, e.g. the livestock load capacity of forest, rotation of rangeland, classification of grazer, monitoring technology and precaution systems; v) traditional knowledge are useful and effective in the improvement of forest grazing; and, vi) it is necessary to extend a new management model step by step, and the process can be greatly promoted by information communication.

Nature forest management and biodiversity conservation in Northeast China

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Northeast forest is the most extensive forest in China. Forest area is 36.57 million hm^2 and accounts for over 27.8% of the national total. Forest storage is 3 billion m^3 and accounts for 30.3% of the national total. Forest coverage is 54.8% ranking first in China. It is a major forest product base in China and supplies more than 1/3 of national commercial timber. The zonal vegetation is broad-leaved Korean pine forest. Compared with the vegetation of Europe and North America in the same latitude, this type of forest is significant for its complex composition and structure, high biodiversity, and specific dominant species. However, since the irrational utilization by clear-cutting, the area of virgin forests has decreased dramatically during the past 100 years. The patterns of species diversity have changed greatly and many species that closely depend on the old growth forests were disappeared.

Different forest management treatments have varied impact on biodiversity. Two kinds of timber logging way are commonly used in Northeast China: Clear-cutting and selection cutting and clear-cutting was a major way for timber logging before 1980's. The study results showed that the influences exerted by selection logging on avian or plant community were much less than those done by clear cutting. There were only 8 species of birds on clear-cutting site after 2 years recovery and all of them were shrub-grass birds. After 50 years recovery of clear-cutting, bird species increased to 15 and 12 of them were forest birds. But this value was much lower than that of virgin forest which had 34 species of birds and 33 of them were forest birds. In selection cutting forest with removal 40% in volume, there were 24 species of birds after 2 years and 72% of them were forest birds. It was much higher than that of secondary forest with an age of 50 years formed on clear-cutting site. For plants, study results showed same trend as birds. After 2 years of selection cutting, 90% of virgin species could be found in disturbed forest. Only abundance was little bit different between virgin forest and selection cutting forest. But in clear-cutting forest site, it needs 60 years for 90% of virgin species to recover when propagules are available. Otherwise, it needs longer for virgin species to recover.

8.01.00 Ecosystems

Current state of forest ecosystems in the Urals

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Keywords: population; forest; anthropogenic transformation; northern taiga; southern taiga

The Urals make a natural boundary between Europe and Asia, extending for more than 2,000 km from steppes in the south to the tundra zone in the north. But the major part of the whole territory of the Urals is covered by forests.

The current state of forests in the Urals is to a large extent determined by historical reasons. Intensive forest felling started immediately after the foundation of the very first plants which used woody charcoal as the main energy source for metals production. Situation with forests specially aggravated from the second half of the XVIII-th and in the following centuries, when the number of metallurgical industries exceeded a hundred. Significant loss of forests occurred also due to numerous fires.

Thus during the last 300 years, various types of human activities, namely mining and metallurgical industries, development of towns and network of roads, intensive agriculture, growth of population, lead to gradual decrease of the primary forest communities represented in the Urals mainly by dark and light coniferous forests, whereas the ranges of the derivative foliate forests were marked to increase.

The detailed analysis of the retained plant communities allows estimating the modern state of anthropogenic transformation of the region territory. Specialists consider that level of these changes not exceeding 10% corresponds to favorable ecological situation. 30% of the territory transformation shows that situation is still normal. But when these changes embrace about a half of the region forest stands, ecological conditions should be regarded as non-desirable. 70% of the disturbed area indicates to a situation of risk, whereas 90% and more reveal critical or disastrous ecological situation. This way of estimation shows that only in the very north of the Ural region ecological situation remains favorable for the vegetation state. On the contrary, in the south districts over 80% of the territories are disturbed, mainly due to agricultural development of lands and creation of agrocoenoses. About 11% of the whole territory now reveals disastrous ecological condition.

Proposing that modern ecological situation has developed during three centuries of the Ural flora exploitation, one can evaluate rate of transformation, the latter making ca 270 square km per year. If the process continues and with the same intensity, we can expect full disappearance of the primary north-taiga forests during the next 55 years, those of the south taiga - in about 60 years, and tree stands of the middle-taiga regions - in 140 years. At present, a critical situation is registered in pre-forest-steppe and pre-taiga regions.

Forest melioration of agrolandscapes

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Keywords: Afforestation; Agrolandscapes; Ukraine

The forest melioration in Ukraine is more than half-century, when the State has begun research and practical works. The most active period of forest meliorative stands creation was the second half of the XXth century, when the interests of land use and ecology had to be taken into account, especially when extensive agriculture development. So far as forest melioration objects were located mainly on the agricultural lands and size of works was more than on the other kinds of recultivated lands, in so far as the agrolandscapes have become the main area of it. Now more than 42,400,000 ha of lands (79% of total area) are in the agrarian sector of economy, 32,000,000 ha from them are arable ones. The land use is not always safe for ecology.

The agrosphere state causes alarm because of soil destruction. 18% of area is damaged by intensive ravine erosion; annual soil losses are 600-650 mln of tons, which include humus and necessary nutrients (K^+, Na^+, Ca^{2+}, P etc.). Deflation and suffusion bring to annual losses of arable lands. The area of such lands is more than 10 mln of ha. They need the immediate melioration, mainly by means of forest cultivation. In the modern conditions, forest melioration is acknowledged as universal, reliable and permanent. Unlike other approaches, forest melioration influence on the soil functions regime in some distance from the forest objects, on the microclimate parameters (heat and water) positive changes, superficial and ground water regime and other important characteristics of agrolandscapes. Forest melioration promotes the improvement of ecological situation and gradual restoration of ecological equilibrium. The last is one of the main conditions of evolutionary functions of landscapes regeneration that is self-regulating and self-rehabilitation with gradual increase of bioecological potential of their natural and changed by man structural components.

Forest melioration plays the main part in the restoration of disturbed relations between natural complexes (forests, arable lands, meadows, water objects), because different spatial forms of shelter belts and their density determine both the landscape structure and homeostasis on the whole. The main tasks of the forest melioration are: to determine the initial and the further notions about necessary and optimal participation of its objects in the site and area structure; to ground the quantitative parameters of the forest meliorative objects on the first stages of the landscapes restructurization; to develop the effective spatial, special, functional & purposal and other kinds of forest meliorative stands, which would promote the increase of biodiversity and saturation of landscapes; use of the forest melioration must take into account not only ecological & economical sense, but also social meaning and correspond to aesthetic demands.

It is already proved that meliorative stands with stable signs of system and with area more than several thousands of hectares can carry out the transgressive functions and regulate the climate. Particularly precipitation increases 15% and productivity of agrocenosis increases 15-35%. There is any alternative to forest melioration by its useful properties. Therefore in the conditions of climate aridization and global warming the meaning of forest melioration as a factor of agrolandscapes stability will grow significantly.

8.02.00 Sites

Effect of timber tree residue and its compost application on growth of some local trees in Egypt

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Keywords: compost; residues; eucalypt; *Casuarina; Acacia*; bark; leaves

The main objective of this study was to find the best way for using disposal wood wastes into organic manure (compost) for increasing the economical return. The experiment was designed to study the effect of different soil treatments which containing timber trees residues such as using wastes directly in cultivation, wastes with add nitrogen, and composted wastes.

Wastes were mixed with each of clay and sandy soils in the ratio 1:1 to study the effect of different soil treatment on plant parameters. The results can be concluded that the utilization of compost of sawdust, bark and leaves after mixing with sandy and clay soils for eucalypt, casuarina and acacia plantations as a growth media is recommended than sawdust, bark and leaves added directly or sawdust, bark and leaves with nitrogen (ammonium sulfat)

On the other hand, utilization of leaves after mixing with sandy or clay soil as a source of soil medium without any treatments for eucalypt, casuarina and acacia plantations is recommended because its superiority to the control.

Fertility status of hill forest soil of the south eastern part of Bangladesh

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Keywords: forest soil; soil fertility; soil degradation

The forest resources of Bangladesh have been severely depleted. There exists a high potential to increase forest resources in the hilly areas of the southeastern part of Bangladesh. The soils of hilly areas are being degraded and deteriorated with time and consequently the soils are becoming less suitable to support forest trees and agricultural crops. In order to prevent and limit the degradation of these hill soils and for keeping the soil fertility to its optimum level very limited soil study was done. For evaluating the present fertility status of the area recently (1998) a study on the physico-chemical properties of the soil was carried out. It has been found that the nutrient elements in the soil have decreased substantially from the previous study results. The pH of soils have decreased during the 10 years period (1988-1998) resulting higher acidity. The reasons responsible for increasing of soil acidity and lowering of soil fertility may be due to (a) destruction of forests and removal of vegetation resulting in exposure of the soil surface which is then oxidized and consequently increased the soil acidity and (b) soil erosion due to run off washed away the top soil containing high organic matter and nutrients.

Study of nutrient deficiencies of sandy soils in the Congo by pot experimentation: effects of the site

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Keywords: *Eucalyptus*; coppice silviculture; production

Since 1978, 42,000 ha of clonal *Eucalyptus* plantations have been established in the Pointe-Noire region for pulp production. These plantations, owned by ECO sa (Eucalyptus du Congo Société Anonyme), are based on two natural hybrids (E.PFI and E.12 ABL* saligna). As felling age is 7 years, management of coppice appeared very early as a main issue. More than 10 trials focusing on this goal were therefore established since 1985. Moreover, complementary experiments were set up to compare coppice and replanted sites production.

Coppice silviculture: The trees can be cut at ground level, without impact on latter coppice production. From 4 months after cutting, there are marked differences in growth between coppice shoots. These differences increase with age: from 2-3 years, only the two bigger shoots per stump (70% of total basal area) keep on growing. Coppice reduction increases growth of the remaining shoots. This operation can be done during the first year, as soon as the dominant shoots can be identified (4-9 months old).

Optimal coppice reduction intensity depends on soil fertility and stump density: as observed with planted crops, the maximum production is obtained, between 600 stems/ha in the low fertility sites and 800 stems/ha in the best sites. As initial stand densities vary between 400 to 800 stems/ha, 1 to 2 shoots per stump are selected. Secondary coppice shoots have to be controlled, manually (bush knife) or chemically using glyphosate (Roundup®). This last manner allows weed control at the same time, and thus, lower costs. It provides the best results for shoot control and stem growth.

A fertilization of 200-250 kg/ha N-P-K (13-13-21) must be applied one year after the harvesting of the previous stand (planted crop or coppice).

Coppice vs replanted sites: Coppice stumps can be weakened with a 40% glyphosate solution (Roundup®). The solution must be applied by spray at a dose of 25-30 ml/stump, just after stem harvest (less than one hour). No return time is then necessary.

A site replanted with the previous clone exhibits about the same MAI as coppice. Moreover the loss of production during the period between harvesting and planting must be taken into account. It appears therefore that a plot may be replanted only if a much better vegetal material can be used (*E. urophylla * E. grandis* vs natural hybrid,…).

Conclusion

These results contribute to efficient management of the Congolese commercial plantations consisting at present of 13,000 ha of planted crop, 19,000 ha of coppice and 10,000 ha of replanted sites.

Forest regeneration utilizing mulching sheets and symbiotic microorganisms

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Keywords: mulching sheet; symbiotic microorganisms; *Pinus thunberghii* Parl., *Pinus densiflora* Sieb. et Zucc., *Pisolithus tinctorius* Coker et Couch *f. tinctorius*; forest regeneration

In order to investigate the possibility of utilizing a combination of a mulchingsheet (MS) composed of polyester random fiber web as the main material and mycorrhizalfungi (MF), effects of their utilization were surveyed for 3-5 years on the growth of *Pinus thunbergii* Parl. and *P. densiflora* Sieb. et Zucc. at model and actual slopes.At plots where spores of *Pisolithus tinctorius* Coker et Couch *f. tinctorius* (Pt) were dispersed as MF and MS were applied after *P. densiflora* was seeded, the stem diameter at ground level and planting stock height showed greater values from the first year, compared with those at control plots.

The growth at the experimental site belonging to Ehime University where seeds of *P. densiflora* were incorporated into the MS showed greater values of stem diameter at ground level and planting stock height from the first year, compared with those at control plots. MS were stuck at the site where 5 years had elapsed after *P.thunbergiiwas* planted at Mt. Tanakami in Ohtsu, Shiga. An increase of 66-494% was shown in the stem diameter at ground level and tree height of *P. thunbergii*, compared with those of control plots during 5 years.

At the Nojiri River experimental site on Sakurajima Island in Kagoshima where *P.thunbergii* of a two year-old planting stock was planted after MS were stuck, *P. thunbergii* showed a strong tolerance against sulfurous acid gas (SO_2 gas). From these findings, it was estimated that MS and MF were effective forthe regene-ration of forests devastated by various causes.

Site productivity estimation using stand variables in neotropical secondary rain forests: methodological considerations and a case study

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Keywords: site productivity; tropical secondary forests; *Vochysia ferruginea*; northern Costa Rica; neotropics

Secondary forests growing on abandoned agricultural lands are becoming an increasingly important part of the forest resource of many tropical countries. Several analyses have drawn attention to the potential of such forests for management for a wide range of products and services. One urgent need is to progress beyond simple estimations of the area occupied by tropical secondary forests, to determinations of forest area by categories of age and site productivity. In spite of the relevance of site productivity estimations to forest management in the neotropics, there have been very few experiences dealing with assessing site quality in broadleaved secondary rain forests.

We estimated site productivity and its variation for the dominant and commercially important tree species *Vochysia ferruginea*, in four secondary rain forest stands 16 to 28 years old in Northern Costa Rica. In the 28 years old stand, 36 sample plots (20x20 m) were installed in 1995 in such a way as to cover the whole range of substrate variation at the site. The stand was assumed to be even-aged and dominate height, estimated as the mean total height of the four tallest *Vochysia* trees in each plot, was used as the measure of site productivity. In a second part of the study, carried out between 1996 and 1999, site productivity and its variation, using the concept of site form (i.e the expected height of a 25 dbh tree) was evaluated in all four stands. 29 sample plots (20x20 m) were installed covering the whole range of soil variation at the sites. Site form was estimated for each plot using a linear model. Adjusted multiple regression models of dominant height and site form on soil variables were fitted by multiple regression procedures.

For the first part of the study, all plots showed low within-plot coefficients of variation for total height (four tallest trees), suggesting homogeneous site productivity conditions in the 400- m^2 sample plots. Dominant height of *Vochysia* was correlated with mean plot canopy height and stand basal area, and with its own basal area.% clay, % organic matter, P, Fe and Cu at soil depth 0-12 cm, were correlated with dominant height. The best fit was obtained using P, Mn, % organic matter and % clay as independent variables (R^2 = 79.5%; s.d. = 1.8 m).

In the second part of the study, site form showed a high between-plot variation (16.2-32.2 m), indicating high variation in terms of site productivity between the stands. Site form of *Vochysia* was significantly correlated with stand basal area and with 26 soil variables. Adjusted multiple regression models of site form on soil variables were fitted. The best fit was obtained using %sand at 12-30 cm depth as the independent variable (R^2 = 59.3%; s.d. = 3.0 m).

Dominant height appears to be a potentially useful indicator of site productivity in broadleaved neotropical secondary rain forests stands of similar age. Meanwhile, site form could be a potential indicator of site quality in situations when age is unknown and different between stands. This study suggests that there may be an important effect of site quality on timber production in this type of forest.

Effect of domestic sludge on the initial growth performance of *Samanea saman* (Jacq.) Mer. in the nursery

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Keywords: soil; sludge; fertilization; *Samanea saman*; seedling growth

The treatment and disposal of industrial and municipal or domestic sludge is an environmentally sensitive problem. Since sludge constitutes organic and inorganic substances, it can be used as a soil amendment, either for land reclamation or for increased plant growth. Application of sludge to land has been practiced in an attempt to disposal of municipal and domestic wastes and to gain potential fertilizer value from the application. Most of the nurseries of Bangladesh use forest topsoil and cowdung or inorganic fertilizers as growing media of seedlings. This results degradation of the fertility of forest site as well as it costs much to transport the soil in the nursery site. So, it is necessary to find a suitable growing media of seedlings in the nursery as well as an alternative safe disposal route of municipal or domestic sludges. The present experiment was conducted in the nursery of the Institute of Forestry and Environmental Sciences, Chittagong University. *Samanea saman* seedlings were grown in 23cm x 15cm (9 x 6) sized polybags filled in with the soil:sludge mixtures in different ratios. Domestic sludge was prepared by composting vegetable wastes, straw, lawn clippings, weeds, used tea wastes, waste paper, discarded portions of fish and meat and other wastes generating form the kitchen. The seeds of *Samanea saman* were collected from the Seed Orchard Division of Bangladesh Forest Research Institute, Chittagong. Seedlings were raised in the polybags in a completely randomized design to see the effect of domestic sludge on the initial growth and biomass accumulation at the end of the experiment. One hundred and eighty seedlings taking thirty-six seedlings in three replicates were laid to grow in control (soil only) and soil mixed with domestic sludge in four different proportions (1:0.3, 1:0.5, 1:1 and 1:2). Height growth (cm) was collected at two weeks interval. The six months old seedlings were randomly selected for harvesting and the collar dia, root length and oven dried weight of leaf, stem and roots were measured. Root length, leaf weight ratio (LWR), root weight ratio (RWR) and root shoot ratio of the seedlings treated by sludges and soil mixes in different proportions were not found significantly different from control (soil only). However, growth parameters like height (cm), collar dia (mm), leaf, stem, root and total dry weight, stem weight ratio (SWR), specific stem weight (SSW) and quality index (QI) were significantly higher in sludge treated seedlings in comparison to the seedlings in the control treatment. In most of the growth parameters, seedlings grown in soil: sludge mixes in a ratio of 1:0.3 performed better and then followed by 1:0.5 and 1:1 mixes. A deleterious effect of sludge was observed in the seedlings when soil: sludge was mixes in a ratio of 1:2. The linear, quadratic, cubic and quintic polynomial trends were analyzed for growth and supporting growth traits of the seedlings in all the treatments. Considering the findings of the experiment, it may be recommended that the domestic sludge may be used in low doses to the seedling grown media

Soil and site classification for forest zoning in ITTO model forest management area (Sarawak, Malaysia)

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Forest zoning is prerequisite for the preparation of a medium-term forest management plan that divides forest management units of approximately 100,1000 ha in size according to forest functions; protection, production, and social. Forest zoning seeks a sound and feasible compromise between forest conservation, economic needs and societal demands. Thus, forest zoning encompassed a multi-disciplinary planning approach, comprising forest engineering, ecologoy, socio-economic, economy and site classification.

A production forest reserve of 166,000 ha's in Central Sarawak studied for site-related management restrictions; soil erosion hazard, soil compaction risk and nutrient status. Soil and site data were obtained based on a 1 x 1-km systematic grid survey of the area. The grid was based on the 1:50,000 topographic map of 100-ft. contour interval. Amount and pattern of rainfall of the area was extrapolated from data obtained from surrounding meteorological stations.

For soil erosion hazard, the universal soil loss equation was applied to models the annual soil loss under undisturbed conditions (primary forest), after ground-based skidding (reduced impact logging with crawler tractors) and off-ground logging (helicopter logging and cable crane system). Two relative thresholds (accelerated erosion is year one after logging and accumulated erosion over one cutting cycle) were used for the determination of the forest functions and prescribed yarding techniques. Soil compaction risk was assessed using soil texture classes up to 50 cm soil depth, classifying them into low, average and severe compaction risk. The local soil types were categorized into five classes of soil nutrient status based on averages for exchangeable bases to depth of 50 cm. Additionally the river buffer zones of 20 m width on each side of permanent watercourses were mapped. Spatial extrapolation and data overlay was done using GIS technology.

Hypothetical zones were derived and prescribed logging techniques to mitigate environmental impact. The postulated zonal areas are approxomately 34% for protection (no logging), 40% airborne yarding and 26% ground skidding. These results form a solid base for further decision making and incorporating other disciplines (socio-economics, biodiversity, etc.) to finally produce a forest function map as part of a medium-term forest management plan in line with the national and international forest conservation sustainability efforts.

Connection between site productivity and floristic composition in Slovenia's beech forests

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Keywords: *Fagus sylvatica* L.; site productivity; floristic composition; site index; total volume production

European beech (Fagus sylvatica L.) is the most important tree species in Slovenia. It is an essential component of forest stands in over 50% of the forests, while in 25% it occurs with other tree species in mixed stands.

Nowadays beech accounts for 29% of the growing stock, but the natural proportion would presumably exceed 58%. In future the share of beech in the growing stock will increase because Slovenian forestry is based on close-to-nature silviculture and natural forest structures. Among prerequisites for rational close-to-nature forest management the determination of performance of site capacity, or site productivity (SP) is of importance. The determination of SP is connected with two questions:

1) Which available method for establishing SP gives the most acceptable results with regard to sites overgrown by pure beech stands and to stands with prevailing beech?

2) What is the appropriate basic unit for determining SP?

The study, which was carried out in 18 locations of mature beech forest stands, includes different site types determined by means of recent floristic composition (Braun-Blanquet approach). Different syntaxa demonstrate presumably variety of site types. A site unit represents a group of forest plots occupied by phytocoenoses of similar floristic composition belonging to the same syntaxon (i.e. the most frequent subassociation, and association). Within each such site unit, scattered in 18 locations, five square sample plots 30 x 30 m in size were chosen as a base for the estimation of SP by means of site index (SI_{100}) and total volume production (TVP). These sample plots were carefully chosen in pure fully stocked beech stands. The mean age of the stands analysed ranges from 94 to 196 years. As site index (SI100) top height at 100 years was used (the average height of 9 largest trees per plot of 900 m^2). The results of the study show that SI_{100} (site index at the age of 100 years) indicates relatively well site productivity (SP). The differences between SP established on the basis of TVP and the maximum mean annual increment (MAIMAX) are very small. The differences between SP estimates for sample plots within the same syntaxon/site unit do not exceed mostly ± 1 m^3/ha/year. So in general we can use well-defined syntaxa as strata for the detection of site units used to establish site productivity (SP):

In some cases however, differences can be more distinct. An explanation can then often be found among statements of classification and ordination procedures of relevé and in ecological indicator values (according to Ellenberg) as well. In such cases we have to divide a syntaxon/site unit into subunits in accordance with definable microsite parameters. In relevé processing FITOSEZ program was used, as a similarity measure Horn’s(1966) modification of Morisita’s (1959) index for proportions was selected. A cluster analysis and principal-component analysis (PCA) were made by means of available general programs, and Ellenberg’s ecological indicator values were used.

Controlling landscape nutrient fluxes with agroforestry

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Keywords: agroforestry; nutrient fluxes; single tree effects

Reducing nutrient losses for maximum productivity of a land use system but also for minimum pollution hazard are a prime goal for regional land use management. Relations between nutrient input and output may be controlled by internal nutrient cycling. Landuse systems with trees may be advantageous by storing more nutrients within the biomass and by a more efficient nutrient cycling than annual cropping systems. The complementary of resource use by associated tree and crop species is a major determinant of the potential efficiency of agroforestry systems in controlling nutrient fluxes. The resulting spatial variability, however, poses difficulties in assessing those nutrient fluxes on an area or even landscape level. Strategies for the assessment of relevant factors for the determination of the nutrient output like single tree effects, plot experiments, extrapolation of point measurements and catchment studies are discussed using examples from a range of climatic regions, in order to both improve internal nutrient cycling and minimize off-site effects of landuse by agroforestry. Singletree observations are a viable method to assess the effects of tree species on ecosystem functions like nutrient fluxes. This function can be linked to properties of the tree, e.g. root distribution, biomass production, canopy architecture or chemical properties of plant tissues. Thus, the root activity and distribution could be showed to affect nutrient uptake and leaching: *Bixa orellana* with a rapid nutrient uptake and fast nutrient recycling through litter fall showed a superficial root system and was not useful for the retrieval of subsoil nutrients, whereas *Bertholletia excelsa* took up nutrients from greater depths and from a farther distance. This information can be used to design a land-use system that combines an accelerated internal nutrient cycling with lower leaching losses, if these two tree species are combined. Plot measurements are the classic way of landuse research, but may be only feasible in geometrically simple agroforestry systems like intensive fallow or alley cropping. Nitrogen leaching was 65% lower underneath a hedgerow of acacias than in a sorghum monoculture. By intercropping, nutrient losses from the annual crop could be reduced by 53%. These effects were related to a deeper and more continuous root system of the alley cropping system than the monoculture. Various examples are now available demonstrating that with agroforestry systems we are able to control nutrient fluxes. The methodology for the assessment of nutrient fluxes has to be adapted to the type of agroforestry system, in order to achieve conclusions on a landscape level.

Increasing nutrient use efficiency by mixed tree cropping in the humid tropics

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Keywords: nutrient use efficiency; mixed tree cropping; humid tropics; tracer

Available nutrient contents are often very low in strongly weathered soils of the humid tropics due to the low inherent nutrient levels and low retention capacity of the soils. Nutrient leaching is a common problem especially in cultivated fields when the soil organic matter content is diminished and additional nutrients are applied. In this contribution, we demonstrate that the nutrient use efficiency can be increased with a combination of different tree crops.

Using a variety of tracer techniques with stable and radioisotopes, the uptake of nutrients was studied in a mixed cropping system with indigenous tree crops for food and wood production. In the first experiment, ^{15}N was applied to *Theobroma grandiflorum* (Willd. Ex Spreng.) K. Schum.; *Bactris gasipaes* kunth.; *Bartholletia excelsa* Humb.&Bonpl.; and *Bixa orellana*. together with chemical fertiliser. The fate of the isotope was monitored during one vegetation period. In a further study, ^{32}P was injected at 0.1, 0.6 and 1.5 depth. The foliar P uptake was compared between the mentioned tree species and fallow vegetation and between dry and wet season.

The tree species showed largely differing magnitude and areas of nutrient uptake. *Bixa* and *Bactris* took up a higher proportion of the applied ^{15}N than *Theobroma* and *Bertholletia* since the former showed higher foliar $d^{15}N$ values. This coincided with a faster biomass production. *Bertholletia* took up only 29% of its total ^{15}N up taken from the fertilised area under the canopy compared to the fertilised areas under the canopies of the neighbouring species. *Bertholletia* seemed to obtain the majority of the fertiliser N from the area underneath the *Bactris*, which was planted at a 4 m distance. Therefore, *Bertholletia* profited more from the fertiliser applied to *Bactris* than around its own stem. Secondly, *Bertholletia* may serve as an important safety net for a cropping system.

Bertholletia, which took up less of their N from the applied fertiliser and more of their N from a farther distance from the stem, had a higher root activity in the subsoil as revealed by the ^{32}P application. By combining trees having an accelerated nutrient uptake with trees which acquire nutrients from a lateral area, it is possible to increase the nutrient use efficiency of a cropping system. This is especially important in the humid tropics were we have to cope with low nutrient reserves and low cation exchange capacities but high leaching rates.

Nitrogen fluxes in forest successions in the humid tropics

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Keywords: Amazon; dissolved organic nutrients; nitrogen; forest successions; subsoil

Under primary forest species of the central Amazon, large amounts of mineral N were found in the subsoil (2m). In contrast, it was shown that in a secondary forest which has been developed after forest destruction by natural or anthropogenic burning mineral N contents in the subsoil were low. It is not clear whether subsoil N is lost by leaching after forest destruction or if the secondary forest is able to use this subsoil N more efficiently than primary forest species. Furthermore, it is not known up to now, if and how fast the subsoil N pool may regenerate under secondary forest.

In this study, we were measuring throughfall, stemflow, and soil solution N (to a depth of 2m) and mineral and total soil N to a depth of 5m in secondary forest and under two primary forest species in three replicates. Solution N was analysed for hydrophilic and hydrophobic organic compounds, ammonium, and nitrate. All of the compartments are analysed for N isotope composition.

Preliminary results indicate that large amounts of nitrate are present in the subsoil solutions exceeding our sampling depth under secondary forest as well as under primary forest species. The amount of organic N decreased with increasing depth in both soil solution and mineral soil. Consequently, soil solution N had a higher proportion of nitrate in the subsoil than in the topsoil. Increasing $d^{15}N$ values in the subsoil show a strong N metabolization with increasing depth, especially under primary forest species.

These results suggest that during the initial phase of reestablishment of the forest cover N released in the topsoil is leached down to the subsoil generating a large available N pool. As nitrate is the major N compound in subsoil solutions, the anion exchange capacity is the most important determinant to conserve this N pool in soil. With further growth of the forest and increasing rooting depth this subsoil N pool may become an important source for forest regeneration.

Evolution de la fertilité des Sols, Trois Ans après Jachère Boisée Artificielle.

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Mots-clés : jachère arborée, *Acacia auriculiformis*, *Eucalyptus camaldulensis*, *Gmelina arborea*, cultures, maïs, riz, évolution de la fertilité, Côte d'Ivoire.

Dans le Nord de la Côte d'Ivoire, trois espèces ligneuses (*Acacia auriculiformis* A. Cunn., *Eucalyptus camaldulensis* Dehn. et *Gmelina arborea* Roxb.) ont été plantées à très fortes densités : 5.000 pied.ha^{-1}. Le dispositif en blocs complets compte quatre répétitions. Après 6 années, ces plantations ont été exploitées. Elles ont produit respectivement 50, 63 et 71 T.ha^{-1} de bois sec qui ont été sortis des parcelles. Après exploitation des arbres, l'essai a été mis en culture de maïs. Chacune des 12 parcelles initiales a été divisée en quatre sous-parcelles auxquelles ont été appliqués deux fois deux traitements croisés: 1) résidus d'exploitation (brindilles et feuilles) laissées sur la parcelle ou brûlées avant la première mise en cultures ; 2) apport ou non d'engrais aux cultures chaque année. Des analyses pédologiques ont été faites au moment de l'abattage et après trois années (1996 à 1998) de culture (maïs, riz et maïs). Les rendements agricoles ainsi que les composantes agronomiques du rendement ont été mesurés.

Au moment de l'abattage, le sol apparaît plus riche en azote et en magnésium échangeable sous *Acacia*. Il est appauvri en azote et en potassium sous *Eucalyptus* et en magnésium sous *Eucalyptus* et *Gmelina*.

Près de deux années après exploitation, le taux de carbone organique est le plus élevé dans les parcelles fertilisées où les résidus forestiers n'ont pas été brûlés. C et N diminuent de *Acacia* à *Gmelina* et à *Eucalyptus* tandis que C/N augmente.

La flore adventice, pendant la période de culture, est modifiée ; certaines espèces indicatrices de sols fertiles sont fréquentes après *Acacia* et rares après *Gmelina* et surtout *Eucalyptus*, et inversement *Imperata cylindrica* devient envahissant après *Eucalyptus*.

Ces différences de richesse du sol permettent un meilleur rendement agricole après *Acacia*. En première année, le rendement du maïs passe de 1,7 T.ha^{-1} après *Acacia* à 0,9 après *Gmelina* et à 0,4 après *Eucalyptus*. En seconde année, les rendements de riz sont respectivement de 1,5, 1,1 et 1,0 T.ha^{-1}. Après trois années de culture, les productions les plus importantes sont toujours obtenues après *Acacia* et montrent que *Gmelina* et surtout *Eucalyptus* ne sont pas de bons précédents forestiers pour l'amélioration des sols agricoles. Les résultats agronomiques sont confrontés aux analyses pédologiques de fin de cycle de culture et commentés.

Phenolic induced nutrient imbalance in forest soils: implications for conifer regeneration

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Keywords: Phenolic compounds; Soil changes; Ericaceous shrubs; Conifers; Regeneration

Phenolic compounds of understory shrubs have been linked to regeneration failure and poor growth of planted conifer seedlings. Water soluble plant phenolics may be leached from foliage as well as from degradation of lignins and tanins. Many phenolic compounds are attributed to allelopathic growth inhibition of forest trees. This may occur due to direct toxicity effect of the phenolics on seed germination and seedling growth, particularly root growth. The degree of inhibition is a function of the type, concentration and composition of phenolic mix in the substrate and the species of affected plant. Apart from the direct toxicity effect on conifers, phenolic compounds can also interfere with available soil nutrients by forming phenole-protein complex and thus can bring about long-term soil changes. This paper reports on several controlled experiments to test the resource-toxin hypothesis involving phenolic compounds and their role in soil nutrient changes. Selected ericaceous shrubs and their respective conifers were used as model plants. Soil amending experiments were conducted with leaf litter of *Kalmia angustifolia*, *Ledum groenlandicum* and *Gaultheria shallon* followed by soil analysis for pH, organic matter, PO_4G, N, K, Ca, Mg, Al, Fe, Zn, Mn, Cu, Ba, and total phenolics. Results showed that *Kalmia* and *Ledum* leaf amendments create significant soil nutrient changes by increasing total phenole and decreasing N contents but *Gaultheria* amendment resulted little change in soil nutrients. *Kalmia* and *Ledum* amended soils also had significantly higher concentrations of Fe, Mn, Al, and PO4G than control. Results are discussed in the context of ecological role of ericaceous plants in long-term habitat change that have implications for forest regeneration.

Anthropogenically induced fire and its effects on soil properties along a vegetation chronosequence in humid tropical ecosystem: a case of Hong Kong Country Park

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Keywords: fire; soil properties; soil nutrient status; humid tropical ecosystem; vegetation chronosequence; south China

There is no doubt that the ecological effects of fire are of great concern. The impacts of fire on ecosystems are variable across gradients in time and space. The current state of knowledge is typified by detailed characterizations of the impacts of particular fires on specific sites from which generalizable insights may not emerge. Although a number of research on the effects of fire on soil properties have been done in the Temperate, Mediterranean and Northern Circumpolar ecosystems, such in-depth study is scarce in the humid tropical ecosystems, particularly in the South China ecological region. This work examined the effects of hill fire on the soil properties, particularly soil nutrient status along a vegetation chronosequence that transcends a newly burnt, short grassland, tall grassland, mixed grass and shrub and woodland vegetation. A retrospective approach was used to study this chronosequence since areas with variable fire history are available in Hong Kong, where hill fires often devastate the country park environment. In a normal fire season, there could be as many as 300 fire outbreaks within the country parks which forms 40% of the territory.

The immediate effects of fire on soil properties were obvious. However, the effect appears to dissipate with successional development. Immediately after fire, soil pH increased with about 0.3 units, while exchangeable Al decreased, which subsequently resulted in the decrease of the total exchangeable acidity (Al + H). The soil gradually acidified along the vegetation chronosequence with the woodland site being most acidic. Soil organic matter reduced after fire and gradually build-up with vegetational successional development. On the woodland site, however, the value of the organic matter significantly reduced probably as a result of the quantity of the litter produced by the standing vegetation. Soil exchangeable cations along the chronosequence are very low, but a build-up of the divalent cations (Ca and Mg) and Na was observed as successional development progresses, while, on the other hand, K decreased with successional development.

N mineralization was positively affected by fire. The quantity decreased 3 months after fire and was subsequently immobilized. In the course of mineral N production, the process of ammonification predominated over nitrification. Both forms of N, however, were prone to seasonal immobilization. Discernible differences in the rates of N mineralization along the vegetation chronosequence were observed probably as a result of differences in vegetation cover. In addition, clear seasonal pattern was also observed. In general, N mineralization rates were consistently higher on the topsoil layers. In this study, the uptake of NH_4-N surpassed the uptake of NO_3-N.

The absence of fire for a relatively long period leads to a vegetational successional development that is probably unique to this environment, albeit gradually. As a result of this slow pace of recovery, fire therefore results in the lowering of the floristic potentials of this ecosystem. However, if fire disturbance is avoided for a period of 3 or more years, the ecosystem starts to recover and as succession proceeds through 6 years and more, shrublands gradually replaces grasslands and ultimately tree species begin to appear as a result of the nutrient replenishment of the soil after a long period of fire absence.

Heavy metal concentration of the rock, top soil and plant from the serpentine and adjacent area in Andong, Kyungpook, Korea

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Keywords: Heavy metal concentration; Serpentine area; Rock; Top soil; Plant

The research for heavy metal concentrations of rocks, topsoils and vegetation in the serpentine area has been made for the amount of their distribution and absorption. The samples from rocks (the serpentinite: SP, gneiss: GN, granite: GR, blackshale: BS and redshale: RS), the top soils and their vegetation (*Pinus densiflora*; PD) in Andong, Kyungpook, Korea. The plant samples were divided into the shoot and root. The heavy metal elements such as Ni, Cr. Co, Fe, Zn and Sc were analyzed in ACTLABS, Canada. Most of heavy metal concentrations in SP rocks (Ni: 1162 ppm, r: 366 ppm, Co: 109 ppm; Fe: 7.48%, Sc: 8 ppm), except Zn (50 ppm), were much higher than those in any other rocks (Ni;65-22ppm, Cr;201-21ppm, Co;16-8ppm, Fe;3.30-0.94%, Sc: 8-1ppm, Zn: 71-20 ppm). All of the analyzed heavy metal concentrations in the serpentine soil (Ni: 2143 ppm, Cr: 232ppm, Co: 159 ppm, Fe: 5.91%, Zn: 56 ppm, Sc: 4 ppm) were much higher those granite soils (18 ppm, 20 ppm, 6 ppm, 1.94%, 45 ppm, 3 ppm, respectively). These supposed that the parent materials directly influenced on their own weathered soils and especially, Ni and Co concentrations of the serpentine soil greatly increased through the weathering of their own rocks. The average heavy metal concentrations of *Pinus densiflora* in SP Ni: 40 ppm, Cr: 71 ppm, Co: 6.75 ppm, Fe: 0.413%, Sc: 0.525 ppm) largely higher than those in granite. But Zn concentrations had the contrary. Also, the concentrations of root (Ni: 70 ppm, Cr: 130 ppm, Co: 12.0 ppm, Fe: 0.747%, Zn: 21 ppm, Sc: 0.9 ppm) were largely higher than those of shoot (10 ppm, 12 ppm, 1.5 ppm, 0.079%, 17 ppm, 0.15 ppm, respectively).

Continuous measurement of CO_2 flux from a forest floor

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Keywords: Chamber method; Continuous measurement; Forest floor; Carbon dioxide flux

CO_2 flux from a forest floor is large component of the forest CO_2 budget. Although there are several methods we can select to measure soil CO_2 flux, each of them has both advantages and disadvantages. Traditional method is so-called the chamber method. It has some variation like as alkali trap technique, static chamber method, dynamic (flow through) method [closed or open system] etc. All of them has a problem that we measure flux in unnatural condition by using chambers, for example, placement of a soil chamber changes air motion. In addition, these methods are difficult to measure flux continuously and to integrate spatially. Although many researchers have reported on soil CO_2 flux from a forest floor, few of them reported diurnal or annual variation.

In this study, we select a closed system of dynamic (flow-through) chamber method with an infrared gas analyzer (IRGA, Li-6262, Licor). To open and shut covers of chambers and solenoid valves are controlled by a personal computer for measuring continuously.

Our site, Kawagoe is a flat land located 35°52'N, 131°29'E with the elevation of 30m. The experimental forest is a temperate deciduous forest (*Quercus serrata* Thunb., *Carpinus laxiflora* Blume, etc.). Mean tree height is about 15m and the maximum LAI is 6. Soil consists of Kanto Loam. Leaf litter is removed in winter, then the soil surface is bare from early spring to early autumn.

CO_2 flux from the forest floor is about 0.05 to 0.2mg/m^2/s. CO_2 flux above the forest canopy ranges -1 to 1mg/m^2/s, soil CO_2 flux occupies the major component of the total CO_2 flux. CO_2 flux of each chamber and soil temperature are mutually related, but the magnitude of the flux of individual chambers is different. The values from a forest floor vary widely. This spatial variety is one problem when we discuss soil CO_2 flux.

We could get diurnal variation of soil CO_2 flux using continuous measurement system. A few papers reported CO_2 flux increased in nighttime. In this study, similar tendencies were sometimes observed. Soil temperature wasn't related to CO_2 flux in this case. We need to measure continuously for clarifying a factor of this diurnal variation.

Characterization of soil temperature in forest gap at a tropical lowland forest

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Keywords: soil temperature; forest gap; tropical lowland forest

Forest gap is one of the basic units in forest dynamics. Gaps when formed developed their own microclimate. However, few studies have been conducted to relate gaps sizes and their microclimate parameters. This study was conducted to characterize soil temperatures at three depths in two gap sizes and to relate soil temperatures with other microclimatic parameters. This study was conducted at Air Hitam Forest Reserve, Puchong, Selangor from September to December 1997. Two gap sizes were chosen; large (500m^2) and small (180m^2). Continuous measurement on soil and air temperature, light and solar radiation were made for seven days. Due to availability of only one data logger, measurements of both gaps could not be made simultaneously. Measurement of soil temperature at three depths were made at the center of the gap while measurement of soil temperatures along a transect were made at 5cm depth. The result show that mean soil temperatures at 1cm, 5cm and 10cm in the large gap were 25.51, 25.45°C and 25.45°C, respectively. The mean soil temperatures in the small gap at 1cm, 5cm and 10cm were 25.26°C, 25.51°C and 25.33°C, respectively. The soil temperatures were higher in the center of gap and change progressively to the edge of the forest. Simple linear regression analyses of soil temperature at three different depths with air temperature were made using the large and small gap data. In both gaps, there were strong relationship between 1cm soil temperature and air temperature with R^2 of 0.96 for large gap and 0.65 for small gap. A linear relationship was found with R^2=0.57 between soil temperature of 1cm depth and solar radiation in the large gap. The study concludes that soil temperatures in the center of the gaps were higher at the center than the edge of the gap. Magnitude of soil temperatures differs with gap size in which larger gap shows higher values compared to smaller gap. The study concludes that soil temperature in the center of the gaps was higher at the center than the edge of the gap. magnitude of soil temperature differs with gap size in which larges gap shows higher values of soil temperature compare to smaller gap. This study also shows that air temperature can be used to predict soil temperature in forest gaps.

Sustainable central European forest management, forest soils and productivity. Shall we be scared from global warming influence on properties of forest soils? A general view

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Keywords: soil science; acidification; mountain forests; soil analysis

Global acidification caused by man activity play an important role in current discussions within natural science. Soil scientific data from 63 deep soil pits obtained from research founded in 1931-1935 in Eastern Carpathian Mountains served as a level for reavaluation after 65 year in the area not affected by local sources of air pollution. The new data was obtained from five study plots at 1272-1550 m above see level characterised by 2130-2380 mm average precipitation and 0.6-1.8°C mean annual temperature. Spodo-Dystric Cambisol on phyllitic schist, Dystric Cambisol on schistic gneiss and Histo-Humic Podzol on phyllitic schist were described on plots covered by Norway spruce (*Picea abies* /L./Karsten) and European beech (*Fagus sylvatica* L.) either pure or mixed forest stands.

Results of the kind can be part of other investigations giving a green light to pondering a likely influence of global acidification on sustainable forest management from soil scientific points of view. General features of effects of acid precipitations on terrestrial ecosystems, their patterns and origin and a development of its evaluation are presented.

The laboratory data was obtained by the same methodology as in the thirties. Loss on ignition, total nitrogen, soil reaction in water, soil reaction in potassium chloride, base content, cation exchange capacity and base saturation was measured. The very complex nature of forest soil formation and the character of the soil forming factors (parent material, organisms, relief, climate and time) were discussed.

The facts lead to an opinion that the real changes in forest soil productivity as a result of acid deposition and the acification of forest soils in the sites with primarily very low base content, naturally extremely weak base saturation under the humid climate are of great importance. Decreasing pH level causes changes in the other characteristics in both surface and subsurface horizons.

Forest clearcutting and site preparation on a saline soil in east Texas: impact on soil chemical properties

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Keywords: clearcutting; soil chemical properties; southern pine; saline soil; east Texas

Changes in soil chemical properties of a saline soil in the Davy Crockett National Forest near Apple Springs, Texas, were monitored under three forest conditions over a two-year period (October 1988 to September 1990). The three conditions were: 1) undisturbed mature southern pine forest, 2) clearcutting without site preparation, and 3) clearcutting with site sheared and windrowed. Regrowth of vegetation in the sheared plot was clipped during the entire period. Soil samples of three slope positions and six depth levels in each 0.2 ha plot were collected two months before and at five different times within 18 months after treatments for laboratory analyses of 14 elements and derivations of six parameters. It was a part of our efforts to investigate why artificial pine regeneration was so difficult to establish on the saline soils in East Texas.

The results showed that although the variations in most parameters seemed to correspond with seasons of the year, they also exhibited significant differences due to various degrees of forest disturbance. Shearing increased soil salinity by increasing the concentrations of total exchangeable cations and Na, total soluble ions Na, SO_4, HCO_3, and Cl, and the levels of ESP (exchangeable Na percentage), SAR (Na absorption ratio), and EC (electrical conductivity). Shearing also increased the concentrations of soil toxicity elements Al, Fe, and Mn, with Al being the most excessive. On the other hand, organic matter content was decreased by shearing, so were TKN and available P slightly. Increases in salinity and toxic parameters were usually significant at the 0-60 cm depths under the sheared plot. Due to low absolute values, none of the increases were above the harmful limit. However, the great increase of soluble Na, especially at the surface horizons, may be responsible for the poor soil drainage in the sheared area. The excessive increases in exchangeable Al may have reached a level affecting root development, nutrient uptakes of N,K, P, or other elements, and seedling growth of southern pine species in the study area. Further studies on the Al toxicity are required. In areas where Al may be a limiting factor in pine regeneration, the soil be limed to rise soil pH or treated with organic matter to provide buffer effects.

The effects of forest treatment on other elements and parameters were in orders of magnitude most unlikely to reach harmful limits or caused deficiencies in nutrient supplies. Clearcutting with all undiserable species and debris left intake is a better harvesting method than clearcutting and shearing in areas with saline soil problems. The regrowth of native vegetation in sheared areas such as oaks and hickories help minimize soil salt concentration, nutrient leaching, and soil water saturation level, providing an better soil environment for pine regeneration.

Influences of spruce stand phases on ground cover vegetation and the microrelief on soil conditions at the Pokljuka Plateau Moraines in the Julian Alps

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Keywords: mixed moraine; Rhytidiadelpho lorei-Piceetum; Podzolization

The Pokljuka plateau lies in the Slovenian part of the Julian Alps. Forests cover about 20 km^2 of its calcareous and mixed moraines. The prealpine fir-beech (*Homogyno sylvestris-Fagetum*) and subalpine spruce forests (*Piceetum subalpinum* s. lat.) predominate, both with a high wood productivity. On moraines with a typically very heterogeneous, undulating micro-relief, very heterogeneous micro-site conditions have been found.

On the carbonate moraines composed of limestone and dolomite materials, the dominant FAO-Unesco soil units are different kinds of Eutric Leptosols, Rendzic Leptosols and Eutric Cambisols that are covered with various species of mainly calciphilic undergrowth. Apart from limestone and dolomite debris, the mixed morraine is composed of marl, cherts, shales, and sandstone. This parent material is covered with predominantly dystric soils with mainly acidophilic ground cover vegetation.

In 1997, on the mixed moraine at the permanent 1 ha research plot near the bog Sijec, we systematically disposed 106 research square subplots (0.25m^2) overgrown with the plant community Rhytidiadelpho lorei-Piceetum in four groups. We chose 25 subplots from the serried spruce stand of mature trees and 15 from land cleared in 1996, 33 from the spruce young growth and 33 from the spruce thicket.

On all subplots the micro-relief was evaluated and the ground cover vegetation was inventoried. The average coverage ranged from 35% in the mature stand to 85% in the spruce thicket. The total number of plant species did not essentially change from the clearing to the thicket, but there were changes in the combinations of plant species and in the coverage of the individual plant species.

Under the canopy of mature spruce trees there were extremely few plant species. Due to felling, growth conditions changed and the number of species rose. After felling and because of the changed light conditions., grass vegetation was exuberant. The frequency and coverage of *Luzula pilosa* and *Luzula luzoloides* had increased. Some other species of the grass (Poaceae) and the sedge families (Cyperaceae) also appeared in the clearing. *Picea abies* coverage in the undergrowth was least among mature trees, increasing from the clearing to the young growth and was largest in the spruce thicket. The Shannon index showed an increase in biodiversity from the group of mature trees up to the young growth, where it reached its peak. In the spruce thicket the level of diversity decreased because of the extreme predominance of spruce in the undergrowth. The soil of each subplot was sounded at 5 points to a depth of 1 m. Most soil bores showed signs of podzolization. Only 9 (8.5%) subplots had non-podzoled soil. These were classified as Dystric and Ferric Cambisols. Eighteen (17.0%) subplots had partly podzoled soil with interlacement of Cambisols and Podzols. On the 79 (74.5%) subplots we found only different kinds of Podzols. Thirty-one subplots had initial to weakly podzoled soil (all bores had a spodic Bsp horizon and the thickness of the albic E horizon is 2 to 10 cm); 29 subplots had moderately podzoled soil (E is 10 to 20 cm) and 19 subplots had strongly podzoled soil (E is over 20 cm).

8.03.00 Forest Hydrology and Water Quality

Sustainable Management of Hydrological Functions of Main Forest Ecosystems in China

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Studies were conducted in the late 60s and early 70s on the hydrological balance of areas under various vegetation covers, in Thermo-Mediterranean climatic conditions. Interest in these studies resulted from concern about the hydrological balance of Israel's aquifers as influenced by large scale afforestation and reclamation of devastated natural oak scrub communities. The studies failed to produce accurate data due to calibration problems of the different methods used, and the extremely large spatial variability in site conditions, which prevented the determination of the water storage capacity of the bedrock-soil complex.

One of the ways to determine the water balance of forest areas is to use plant physiological parameters as an indicator of water availability in the bedrock-soil complex. Of the several parameters available, we selected the sap flow velocity, which provides a direct measure of the transpiration rate of the tree.

Sap flow was measured continuously over periods of several days 8 to 15 times during a year on 8 or 16 trees, whose diameter distribution represents the diameter distribution of all the trees growing in a plot situated either in *Pinus halepensis*, *Quercus calliprinos*, *Q. ithaburenis*, *Phillyrea Iatifolia* and *Tamarix aphylla* forests (all native species); and in *Eucalyptus camaldulensis* plantations, an introduced species. Results of these measurements were used to scale up the single tree water use to stand water use in a given environment.

The relationship between water availability (rainfall), and the estimated amount of water used by the forest vegetation should be regarded as a major factor in forest management.

Water use by fast-growing *Eucalyptus* plantations in southern China

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Key words: Eucalypt plantations, water use, heat pulse technique.

Eucalypt plantations make up more than half of the 600 000 ha forest estate on the Leizhou Peninsula and neighbouring areas of western Guangdong in southern China. Water uptake by eucalypt plantations may contribute to the depletion of scarce groundwater resources, and soil moisture shortage as a result of high water use may also limit tree growth during the dry season. Litter removal and whole-tree harvesting are common practices, although they are believed to contribute to fertility decline, soil crusting, increased runoff and severe erosion. However, there is little quantitative information on water use or water balance of plantations in southern China.

A new project sponsored by the Australian Centre for International Agricultural Research aims to measure stand water use for eucalypts and other species on the Leizhou peninsula subject to various site conditions and management options, and quantify the components of the plantation water balance on annual and seasonal time scales. The completed project will provide data sets of intensive observations of stand water use and environmental conditions for representative plantations, and modeling tools for applying these to predict the productivity and sustainability impacts of management alternatives.

The poster displays the results obtained from monitoring water use in two plantations of *Eucalyptus urophylla* during the dry season from September to March, with concurrent records of leaf area index, soil moisture, and potential evaporation. Water use of single trees was measured by the heat pulse technique, and scaled up to whole-stand estimates on the basis of sapwood area. Climate parameters including solar radiation, relative humidity, temperature and wind speed were recorded at 30-minute intervals by an automatic weather station at each site. Soil moisture was also automatically monitored at frequent intervals using buried dielectric sensors. Leaf area index was determined at monthly intervals from ceptometer measurements along transects through each plantation.

The daily and longer term variation in plantation water use observed at each site during the dry season is attributable to changing seasonal climate conditions and the depletion of soil moisture stored in the soil profile within the root zone. The data allow separation of the reduction in plantation water use due to leaf shedding from that due to decreased sap velocity.

The results will be combined with additional hydrological observations to estimate annual recharge beneath plantations for comparison with alternative land uses, and to derive a quantitative response to suggestions that groundwater depletion and erosion are aggravated by plantation establishment. The data will also be valuable as input and validation data sets for modeling of plantation growth and hydrology.

Mapping of evapotranspiration at forest areas by infrared radiation thermometer images

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Key words: evapotranspiration, remote sensing, infrared radiation

A knowledge of evapotranspiration from a forested watershed is important for solving water resources and forest management issues. Evapotranspiration is also an important component of the hydrologic cycle of forested watersheds

The purpose of this study is to map evapotranspiration from forested areas using the surface temperature (ST) method, and to estimate it using the image data of surface temperature by an infrared radiation thermometer and energy balance data. The image data of surface temperature were measured on the ground or by using balloon remote sensing at a height of 100-200 m.

Comparisons were made of estimates of evapotranspiration using the ST method with those from the Bowen ratio and eddy correlation methods. The results show that averaged differences of hourly sensible heat flux are from -35 W m^{-2} to 26 W m^{-2} between the ST and eddy correlation methods. Estimated values of hourly evapotranspiration by the ST method are roughly equal to those by the Bowen ratio and eddy correlation methods up to about 0.6mm hr-1 and are smaller than those over about 0.7mm hr-1. Mapping of transpiration using the ST method on the ground is ascertained by such results.

Other results are given by balloon remote sensing. A small balloon was equipped with an infrared radiation thermometer sensor, a control system, a battery and a micro wireless video camera. The measurement of surface temperature by this remote sensing system was carried out over 15 second intervals . The angle of the sensor was controlled by an operator who checks the pictures sent through this system. There were differences between the surface temperature of the stands measured from the balloon and from the ground. Evapotranspiration estimated from the balloon is smaller than that from the ground. It is concluded that surface temperature is more accurately assessed using balloon remote sensing than using the infrared radiation thermometer on the ground.

The study was conducted in 2 stands of Japanese cypress. These stands were different in aspect and slope angle. The difference in surface temperature at the two plots was 1.8^{o}C on average. Evapotranspiration estimated using the ST method at the plot where surface temperature was lower, was about 0.07mm hr-1 higher than the other plot. Evapotranspiration using the Bowen ratio method showed similar values. The ST method based on balloon remote sensing is good for estimating evapotranspiration from large forested areas with different aspects and slope angles.

Interception loss by stands of Douglas fir and radiata pine, South Island, New Zealand

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Key words: Douglas fir, *Pinus radiata*, interception loss, throughfall

There are about 1.4 m ha of exotic forests in New Zealand, and current afforestation rates are over 50 000 ha per year, mostly on land originally in pasture. Large-scale conversions of this type may significantly alter water yields. When pasture is converted to forest, changes in runoff are largely controlled by changes in interception loss and transpiration. In areas where the canopy is wetted frequently or remains wet for long periods, interception loss exceeds transpiration . Thus water yield changes in medium-to-high rainfall regimes are likely to be dominated by changes in interception loss.

The bulk of New Zealand's plantation estate is in *Pinus radiata* and rainfall interception by stands of this species have been widely investigated. In recent years, Douglas fir (*Pseudotsuga menziesii*) has become a popular alternative species especially in drier and colder areas. To assess the impact of plantings of Douglas fir on water yield, it is crucial that we have some understanding of the expected interception losses likely to be associated with this species under the silvicultural regime practiced in New Zealand. However, little information is available on the water use characteristics of Douglas fir as a plantation species.

Throughfall and stemflow were measured at 3 sites 60 km west of Christchurch for a 9 month period (November 1998 to August 1999). One was in a 17-year old (654 stems/ha) stand of radiata pine, and the other two were under 18-year old (1360 stems/ha) and 54-year old (570 stems/ha) stands of Douglas fir. Rainfall during the period was 700mm. Total interception loss was 23% under radiata pine, and 33% and 34% for the 18-year old and 54-year old Douglas fir stands respectively. A single factor ANOVA showed no statistical difference in the event-based interception for the two Douglas fir stands.

Studies elsewhere have shown that interception loss under Douglas fir is dependent on age class, stand density, and climate, and that values tend to fall between 30 and 40%. The results of the present study lie within this range, but they suggest that differences in interception loss due to age and stocking density cannot be detected. They further suggest that losses under Douglas fir stands exceed those under mature radiata pine in the climatic regime characteristic of this area.

A long- term hydrological monitoring of a small mountainous catchment

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Key words: hydrological monitoring, flood flows, low flows

The Takaragawa Forest Experimental Station was established by the Forestry and Forest Products Research Institute (FFPRI) in 1937 to clarify the influence of forest development on streamflow and floods in the headwaters of the Tone River in central Japan. Hydrological measurements at the 19.1 km^2 Honryu Catchment, a small mountainous catchment within the station have been taken over the past 60 years. Results of the hydrological studies and statistical summaries of hydrological data have been reported by the FFPRI. Long-term hydrological monitoring is important not only for forecasting water resources and floods in the region but also as an indicator of conservation and maintenance of soil and water resources for sustainable forest management (the Montreal Process, 1995). This paper describes a set of streamflow data from 1938 to 1997 which characterises the hydrological environment of the Honryu catchment.

The annual streamflow from the Honryu catchment varies from 2,296.6mm yr^{-1} to 4,120.3mm yr^{-1} with a mean of 3,127.9mm yr^{-1}. The estimated snowmelt runoff (total streamflow from April to May during the snowmelt season at the catchment) accounts for about 51% of annual runoff. The long-term trend of snowmelt runoff with a small variation is almost parallel to that of annual runoff. However, annual runoff over the past 15 years has been highly variable perhaps because of abnormal weather compared with other periods.

A flood and low flow probability analysis for the catchment was conducted using the Gumbel method to estimated the magnitude of floods and low flow which have occurred during the recent abnormal weather. The largest flood flow (160.2 m^3 s^{-1}) which occurred in July 1983, was equivalent to a return period of 130 years. The smallest low flow (0.21mm day^{-1}) which occurred in September 1951, was equivalent to a 80-year return period. Flood flows have tended to increase owing to the abnormal weather. However, the low flow of 1994, which created a critical water deficiency in the Tokyo Metropolitan area was a 1-in-7 year event. This indicates that the problem of low flow is more closely related to the water demand in the region than to the hydrological environment. Long-term monitoring with high accuracy at the station is recognized as a useful indicator to understand changes in the hydrological environment.

Soil water-retention characteristics of natural Scots pine and Norway spruce sites in Finnish Lapland

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Keywords: forest soil, particle size, spatial variability, site class, till soil, water content.

Scots pine (*Pinus sylvestris* L.) has been the most widely used tree species in forest regeneration in Finnish Lapland since the 1950s. However, severe failures have occurred in pine plantations during the last three decades, especially on sites formerly occupied by Norway spruce (*Picea abies* L. Karst.). Unfavourable physical soil conditions, mainly excess water and low temperatures, have been suggested to be one of the causes of these failures. However, there is a lack of information about the physical soil properties on different sites. The aim of this study was to survey the physical soil properties, especially water-retention characteristics, and their variability on mineral soil sites naturally dominated by Scots pine and Norway spruce in Finnish Lapland.

Data were collected from sites dominated by natural stands of Scots pine (n=10) or by Norway spruce (n=10) in central Lapland. The soil was till on 19 sites, and sorted sand and gravel on one. Soil characteristics were measured according to standard laboratory procedures. Air-filled porosity was estimated by subtracting the water content at a given matric potential from that at -0.3 kPa.

The desorption water-retention characteristics and other measured variables showed similar values to those reported earlier for till soils in Fennoscandia. These properties differed (ANOVA) significantly ($p<0.05$) between the sites (n=20). The most significant differences were in the water retention (vol.%) at -5 and -10 kPa matric potentials (around field capacity) and in the sum of the organic matter content and fine particle fraction <0.06mm (grav.%). In general, the variables showed spatial dependence within sites of <60 m (semivariogram analysis).

Almost all the variables differed (t-test) significantly between the pine (n=10) and spruce sites (n=10). Compared with the spruce sites, the pine sites had on average thinner genetic soil horizons, and lower organic matter and fine particle-fraction contents and water retention. The air-filled porosity and saturated hydraulic conductivity were higher on the pine sites. The proportion of pine (of basal area) in the tree stand showed a significant positive correlation with the air-filled porosity at -5 and -10 kPa matric potential. About 80% of the observations made on the pine sites occurred at points where the mean water content and air-filled porosity at -10 kPa matric potential were <30 and >20 vol.%, respectively. The respective values for spruce were >30 and <20.

Water retention at -1 to -10 kPa matric potentials correlated best with the sum of the fine particle fraction and organic matter content, while at lower potentials it correlated best with the organic matter content. Air-filled porosity at -10 kPa and saturated hydraulic conductivity correlated best with the fine particle fraction.

This study suggests that sites on which pine occurs naturally tend to have a lower soil-water content, especially around field capacity, than spruce sites either due to the lower water-retention capacity or to the lower water table in situ e.g. on hilltops. This conclusion is in line with recent surveys which show that Norway spruce occurs naturally on sites with a higher water-content range (10-50 vol.%) in the topmost 20 cm soil layer, while Scots pine tends to occur within a markedly lower and narrower moisture range (1-28 vol.%). Therefore, pine-plantation failures could be avoided by planting pine seedlings on sufficiently dry sites.

Effects of variation of rainfall on the chemistry of streamwater

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Key words: streamwater chemistry, forested catchments

Streamwater chemistry is the product of various environmental factors in forested catchments, but hydrology is one of the most important. We compared the chemistry of streamwater of forested catchments in two areas with contrasting annual precipitation. One is located on Mt. Tatsunokuchi in Okayama city, Okayama prefecture (E 133°58', N 34°42', altitude 45-250 m, and annual precipitation 1000 mm). The other is located at the foot of Mt. Hira in Shiga town, Shiga prefecture (E 135°55', N 35°13', altitude 320-450 m; annual precipitation, 2500mm). Hydrological observations at Okayama extend back to 1926. Those at Shiga began in 1995. Sampling in Okayama was done twice weekly from June 1994 to May 1995 and bi-weekly from June 1995 to May 1996. In Shiga sampling was done twice a month from October 1995 to March 1998. Measurements were made of pH, electrical conductivity, dissolved organic carbon, inorganic carbon, cations, anions and silica. Electrical conductivity and the concentrations of most of the other constituents at Okayama were apparently higher than other normal steams in Japan. During storms, the concentrations of HCO_3, Ca, Mg and Na decreased, and those of K, HNO_3 and dissolved organic matter (DOC) increased. At Shiga, the concentrations of most constituents were lower than those of Okayama. The anion and cation concentrations at Shiga were relatively constant and their CVs were less than 25%, except for NO_3.

The Okayama area is characterized by less precipitation and more insolation than Shiga. Baseflow is normally under 0.2mm per day which favours high concentrations of chemical constituents. Cl concentrations were also high in Okayama, but input and output of Cl were almost balanced in both catchments. At Shiga, discharge exceeded 1.7mm per day and was more stable than that at Okayama, which was reflected in the relatively constant concentrations of the streamwater constituents. These results suggest that hydrology has a strong influence on the chemistry of streamwater in forested catchments. If global warming decreases precipitation in the future, it will not only lead to a decrease in runoff from forested catchments, but will also alter water quality.

Soil impact from manual felling and cable yarder compared to feller-buncher and rubber wheeled skidder in tropical forest plantation.

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Key words: soil disturbance, forest harvesting

Areal extent of soil disturbance, soil dry bulk density (DBD), loss on ignition (LOI) and steady state infiltrability (SSI) have been investigated with different harvesting methods. The investigations were conducted within a paired catchment study on environmental effects and production when converting dipterocarp forest to *Acacia mangium* plantations in western Sabah, Malaysia.

The disturbance by cable yarders was 9% of the clear-felled area. These tracks and landings were made with crawler tractors. The impact on the soil from crawler tractors at this site has been thoroughly described earlier. After only a few passes, most top soil is removed, resulting in compact surface soil devoid of organic material and soil structure. SSI is reduced to practically nil, and natural rehabilitation may take as much as 15-25 years.

Areal distribution of soil disturbance from the feller-buncher and the rubber wheeled skidder was not investigated in the same way as for the cable yarder and for crawler tractors. However, the disturbance was estimated to be more than 25% of the clear-felled area, which is the normal figure for a crawler tractor operation in the area. Both the feller-buncher with crawler motion and the rubber wheeled skidder, reduced SSI as much as crawler tractors do. This was the case with a few passes even when running on top of logging residues, or not using a blade to push top soil aside. In the case of motion on top of residues, compaction in terms of DBD was less compared to tractor tracks, due to the higher content of organic material. Because running on top of residues incorporated some of the residues into the soil, organic content (LOI) of the disturbed soil was in many spots considerably higher than in the undisturbed control.

Soils in this region are normally moist at all times under the forest canopy and have a fragile top soil structure. Hence machinery, even running on top of residues, can drastically reduce soil permeability for water and roots. This underlines the preference for systems such as cable yarders that minimise the area affected. The cable yarder uses only main tracks and landings which are are easy to find and to use again. With second and third order tracks from tractors, feller-bunchers or different kinds of forwarders, it is not as likely that old tracks will be used again as these tracks are planted and not as easy to identify after a decade or more. Quicker natural rehabilitation may occur where organic matter is incorporated into the soil when running on top of residues.

Sustainable management of hydrological functions of main forest ecosystems in China

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Key words: forest ecosystems, interception, moisture holding capacity

Water and forests are closely related and mutually influenced through various physical, chemical and biological processes within an ecosystem. Their complicated interactions make a significant contribution to the water cycle by which mass circulation is driven and energy flow occurs. Forest hydrological functions refer to the effects of forests on the redistribution of rainfall, water conservation, water purification, protection of water and soil erosion, regulation of flooding and runoff, as well as drought mitigation and water logging. The sustainable management of forest hydrological functions is critical to the maintenance of human living and healthy environments.

Based on case studies in forest ecological research stations in different geographical zones in China, the characteristics of hydrological functions of the main forest ecosystems in China were quantitatively analyzed and compared among forests according to three spatial layers, i.e. canopy, litter and soil. Furthermore, the sustainable management strategies of forest hydrological functions were explored.

Canopy rainfall interception ranged from 134 to 626mm, and was ranked in the following order (lowest to highest): tropical mountain rain forest, subtropical western mountain evergreen conifer, tropical semi-deciduous monsoon forest, temperate mountain deciduous/evergreen conifer, cold-temperate/temperate mountain evergreen conifer, subtropical bamboo forest, subtropical/tropical eastern mountain evergreen conifer, cold-temperate/temperate mountain deciduous conifer, temperate/subtropical deciduous broadleaf forest, subtropical mountain evergreen broadleaf forest, subtropical/tropical south-west mountain evergreen conifer, south subtropical evergreen broadleaf forest, subtropical mountain evergreen/ broadleaf forest. Within the rainfall range of 500-600 mm, there was no statistical difference in interception among the majority of forests, but there was a difference between semi-deciduous monsoon forest and bamboo forest, evergreen broadleaf forest, China fir forest, evergreen/deciduous broadleaf forest, *Paulownia* plantation, Chinese pine forest, and between Scotch pine forest and oak forest, bamboo forest, evergreen/deciduous broadleaf forest, masson pine forest, Chinese Fir forest. Interception is largely dependent on stand structure and canopy coverage, rather than tree species.

The moisture holding capacity of litter can be two-to-four times as much as its dry weight, but varies with forest type. The tropical mountain rain forest has relative lower capacity compared to subtropical mountain evergreen/deciduous broadleaf forest. The soil non-capillary moisture capacity of forests ranged from 36-142 mm with an average of 89 mm. Evergreen broadleaf forests have a non-capillary capacity of more than 100 mm, while cold-temperate/temperate deciduous broadleaf forest and evergreen conifer forest have a non-capillary moisture capacity of less than 60 mm. The soil non-capillary moisture capacity accounted for more than 90% of the total as an ecosystem, followed by the moisture holding capacity of forest litter, which ranged from 3-10mm, but interception only occupied a small proportion (less than 2 mm).

Sediment generation following harvesting of *Pinus radiata* in New Zealand: a variable story

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Keywords: sediment generation, *Pinus radiata*, harvesting

Understanding the variability in soil erosion measurements is critical if they are to be used in soil erosion models or for regulatory compliance purposes. It is generally accepted that variability in soil erosion measurements can be large, but this is not well documented. Often the number of replicates needed to satisfy low coefficients of variation are potentially large and are traded against cost and practicality of conducting the experiment. A study was initiated to determine sediment generation from a range of plots and small basins following clearfelling of a radiata pine plantation on the Coromandel Peninsula, in the North Island of New Zealand.

Bounded and unbounded 1 m^2 to 9 m^2 plots were installed on steep slopes(16^o-36^o, mean=27^o) a few weeks after clearfelling. Plots were located on deeply disturbed sites (exposed mineral soil) or lightly disturbed sites (litter and/or topsoil removed). In addition, nine small (0.25-2.3 ha) harvested ephemeral sub-catchments were monitored for sediment yield. Two unbounded plots (166 and 193 m^2) were located on the upper slope to the crest with maximum slope angles of 40-45°. The plots were cleared of all surface waste wood and branch material to expose erodible soil, and five 0.5 m-wide runoff collectors were installed across 6-7 m of slope width.

On a per m^2 area basis an order of magnitude variation existed between plots. For the first 3 months of measurement, the sediment generated on the 9 m^2 plots averaged 20 and 130 g/m^2 for light and deeply disturbed plots respectively. For 1 m^2 plots, it averaged 1 and 50 g/m^2 for light and deeply disturbed plots. Generated sediment values decreased from a high 2 months after harvesting. The average monthly unbounded plot yields from April to September 1999 were 10 g/m^2 (range 2.8-18.4 g/m^2) for the 166 m^2 plot and 0.2 g/m^2 (range 0.02-0.3 g/m^2) for the 193 m^2plot. Thus over a year, total sediment yield would average 20 -120 g/m^2. Despite similarities in treatment, size, and slope gradient between the plots, the larger plot differed in that there was more litter material mixed in the upper 10-20 cm of soil; this may have limited soil detachment and sediment delivery to the collectors.

Total sediment yields from the sub-catchments were in the range of 0.2-8.4 kg/ha/yr (0.02-0.82 g/m^2/yr) with a mean of 2.4 kg/ha/yr (0.24 g/m^2/yr) and a median of 1.6 kg/ha/yr (0.16 g/m^2/yr). The relationship between specific sediment yield (kg/ha) to the proportion of exposed soils is weak and accounts for about 38% of the variation.

Clearly sediment yields from plots are two-to-three orders of magnitude greater (in the first three months) than estimated annual yields from small basins. This difference is an artifact of the reporting convention for sediment yield. Care must be taken in extrapolating soil losses from plots to a larger scale. Soil losses from plots cannot be assumed to equate to losses at the basin

Effects of rainfall on nutrient dynamics and ligno-cellulose degradation of decomposing forest litter

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Key words: forest litter decomposition, nutrient dynamics

The dynamics of ecologically important chemical elements under various natural systems during the decomposition of forest litter is well documented. However, information on environmentally modified systems such as rainfall reduction is nil. In this study, the influence of rainfall on changes in concentrations and amounts of nutrient elements, lignin and cellulose in decomposing forest leaf litter were monitored for one year. A transparent plastic cover was installed to control the amount of rainfall reaching the forest floor. Leaf litter of *Quercus serrata, Quercus acutissima*, *Acer rufinerve* and *Pinus densiflora* was incubated in litterbags and sampled at 3, 6 and 12 months after set up. Residue litter was dried (60°C, 72 h), ground in a Wiley mill to pass a 0.5-mm screen. N and C of litter and soil samples were determined by dry combustion (N-C Analyzer-Sumigraph High Sensitive NC 90A). Other elemental analyses were prepared using a 1:1 mixture of HNO_3 and $HClO_3$ following the wet oxidation procedure (Jones and Case, 1990). The extracts were analyzed for their Ca, Mg, P, Mn, Fe, Al, Co and Zn using the inductively coupled plasma spectrometer (ICPS-2000, Shimadzu Co., Kyoto, Japan); and K by flame emission spectrometry (AA-6700F Shimadzu). Lignin and cellulose were determined by proximate analysis via acid detergent fiber (ADF) method, and total extractable polyphenols (TEP) by AOAC method using Folin-Denis reagents.

Results indicate that fully exposed and partially covered litters were comparable but differed when compared to fully covered ones. The nutrient dynamics pattern in covered litters deviated from the normal trend. The concentrations of both macro- and microelements had generally increased with time, irrespective of covering regime. Some exceptions were noted in *Q. acutissima* (P, Mn, Zn), A. rufinerve (K, Mg, Fe) and *P densiflora* (N, K, Ca, Mn, Cu), whose concentrations had either decreased or fluctuated during the course of the study. The amounts of these elements had followed three patterns: 1) element mass had initially increased then decreased, 2) the element mass had decreased all throughout, and 3) the element mass had fluctuated but tended to decrease towards the end of the study. In both the concentrations and amounts of various chemical elements, significant differences were noted even within species with comparable mass loss rates. Apparently, the litter incubated in covered plots was different from that in fully- and partially exposed ones. Generally, the C/N ratio of residue litter had declined through time, with the exception of covered *P. densiflora* and *Q. serrata*, where a rise in C/N ratio was apparent on the 12th month. The C/N ratio of covered litter was different from fully- and partially exposed litter across all species, except P. densiflora whose value had increased on the 12th month. The concentrations of lignin in exposed litter for *A. rufinerve* and *Q. acutissima* were higher after 3 and 6 months while those for *Q. serrata* were higher throughout the study than covered litter. On the other hand, *P. densiflora* was not affected by cover treatment. The concentrations of cellulose in covered litter seemed to remain constant after one year. After 12 months, the concentrations of cellulose in exposed *A. rufinerve Q. acutissima* and *Q. serrata* litter were significantly lower than the uncovered ones.

This study has demonstrated that rainfall affected the mobility of chemical elements. In some elements, the concentrations and mass were significantly different despite comparable litter mass loss rates. Likewise, zero-rainfall significantly reduced cellulose and lignin degradation. Finally, rainfall, through its buffeting effect, may alter the turn-over of ecologically important elements in the forest ecosystem.

Evaluating evapotranspiration and surface conductance of a tropical rainforest in Peninsular Malaysia

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Key words: rain forest, evapotranspiration, surface conductance

Understanding the effects of the tropical rain forest on climate at both the local and global scale as well as on the regional water resource is one of the most important scientific concerns involving environmental issues. It requires intensive observational studies for estimating energy exchange including heat and vapor fluxes between the tropical forest and the atmosphere.

Observations on the energy exchange above a tropical rain forest have been conducted in the Pasoh Forest Reserve in Peninsular Malaysia. This study evaluates surface conductance, which represents stomatal response to environmental variables at the whole catchment scale. This evaluation assists in quantifying the effects of these variables on the energy exchange above the forest. It is necessary for estimating long-term evapotranspiration rates from a single source or "big leaf model" such as the Penman Monteith equation applied to estimating evapotranspiration from an Amazonian rain forest. The analyses were made using data collected with the aid of a 52 m tower in the forest reserve, where the canopy height was about 35 m, but with some emergent trees over 45 m. The Bowen ratio method was used for estimating sensible and latent heat fluxes from the forest canopy, and the profile method, taking into consideration the effects of atmospheric stability, was applied to estimate aerodynamic resistance. The surface conductance was calculated through the Penman Monteith equation from the fluxes and the resistance.

Results from the data set collected during the rainy season showed that surface conductance was mainly controlled by the specific humidity deficit and solar radiation, as expected from common stomatal responses. An empirical functional expression for these relationships obtained from other forests explained the characteristics of the surface conductance in our forests although the values tended to be large compared to those from other forests. The results will be applied to elucidate the characteristics of surface conductance in drier conditions.

Water and soil loss from a eucalyptus plantation in Kerala, India

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Key words: *Ecalyptus* plantation, soil loss

Eucalyptus is one of the important species grown by the Forest Department of Kerala State to meet industrial pulpwood requirements. Water and soil loss through accelerated erosion on sloping terrain starts as soon as the natural vegetation is removed, and eucalyptus plantations are no exception to this rule, although the actual loss has never been quantified. This study was established to generate data on loss of water and soil through surface runoff from a *Eucalyptus tereticornis* plantation in the Thrissur Forest Division of Kerala.

The study site at Palakathadom, Machad Range, Thrissur Division, is moderately steep with slopes of 15 to 20% and undulating terrain on all aspects. *E. tereticornis* was replanted in 1992 at a spacing of 2 x 2m. The study was carried out during 1994-95. The ground was bare except for some grasses and shrubs and some leaf litter. The soil is a fairly deep, well drained ferralsol derived from gneissic parent material. It is an acidic, reddish yellow sandy loam with a massive structure and is low in organic carbon and nutrients. The climate is humid tropical with 2000-3000 mm rain and temperatures ranging from $18^{-}38^{o}$C. Most of the rain is contributed by the southwest and northeast monsoons. The area receives around 120 rainy days annually and rainfall exceeds 10 mm on more than 60 days.

Soil and water loss from the eucalyptus plantation was quantified by establishing three 50 x 8m runoff plots along the slope and measuring runoff and sediment concentration. Stage level recorders of the Stevens F-type with stage graphs of 8 days duration were used to calculate runoff while sediment load was sampled daily from water collected in cisterns with a multi-shot divisor system arranged in series.

In 1994, the plots received on average 1183 m^3 of rainwater of which 227 m^3 (19%) was lost through surface runoff. The highest value recorded on a particular day was 33.8 m^3 of rain and 8.45 m3 of runoff. In 1995, 898.8 m^3 of rain fell on the plot of which 178.25 m^3 (20%) was lost as surface runoff. A peak day in 1995 received 78.6 m^3 rain and lost 42 m^3 (54%) through surface runoff.

When seasonal differences were considered 88% of the total runoff in 1994 occurred during the south west monsoon, while in 1995, 90% was lost during this season. During the north east monsoon the loss was 11.5% of the total runoff for 1994. The loss in 1995, during this season was negligible. Loss of water during the summer rains of 1994 was also meagre although in 1995, 7.5% of the total runoff occurred during the summer season.

8.04.00 Natural disasters

The influence of plenitude and species of the forests on dynamic and erosion processes in Tajikistan.

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Keywords: mountain forests; dynamic and erosion processes; high zones

The mountain forests of Tajikistan play very important nature protective role. All of them are belong to the first category. By existing laws of the Republic the cutting down of forests is absolutely forbidden. However the intensive cutting had been take place since 1992 and restoring of forests happens slowly. The main types of the forest vegetation are broad-leaved forests, small-leaved forests, jungles, xerophitic sparse woodland, junipers, mixed forests, shrubbery and half-shrubbery vegetation. By depending on high natural-climatic zones the mountain forests are situated in such sequence: jungle-valley zone, small-leaved (sometimes broad-leaved) forests and kserophitic sparse woodland-low mountain zone, juniper, mixed and broad-leaved forests-middle and high mountain zones. The biggest part of forest areas are subjected to erosion and dynamic processes. This is because the forests which plenitude is bigger than 0,6 are occupy insignificant areas. The biggest index of the dynamic and erosion processes can be observed in the forest formation which plenitude is 0,1-0,3. The aforementioned processes are almost absent in the forests with 0,6 plenitude. The landslides sometimes can be observed here. In the forests which plenitude is bigger than 0,4 the temperature of soil and air is below than it is in open territories. The amount of precipitation until 20 mm stays on the leave surface. It is used for moistening of the leaves and for evaporation. The amount of precipitation above 20 mm reaches the soil surface but surface flow didn't formed. The amount of precipitation above 30 mm are forming the small amount of surface flow. The drop erosion is developing here. The soil indexes are better under the forest than in the open territory. By depending on natural factors the leaves can hold different amount of precipitation. The different types of trees are regulating dynamic and erosion processes. The detail characteristics of the forests and their influence on environment is given. The highest index of the soil washout can be observed in the *Amygdalus* and *Cercis* zone and it comes to 250 t/ha. The intensive development of the soil degradation observed in the *Pistacia* zone (4-113 t/ha) and depends on complex of natural factors and peculiarities of the growth of *Pistacia* especially with dynamic of the leaf surface. In these forest formations there are surface, gully, underground erosions, land sliding can be observed. The soil degradation in the nut forests with plenitude 0,1-0,3 comes to 24 t/ha. The soil washout and the flowing coefficient in the juniper forests with plenitude 0,1-0,3 comes 55 t/ha 0,14-0,52 respectively. The surface, gully and drop erosions, karst can etc. are wide spreading here. The influence of the different climatic, soil and erosion indexes on the forests is investigated. The investigations are carried by such scheme: precipitation-forests-surface flowing and infiltration-changes of environment.

The characteristics of shallow landslides occurring after clear-cutting beech stands and planting conifers on heavy-snow mountain slopes in central Japan

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Keywords: shallow landslides, topographic factors, slippage of snow cover, stump roots, restraint function

The distribution and the transition of shallow landslides, those have occurred after clear-cutting beech (*Fagus crenata* Blume) stands and planting conifers (*Cryptomeria japonica* D.Don or *Larix leptolepis* Gord), on heavy-snow mountain slopes in central Japan were investigated using aerial photographs.

Relationships between the distribution and topographic factors were analyzed by using quantification method. In the analysis, azimuth, inclination, elevation, longitudinal-section form and cross-section form were employed as the factors. The analysis units were 25m, 50m and 100m meshes. The item to be related to the distribution of shallow landslides most closely was azimuth. The feature of the distribution of shallow landslides in the investigated area was different from that in the cause of heavy rain. The following categories promoted the instability of shallow landslides: azimuths of SE, inclinations larger than 30-35°, elevations between 1300 and 1400m, concave longitudinal-section and cross-section forms. On slopes of these conditions slippage of snow cover is more severe. According to the results, the distribution of shallow landslides was considered to be caused by the difference of slippage of snow cover.

The number, the area and the range of shallow landslides increased for more than 10 years. However, heavy rain or heavy snow initiating the landslides was not found during this period. Small shallow landslides, less than 100 m^2, held a greater part in number through the survey duration. The area of shallow landslides increased according to data collected in the years after afforestation.

However, the area of shallow landslides changed in very little in the area that afforestation was not carried out. As a result, the occurrence process of shallow landslides was concluded as follows: 1) the glide of snow cover was restrained by the stumps and the effect of the stump roots on slope stability emerged in the several years after the clear-cutting. 2) the glide of snow cover became obvious with the decrease of the stumps and the effect of the stump roots on slope stability deteriorated. 3) the glide of snow cover was restrained by ground clearance and the frictional resistance increased at the bottom of the snow cover be cause of weeding. 4) the brush wood decayed and the restraint function of the glide of snow cover was lost, while the growth of planted trees was not enough to restrain the glide of snow cover and affected slope stability for several years after planting. 5) the shallow landslides resulted in shear fracture by the annual snow displacement.

Characteristics of landslide distribution in the Toyama Prefecture, Japan- spatial analysis with GIS

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Keywords: landslide GIS, geologic and geographic analysis, Tertiary formation, active faults

Toyama prefecture, which is frequently affected by landslide disasters, is located on the western coast of the central part of Japan. About 280 landslide areas in the prefecture are reserved for landslide-threatened areas by the Japanese Landslide Prevention Law. It is very important to recognize characteristics of landslide distribution to locate vulnerable landslide areas. Basic information related to landslides is usually on maps. Many maps, such as topographic maps, geological maps, landslide location maps and so on, are published by the national and local governments. It has not been easy to do some spatial analysis with those maps, because most of them have been paper maps and produced in different scales. However, we are able to obtain some digital maps and able to use relatively cheap PC based Geographic Information System (GIS) software recently. Purpose of this study is to make a data set of landslide related matters with digital and paper maps, and to do some spatial analysis with GIS.

Maps used in this study are: (1) Digital Map 25000 (Administrative Boundaries) by the Geographical Survey Institute (GSI); (2) Digital Map 50m Grid (Elevation) by the GSI; (3) FD Map (Railroads, Roads and Rivers) by the GSI; (4) Geological Map of Japan 1:1,000,000 by the Geological Survey of Japan (GSJ); and (5) Landslide Distribution Map by the Toyama Prefecture. The maps (1)-(4) were distributed in digital format so they were imported from a GIS software directly, but (5) was distributed as paper maps, so it was necessary to digitize all landslide area polygons by a digitizer. Municipality polygons from (1), which were divided by 1:25,000 map borders, were combined and the prefecture polygon was combined from the municipality polygons as vector data. Railroads, roads and rivers from (3) and faults from (4) were added into different layers as line type vector data. Geology polygons from (4) were added and extracted by the prefecture polygon as vector data. Elevation data from (2) was combined and added into a raster layer.

The results of some spatial analysis showed that, more than 90% landslide-threatened areas were located, at least partially, inside the Tertiary formation and more than 50% areas were located, at least partially, inside the 2 km buffer zones from faults. They suggest that the distribution of landslides is strongly related to geologic factors.

Spatial analysis of geologic and geographic factors with GIS will be effective for recognition and identification of landslides. Detection of vulnerable locations will be possible if combined with other investigations, such as aerial photographs and satellite data interpretation.

Potential soil erosion risk in the watershed basin of Struma River

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Keywords: soil erosion inventory; GIS; anthropogenic impact; suspended sediment; topography; vegetation

The Struma river basin occupies the southwestern part of Bulgaria, covering an area of about 9000 km^2 inside the country. The present project aims to make an inventory of the potential erosion in the Struma Watershed in western Bulgaria by modeling in a Geographical Information System (GIS) environment. Few studies on the difficulties rendering such an approach operational exist at present since most scientific studies tend to work in ideal environments with very good data availability. In the present study, only available data, of the kind that can be found in most countries has been used. Field plot measurements and suspended sediment measurements have been used for validation and comparisons between different measurement levels have been made. The use of digital GIS technique will permit easy up-date and enlarging of the current database.

In most of the Struma River watershed the natural features (relief, main rock type, precipitation, soil and vegetation) combine to favour the development of erosion processes. The mountain part of the watershed has a very rugged relief. Areas with slopes over 10% prevail. At some places the vegetation is insufficient to protect the soil from erosion. The cultivated areas on steep slopes are abundant. The anthropogenic impact on erosion intensity is also significant in the lower parts of the watershed. The eroding riverbanks, including those of the tributaries also make a considerable contribution to the generation of sediments in the river.

It was concluded that the results from the modeling and actual measurements of suspended sediment correlates well. It was also concluded that it is difficult to transfer information from one scale of measurement to another as well as adapting measured data to data acquired by modeling.

Concerning erosion in the Struma watershed it has been concluded that topography has a very strong influence on potential soil erosion. Soil erodibility is the second factor influencing erosion, mainly on Distric Cambisols (CMd), Eutric Cambisols (CMd) and Humic Cambisols (CMd) soil types. The inclusion of vegetation in the modeling that was done for the two pilot areas shows the extreme importance of this factor on erosion intensity. Large areas that was classified as high potential erosion areas was classed down to moderate or even low actual erosion at sites were the vegetation cover was important. The scale of mapping proved to be very important when comparing the results for the two areas using the scale of mapping for the whole watershed and when using the detailed 1:25000 input data for the pilot areas. Topography was much more accurately depicted in the pilot areas and results for the potential erosion modeling generally higher. This implies that the results from the general modeling should be used for general planning and prioritising soil conservation actions while the 1:25000 scale could be used for actual in site planning of conservation measures.

The major benefit of this project is that a methodology for soil conservation planning has been tested and found very appropriate when addressing this kind of problem. Interesting links between different scales has been examined and the need for more knowledge in this field has been underlined by the analysis.

Use of intensive soil working technique in afforestation of wastelands

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Keywords: soil erosion; water retention; 'V' shape furrows

The degraded forest wastelands are prone to heavy grazing in India and are consequently eroded and compact. Therefore, 90% of rainwater runs away leaving very little portion of it to percolate into subsoil. By traditional pit planting method only about 20.25 cubic metre rainwater can be harvested perha at a given time. This is highly inadequate. In order to harvest maximum precipitation by percolation there is need to carry out intensive soil working before planting operation. The method suggested in this paper deals with technique of water retention through ploughing and digging of 'V' shape furrows intercepted by small bunds at 2 metre intervals. By this technique, 1500 cubic metre of rainwater can harvested perha at a given time. The technique is very simple but effective and relevant in plain areas having low rainfall and high temperature, particularly the drought prone area. Accordingly this applied research study was carried out, on a moderate scale, in Jalgaon district of Maharashtra State in India. (Note-the study has earned Brandis award to the author for the year 1991 of Indian Forester, a monthly journal of forest and forestry research, Indian Council of Forestry Research, Dehradun, India. Summary of the paper was also published as voluntary paper by XIth. World Forestry held in Turkey in 1997).

Problems of development of adir slopes of the Hissar Valley in Tajikistan

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Keywords: landslides; erosion; mountainous seismoactive territories; aerial survey; engineering and geological exploration

The development of mountain seismoactive territories is traditionally confronted with a number of difficulties:

- Geomorphologic shortage of arable lands and lands good for construction;
- The development of nearly all types of dangerous geological processes on the slopes;
- High Seismisity;
- Shortage or abundance of water;
- Large areas of easily eroded volume changeable soils, etc.

Traditionally valley and mountain cavities are the first to be developed and then foothill territories. In Tajikistan one of the main zones for economic development is the Hissar valley situated on the junction of two largest tectonic regions-south Tyanshan and south Tajik regions. The cultivated zones are mainly situated on the medium-sized and high foothill adirs, surrounding the valley. The largest seismoactive tectonic breaks Hissaro-Kokshalsky in the north and Ilyaksho-Vahsh in the south, run across the adir foothills. From time to time seismic and tectonic activity of the breaks intensifies landslides and erosion just on the inhabited and cultivated territories. It causes damage and threatens people's lives. The typical example of such phenomena is the territory adjacent to the northeast outskirts of Dushanbe-capital of the Republic of Tajikistan. Agricultural development here is concentrated in the valley and in the watersheds of 4 erosive gullies-Gulbista, Kiblai, Kamchin, and Loiob. The upper reaches of these streams represent huge circuses of ancient seismogenic landslides aggravated by the seismic breaks. The decoding of aerial survey, engineering and geological exploration showed that during the last 30 years the activity of dangerous geological processes was registered 3 times in the anomalously rainy years (1969, 1987, 1998) that caused motion lasting 3-4 years, a rise in the ground water level and erosion. These dangerous geological processes every 10-12 years make it important to displace as soon as possible inhabitants from the villages, situated in the land sliding circuses. It should be also mentioned that the zones of landslides are the places that cause mud flows and threaten the northeast outskirts of Dushanbe. The size of active landslides in 1998-1999 is ranging from 5-7 thousand to 60 millions cubic meters (Loiob). Frequent landslides and erosion in the adir area of the Hissar valley bring to the forefront the task to resettle households from those dangerous territories and to make forest-park belts and gardens here. These actions will help to solve the problems of ecological improvement of the environment and to reduce the consequences of dangerous geological processes.

Ring shear tests on mixtures of fine sand and loess

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Keywords: sliding surface liquefaction, ring shear test, excess pore pressure, shear resistance, fine sand, loess

Liquefaction landslide is usually characterized by high sliding velocity and large run-out distance. It always causes great hazards. In the studies of earthquake-triggered-landslides based on ring shear tests, a concept of Sliding surface liquefaction was proposed by Sassa to interpret the high mobility. Sliding surface liquefaction takes place along sliding surface, it even can happen in medium or dense soil structure, because grain crushing along the sliding surface can result in volume shrinkage and then lead to pore pressure generation.

Two new sets of almighty intelligent ring shear apparatus were made and improved by Sassa to simulate the earthquake-triggered-landslides. The obvious advantage of ring shear apparatus is that there is no limitation in the shear displacement during shearing. For the sliding surface liquefaction, the most obvious characteristic is that with increasing of shear displacement, accompanying the grain crushing, pore water pressure built up gradually and then shear resistance decrease slowly, and finally reach constant value respectively, known as the steady state.

The relationship of grain crushing and sliding surface liquefaction had been mostly studied by using different samples under different loading conditions (static loading and dynamic loading). But the effects of grain size on sliding surface liquefaction behaviour had been poorly studied. It was pointed out that fine sand with some content of clay, are more prone to suffer from liquefaction failure, showing larger run-out distance, and many researches on this aspect had been carried out based on triaxial tests. However, the undrained behaviour of fine sand along the sliding surface is still poorly understood and requires further study. Therefore, in this research, a series of tests was conducted on fine silica sand in ring shear apparatus to study the undrained shear behaviour.

By mixing loess into silica sand with different loess content, the undrained shear behaviour of the mixtures had been studied, and then the pore pressure generation behaviour has been analyzed. It was found that with increasing loess content, the shear resistance at phase transformation and final steady state becomes smaller. In some tests on sample with greater loess content, the results show that even turned into drained condition after being sheared to steady state, the generated high pore pressure within the shear zone can be kept through a very long time due to the very low permeability of shear zone.

A Modified Geotechnical Simulation Model for the Quasi-Three-Dimensional Prediction of Landslide Motion

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Keywords: Landslide; Prediction; Shear resistance, Thickness change, Pore pressure generation possibility

On the previous work (Table 1) of geotechnical simulation on the motion of landslides conducted by Sassa (1988), a modification is made on the shear resistance item and the geotechnical simulation model is improved.

Table 1 Geotechnical model on the motion of landslides by Sassa (1988).

Landslide has a two-layer structure, upper debris layer overlaying on the sliding zone (sheared layer). After sliding for a certain distance, the soil at sliding zone will reach its steady state, and the shear resistance will mobilize to the minimum value (Eq.(4)). In the sliding process, the thickness of upper debris layer always becomes thin, and results in decrease of the normal stress (Eq.(5)). Then, the apparent friction coefficient $\tan fa$ can be obtained by Eq.(6). Here *h* is the thickness of the sliding mass, and *Bss* is pore-pressure generation possibility. When the upper debris layer becomes thinner than a critical thickness, *hcr* (defined by Eq.(7)), suction will take action. In the actual case, because it is almost impossible to keep suction in the sliding zone, we assume that the apparent friction coefficient equals to

$$\frac{\partial M}{\partial t}+\frac{\partial}{\partial x}(u_0 M)+\frac{\partial}{\partial y}(v_0 M)=gh\frac{\tan a}{q+1}-kgh\frac{\partial h}{\partial x}-\frac{g}{(q+1)^{1/2}}\cdot\frac{u_0}{(u_0^2+v_0^2+w_0^2)^{1/2}}\{h_c(q+1)+h\tan f\} \quad (1)$$

$$\frac{\partial N}{\partial t}+\frac{\partial}{\partial x}(u_0 N)+\frac{\partial}{\partial y}(v_0 N)=gh\frac{\tan b}{q+1}-kgh\frac{\partial h}{\partial y}-\frac{g}{(q+1)^{1/2}}\cdot\frac{v_0}{(u_0^2+v_0^2+w_0^2)^{1/2}}\{h_c(q+1)+h\tan f\} \quad (2)$$

$$\frac{\partial h}{\partial t}+\frac{\partial M}{\partial x}+\frac{\partial N}{\partial y}=0 \quad (3)$$

h: depth of the sliding mass; *M*, *N*: Discharge in x and y direction per unit width, respectively ($M = u_0 h, N = v_0 h$); *k*: lateral pressure ratio; $\tan f$: apparent friction coefficient of the soil in the sliding zone; *hc*: cohesion head (defined as cohesion $c = rgh_c$, it is zero after sliding for a long distance. ρ: density); $\tan a$, $\tan b$: inclination of the intersection between the original slope surface and the x-z plane, y-z plane, respectively. $q = \tan^2 a + \tan^2 b$, $w_0 = -(u_0 \tan a + v_0 \tan b)$

$\tan f$ when *h* is smaller than *hcr*, as presented in Eq. (8).

The apparent friction coefficient will increases with the decrease of the thickness. It is also affected greatly by the *Bss* value. This model is added to Sassa's model, and the simulation program is modified.

$$t_{ss}(h, B_{ss}) = t_{ss} + (s(h)\tan f - t_{ss})(1 - B_{ss}) \quad (4)$$

$$s(h) = gh\cos^2 q \quad (5)$$

$$\tan f_a = \frac{t_{ss}(h, B_{ss})}{s(h)} \quad (6)$$

$$hcr = {}^{t_{ss}}\!/\!{}_{g\cos^2 q} \quad (7)$$

$$\tan f_a = \tan f\,,\ \text{when } h \le hcr \quad (8)$$

An application study is then carried out on the Sumikawa landslide, a rapid and long runout landslide occurred in Akita Prefecture in 1997. The simulation results of aerial prediction shows a good correspondence to the actual landslide.

8.05.00 Forest Fire. Land Use, climate variability anf forest fires in South-east Asia

Fire occurrence in relation to weather conditions

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This paper presents and evaluates the effects of fine fuel moisture content of forest floor fuels on fire occurrence in Mediterranean ecosystems of Turkey. Fine fuel moisture contents were measured in an even-aged, fully stocked red pine (*Pinus brutia*) stand near Izmir. Three fuel samples were taken daily in the early fire season in June and once or twice a week thereafter. Fuel samples were weighed and oven-dried at 100 ^{o}C for 12 hours or until no change in weight was attained. Moisture contents were determined based on the weight difference between before and after oven-drying. Weather measurements were taken daily at noon local standard time from a nearby weather station located at Menderes Interantional airport. Measurements included temperature, relative humidity, wind speed and direction, and precipitation. Fire occurrence data during the study period was obtained from the Regional Forest Directorate in Izmir. Analyses showed that a close relationship exists between weather conditions and fire occurrence. Indexes generated from this study should be invaluable for fire managers in the region and other places having similar conditions.

Further posters regarding the topic 'Forest and Fire' can be found in Part 3 / Task Forces A2 (this volume).

8.06.00 Wildlife

Capercaillie (*Tetrao urogallus* L.) as the indicator of conservation and changes in forest ecosystems in mountain landscape of Slovenia

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Keywords: forest ecosystem; Capercaillie populations; human impact; habitat suitability; Slovenian Alps, forest history

The present analysis of indigenous European beech-silver fir forests in the eastern part of the Karavanke range in Carinthia and in the eastern part of the Kamnik-Savinja Alps, both in northern Slovenia, in the last two centuries - the transition period from rural-pasture landscape with a low proportion of forest to forested landscape - shows the influence of changes in which high-altitude pastures reverted to scrub and coniferous (Norway spruce and Alpine larch) woodland on the increase of Capercaillie (*Tetrao urogallus* L.) populations, after the year 1875 to their peak in 1933. After last prove optimum of population density in 1961 a sharp fall was observed until the minimum was reached in 1982. This is attributable to a decreasing fluctuation phase of Capercaillie populations and to an increasing adverse human impact on the mountainous forest area.

On the carbonate Peca (2126 m o. s. l.) and non-carbonate Smrekovec with Mozirje mountains (1684 m o. s. l.), on the two mountains under investigation in this study (309 km^2) with 80% of forest cover, the density of populations does not differ (0.9 birds/km^2), but it differs significantly at the height of over 1100 m, that is above inversion layers, in favour of Smrekovec with Mozirje mountains (2.8 birds/km^2) with lower pH (neutral and acid soil).

The results of the study show an positive influence of forest areas in the mountains preserved from period of the Josephine military maps from 1784-1787 (on Smrekovec with Mozirje mountains 34.2% and on Peca 10.9% of forest cover) on the distribution of Capercaillie habitats in the current forest coniferous landscape. The proportion of the number of

overgrown centres of habitats in forest areas from 200 years ago is up to three times higher than the then (today's) forest cover. Distribution of capercaillie leks and overlapping with forest areas from the period 1784-1787 in the present forest landscape is distinct in north eastern positions of slopes, as the preserved forest land on the unsuitable rural surfaces. The present proportion of forested land was attained by Smrekovec with Mozirje mountains as early as 1875, and by Peca only in 1962.

On these two mountains, an increase in the proportion of forest areas preserved from the period 1784-1787 in Capercaillie habitats of subpopulations in 500 m around the centres of leks is leading to a significant decrease in the distances among habitats ($p<0.001$), from about 1500 m at 0% of preserved forest area to 700 m at 80%.

Monitoring of Capercaillie in whole area of Slovenia showed that the condition of population density in 1998, is alarmed, specially in Dinaric Alps area. Only 48,8% of 592 known leks in Slovenia occur active sub-populations. In potential habitat on the 33,8% surface of Slovenia in area from 1600 to 600 m o. s. l. in 200 m altitude zones we found out significantly linear decrease of share of active leks, from 70,3% to 16,0%. Maximum of active leks is in layer betwen 1201 to 1400 m o. s. l. with 42,5% of all active leks, maximum of population density in 1998 is in layer between 1401 to 1600 m o.s.l., with 6,5 birds /10 km^2. In this area of both layers with 1.015 km^2 on the 4,7% surface of Slovenia, we establish suitability of habitats. Capercaillie, this endangered species of mountain forest fauna in Middle Europe, indicates the conservation of this forest ecosystems and habitats of other rare species of forest fauna (biodiversity) under the forest border at 1650 m.

Social changes in the Kani tribals and its impact on human-wildlife conflict: a case study from the tropical forests of southwest India

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Keywords: Tropical forests; man-wildlife conflict; crop damage; Kani tribals

Man-wildlife conflicts and social changes of Kani tribals inhabiting the Peppara Wildlife Sanctuary in southwestern India was studied during the years 1993 to 1996. The study was carried out by observational methods and also from field plots. Structured questionnaire was used to collect data on the social aspects of the tribals. Major man-wildlife conflict was in the mode of crop damage and human slaughters. Out of the thirty species of larger mammals, five species were recorded as destructive to 17 crops of the tribals. Crop damage by wild boar (*Sus scrofa*) was severe, followed by elephant (*Elephas maximus*). Thirteen indigenous crop protection methoods were recorded from the area, which are effective up to certain extent.

Analysis of social changes of Kani tribals revealed that peripheral settlements of the sanctuary have more educated people compared to the settlements deep inside the sanctuary. Access to the educational institutions was comparatively easy from the peripheral settlements. Due to the high educational background, people in the perpheral settlements cultivated cash crops like coconut, cashew nut and casava in large scale and due to this crop damage was severe in the peripheral settlements. Where as in the interior settlements, tribals cultivated only traditional crops, with low input and the crop damage was of low intensity. Crop damage is found linked to the cropping pattern and location of the settlements in the sanctuary.

The effects of forest management on the biodiversity of insect communities

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Keywords: insect communities; forest management; harvest systems; biodiversity

As forests continue to be managed for commercial production, sensitive land stewardship requires principles for applying forest harvest techniques in a way that minimizes the impact on non-commercial species of plants and animals to retain biological diversity. To date, appropriate strategies in forested landscapes have been constrained to the management of a handful of vertebrate species.

The Penobscot Experimental Forest in Bradley, ME has provided an unusual opportunity to evaluate the effects of different harvest systems on biodiversity. We deployed insect traps from 1995 through 1998 in 10 ha stands that ranged from even-aged shelterwood and clearcut harvest systems through uneven-aged selection harvest systems that retained a significant portion of mature trees within the stand. Diversity was high in the selection stands, that had moderate levels of plant species diversity and high levels of plant structural complexity, and the clearcut stands, that harbor a relatively rich plant species community and low structural complexity. Communities in the clearcut stands were distinct from those in the selection stands and were relatively rich in herbivore and parasitoid species, while those of the selection stands were rich in fungivores and predators. Stands managed under a shelterwood system provided low plant species diversity and low structural complexity resulting in the dramatically lower levels of insect diversity. Plant species richness and structural complexity were not correlated in these studies. The results of these studies provide prescriptions for managing forests at the stand and landscape levels in order to foster the maintenance of biodiversity.

8.07.00 Biodiversity

The community structure and species diversity of *Pinus massoniana* forest in the Three Gorges Reservoir Area, China

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Keywords: community structure; species diversity indices; sub-tropical pine forests; human disturbance

The Three Gorges Reservoir Area is located in the sub-tropical moist region of China. *Pinus massoniana* forest is one of the important vegetation types and the main commercial forests in this area. According to the data of 32 plots, the forest was divided into 21community types. The vertical structure of all community types is obvious, it can be divided into tree layer, shrub layer and herb layer. The trend of the species richness index, diversity index and evenness index of different layers in all community types is herb layer>shrub layer>tree layer. But maybe because of the strong disturbance of human activities in the area, the trend of these indices along the altitude gradient is not obvious.

Monitoring changes in tropical forest environments using moths

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Keywords: tropical forests; moth diversity; monitoring; environmental assessment; disturbance impacts

Changes in tropical forest environments may occur naturally or be induced by man. Physical and climatic changes arising from man's activities can affect the ecological functions of tropical forest ecosystems. Examples of physical changes are conversion of land-use, or logging activities, whilst climatic change may be brought about through the greenhouse effect. In assessing the effects of these changes on forest ecosystems, monitoring organisms is far more informative than monitoring physical and chemical variables. Choosing the right organisms, however, is important if they are to be an appropriate tool for monitoring and interpreting change.

Moths from the superfamily Geometroidea or in short, geometroid moths, are a suitable group of insects for monitoring changes within the tropical forest environment because of their abundance, species richness, ubiquitous occurrence and importance in the functioning of the natural forest ecosystems. The response of geometroid moths to changes in the forest environment results from changes to the floristic components of the forest. As larvae, they exhibit a high degree of specificity in their herbivorous diets and feed on various parts of the plants such as flowers, leaves and fruits or seeds. As adults, some groups are nectar feeders, indirectly playing the role of pollinators.

Monitoring and detecting changes in the abundance, species richness and species composition of the geometroid moths gives a good indication of the state of a forest environment. These measurements can also be used in a predictive sense in relation to environmental assessments. An assessment of the state of the forest environment may include the levels of disturbance or recovery of the forest. The assessment carried out can be based on the presence or absence of, and/or the increase or reduction of geometroid moth species unique to a particular forest ecosystem. High numbers of geometroid moth species unique to the environment may in turn suggest a potential loss of these species following the destruction of this forest.

Some genera or species of geometroid moths are good indicators of a particular type of change in the tropical forest environment. High representation of species from the subfamily Sterrhinae for example, indicates that the forests are highly disturbed, a result that is usually associated with an open forest canopy such as in a logged forest. For more detailed conservation evaluation, however, the choice of a particular key geometroid moth species or genera within a group will depend on the precise objective. Geometroid moth species that are unique only to a particular forest site stand out and provide a strong argument for conserving the site. *Chloeres quantula* Swinhoe, for example, is such a species that has been found to be unique to mangrove. Species from the genera Ornithospila and Ectropidia on the other hand have strong associations with dipterocarp representation.

Biological indicators for monitoring the genetic and reproductive status of declining populations of red spruce, *Picea rubens*

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Keywords: population viability analysis; conservation; forest genetic resources; genetic diversity; reproductive success

Red spruce, *Picea rubens* Sarg., has historically been an important and characteristic component of old growth , late successional, upland forests of eastern Canada. However, this species is in decline and has become increasingly rare across most of its range in eastern North America as a result of environmental changes related to various human impacts, including harmful forest harvesting practices. Various reproductive (e.g., cone, seed, and seedling growth) traits and biochemical genetic estimates of diversity were used as indicators of the status and viability of natural populations across the northern margins of the geographic range. These traits were quantified to provide benchmark information for population monitoring. In general, the reproductive and genetic status of small, isolated stands from disjunct populations at the margins of the geographic range in central Canada compared favourably with the fecundity and genetic diversity of much larger, more extensive populations of eastern Canada. While some of the smaller, remnant populations appeared to be quite resilient to the effects of small population size, increased levels of inbreeding and inbreeding depression were beginning to affect fecundity, growth performance, and genetic diversity. Traits such as filled seed production per cone, the ratio of seed weight to cone weight (a measure of reproductive efficiency), seed efficiency, and the ratio of filled seed to aborted seed provide useful indicators for assessing reproductive status in trees at risk due to small population size, low within population densities, and the restricted gene flow imposed by population isolation. The reproductive indicators described here have general validity for assessment and monitoring population viability in most conifers; they are relatively easily measured; and they provide useful indicators for monitoring biological processes important to maintaining population viability. Our results suggest that in the short-term, small remnant forest stands can maintain surprisingly high levels of reproductive fitness. However, in the longer term, such small remnants can be expected to lose genetic diversity through inbreeding and genetic drift. Furthermore, such populations are at increased risk of local extirpation through stochastic events. It is often difficult to separate the genetic from the environmental effects on reproductive fitness in small populations at the margins of their geographic range because such populations experience both the genetic effects of reproductive isolation as well as the effects of physical stress in environments to which they may not be well adapted

Ecological research on plant biodiversity and biomonitoring in tropical evergreen forests of peninsular India

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This paper consolidates the results of plant biodiversity inventories in the permanent plots established in various tropical evergreen forests of peninsular India and discusses the potential use of those data and goals of biomonitoring. Large-scale plant biodiversity inventory program on a 30-ha scale at Varagalaiar tropical wet evergreen forests of Anamalais, Indian Western Ghats, yielded a total of 432 vascular plant species, of which 153 were tree species (>30cm gbh) in a total sample of 13,418 stems, 75 species of lianas in a sample of 11,200 stems (>1cm dbh) and 155 species of understorey plants in a total density of 2,18,471 plants and 26 species of herbaceous vascular epiphytes in 3,392 individuals. The recruitment of trees (>30cm gbh) for the one-year period was greater (mean 4 trees per ha) than the mortality (mean 3 trees per ha). In the Kolli hills of Eastern Ghats, four 2-ha permanent (contiguous) plots were established with increasing human disturbance, to evaluate the difference between them in tree species composition, stand structure and dyanamics. A total of 3,825 stems >30cm gbh (266-632 per ha) and 78 species (26-54 species per ha) were enumerated. Reduction in species richness (by 52%), basal area (56%) and tree density (58%) is evident in disturbed sites. First recensus data are in analysis stage. In two tropical dry evergreen forests at Kuzhanthaikuppam and Thirumanikkuzhi near Cuddalore town on the Coromandel coast of India, woody species diversity and density were 38 and 42 species per ha and 1367 and 994 stems per ha respectively. First recensus is being recently completed. Permanent plots provide opportunities for multifaceted research activities(e.g.forest production, various component interactions, forest functioning etc.). Repeat census of permanent plots has the advantage of multi-taxa monitoring in a cost-effective manner than separate species studies and these data are useful in basic and applied research in forest ecology.The fronitiers in this research area will be discussed in the light our large-scale ecology research program

Spatial and temporal changes in plant biodiversity

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Keywords: plant diversity; spatial and temporal changes; hardwood forests; diversity indices

Biodiversity of a forest is not static but dynamic. In a given forest, the plant diversity changes spatially, biodiversity measures for different locations vary considerably, as indicated by measurements of fixed area plots. Depending on the time of the year, the diversity of plants in a given forest will vary also. The results of a study are presented for which diversity was assessed on sample plots in a hardwood forest in Southern Germany. Observation were taken since 1997 every 3-4 weeks during the growing periods, all plants on small sample plots were measured, counted, or their cover percent estimated. For these data diversity indices were calculated. It was found that the spatial and temporal changes in diversity was significant, the various indices studied showed different trends. The problems of measuring diversity of plants on sample plots are discussed.

Impact of disturbance and fragmentation on conservation of biodiversity and genetic resources a global synthesis of current knowledge and impacts

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Keywords: disturbance impacts; fragmentation; tropical forest biodiversity; conservation of genetic resources; conservation policies and strategies

We review past and current research activities with respect to the impact of disturbance and fragmentation on the conservation of tropical forest biodiversity and genetic resources. Following the Rio conference in 1992, substantial financial and manpower resources have been invested in researching these issues, yet very little effort has been put into synthesizing and integrating the acquired knowledge. We attempt to consolidate the gains from past and ongoing projects to reach such a synthesis. The goal of the publication is to evaluate current knowledge regarding the impact of disturbance and fragmentation on conservation of biodiversity and genetic resources, as it relates to the implementation of the CBD. We do: a) by describing and comparing the impact pathways for conservation of biodiversity and genetic diversity, respectively, and with particular reference to policy implementation strategies; b) through a concise synopsis of what is known, key elements not known and topical research areas; c) through a critical review of projects that have been, and/or are being conducted, and discussion of issues for/from each project still to be resolved; d) through a critical review of methods that have been used and discussion of methodological issues still to be resolved (this will serve to examine the compatibility among results obtained by various projects. The global emphasis will be reached through comparison of the themes within eco-regions, followed by comparison of themes among eco-regions.

Extrapolation of multivariate diversity measures, with a case study from the tropical rain forests of Sumatra

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Keywords: Multivariate diversity measures; Tropical rainforests; Sumatra; Tree species diameter models

Sample plots have a limited area. The species-area relationship is commonly used to estimate the number of species in a forest from data collected from such a finite-area sample plot. This paper first considers and compares a number of non-linear models that may be used in this extrapolation. The dependent variable is then extended to other measures of species diversity than species count.

Finally the work is generalised to area-based extrapolation of the Renyi Functional Alpha-diversity measure. A less commonly considered sampling constraint is that of the tree-diameter cut-off used. This can have a major effect on diversity measures. The use of species diameter models are therefore developed which allow an extrapolation to zero diameter. The generalisation to multivariate functional diversity measures will also be considered. Finally the development of joint area-diameter (cut-off) models is reported, and their use for extrapolation. These new methodological techniques are developed in the context of a case study on data collected on trees in a tropical rain forest in Jambi, Sumatra.

Introduction d'espèces pour la foresterie ou l'agroforesterie et risques d'invasions biologiques

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Keywords: agroforestry; alien species; potential invasiveness; threats to native biodiversity

Les invasions biologiques sont aujourd'hui considérées comme une menace majeure à l'égard de la conservation de la biodiversité. Or, l'introduction incontrôlée d'essences ligneuses utilisées dans des programmes agroforestiers ou forestiers peut donner lieu à de nouvelles invasions biologiques, tout particulièrement, mais non exclusivement, dans les milieux insulaires. Ce risque est d'autant plus important que les espèces forestières colonisatrices ont été largement privilégiées ces 40 dernières années et qu'il est aujourd'hui matériellement possible de faire parvenir des semences de toutes essences forestières dans toutes les parties du monde. Les invasions à partir d'espèces ligneuses potentiellement invasives dans le monde sont bien renseignées en Amérique du Nord et en Europe, mais assez peu sur les autres continents, à l'exception des îles du Pacifique, de la Nouvelle-Zélande, de l'Australie et des îles de l'océan Indien. Les Mimosacées, les Pinacées et les Papilionacées constituent les familles qui recouvrent le plus d'espèces forestières invasives. A elles seules, les Mimosacées regroupent plus d'un tiers des espèces ligneuses invasives utilisées en sylviculture ou en agroforesterie. Parmi celles-ci, certaines espèces potentiellement invasives ont bénéficié d'efforts de diffusion très importants, comme *Leucaena leucocephala* ou différentes espèces du genre *Prosopis*.

Certaines plantes ligneuses invasives ont un développement tel qu'elles supplantent des formations végétales entières, comme par exemple différents acacias d'origine australienne dans les *fynbos* d'Afrique du Sud. La composition des écosystèmes et de leur biodiversité est dans ce cas fortement perturbée. On peut également assister à une homogénéisation des habitats, un appauvrissement des communautés, et à des modifications de la biomasse. Mais le plus souvent, les modifications induites par les plantes invasives portent sur la structure et les fonctions des systèmes écologiques et de leur biodiversité. La physionomie de la végétation est modifiée, la structure des populations est perturbée, les caractéristiques des sols peuvent changer, ainsi que les caractéristiques hydriques. De même, les invasions de plantes ligneuses peuvent entraîner des modifications des régimes de perturbation (ex : feux), des cycles biogéochimiques, de l'érosion, des régimes hydriques ou de la productivité primaire.

Dans l'attente d'une meilleure connaissance des critères de caractérisation des plantes invasives, le principe de précaution doit s'appliquer en situation de doute ou en connaissance de cas d'invasion pour une espèce donnée, observés en d'autres pays. Des bases de données sont aujourd'hui consultables sur Internet et permettent maintenant de décider d'une introduction en connaissance de cause.

Une liste d'une centaine d'essences potentiellement invasives à usage forestier ou agroforestier est fournie. Environ 25% de ces espèces seulement ne sont invasives que dans les îles, ce qui atteste du fait que les espaces insulaires, bien que plus sensibles aux

invasions biologiques que les zones continentales, n'en ont pas pour autant le monopole.

Strategies for conserving biodiversity in the Kii Peninsula, Japan

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The Kii Peninsula is located at the central part of Japan's mainland, and it has rich natural resources including forest and wood products and unique wildlife habitats. In addition to its resources, the area has attracted various national and international attentions in recent years, because the Miyagawa Basin of the Kii Peninsula is a now candidate for third Japanese "Model Forest."

However, because of lacking adequate protection and distracting of natural habitats, the Peninsula's biodiversity is in dangerous status. Many mammalian species such as Japanese serow (*Capricornis crispus*) and Japanese black bear (*Selenarctos thibetanus japonicus*) are listed as endangered species in the Peninsula (Yoshida et al 1997). We believe that these species and other biodiversity should be maintained at large scale of ecosystem, not just for small land-uses, especially for a new "Model Forest " establishment.

The Gap Analysis is unique and well-known method for proactive approach for assessing the current status of biodiversity at large regional base and at the all level of ecosystem. By using computerized mapping software called GIS (geographic information system), we are able to identify "gaps" in biodiversity conservation. Gap analysis is basically a coarse-filter assessment of representation of actual vegetation types, satellite imagery, and wildlife-habitat relationship model (Noss and Scott 1997). If "gaps" between hot-spots of biodiversity and our conservation efforts are identified by this analysis, new appropriate conservation or management practices should be taken in order to protect biodiversity in the Kii Peninsula.

Our Gap Analysis includes three primary layers of GIS maps: land ownership and uses, distribution of vegetation cover, and distribution of terrestrial wildlife species as predicted from wildlife-habitat relationship model. By using the GIS function of map overlays, wildlife distribution and land ownership are compared to estimate the relative extent of protection afforded each vertebrates species (Edwards 1995).

The objective of this study is to apply Gap Analysis for assessing the conservation status of wildlife habitats in the Kii Peninsula. We will briefly explain the process used for this analysis and models used for mapping wildlife and vegetation cover distribution. To assess adequate conservation level, we will use several "key species" of the Peninsula to define "gaps". One of key species must be represented from each vertebrate classes. Key species for this analysis are listed in following Table 1. Our tactics to conserve biodiversity in the Kii Peninsula is to establish new preserves or alternating land-use practices based on the "Gap Analysis".

Table 1: Key species for the Kii Peninsula Classes Species common name Scientific name Mammal
Japanese black bear *Selenarctos thibetanus japonicus*
Japanese serow *Capricornis crispus*
Japanese dormouse *Glirulus japonicus*
Aves Japanese golden eagle *Aqulia chrysaetos japonica*
Japanese falcon *Falco peregrius japonesis*
Japanese harrier *Ciurus aeruginosus*
Reptiles Loggerhead (Marine turtle) *Caretta caretta*
Amphibians Asiatic salamanders *Hynobidae* spp
Japanese giant salamander *Megalobatrachus japonicus*

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8.08.00 Forest and Climate

Research on effects of climatic factors on forest vegetation changes in the north part of eastern Anatolia Region

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Keywords: ecology; forest; vegetation; climate; geology; watershed

This is a fundamental research and the aim of this research is to determine nature vegetation changes and relationships with climate (temperature, rain, humidity etc.), which is one of the environmental factors in the North Part of Eastern Anatolia Region.

The research area, which is a watershed, is at passing zone between two different regions because of assorted plants and climate conditions. It will be very useful to determine relationships between climate and vegetation for future planting in the area. Scotch pine, juniperus, fir, oak have constituted the forest vegetation of the area.

Firstly general geology, general geomorphology, climate and vegetation of the area have been explained. Then effects of climatic factors on vegetation changes have been handled. Temperature, rain and humidity degrees belong to last 25 year degrees, supplied from General Directority of Meteorology, have been used as climatic factors.

This research has been carried out in three phases. In land working plant samples were picked up, spreadings of plant groups have been examined by paying attention to slope and aspect condition also a vegetation map has been drawn. In laboratory studying, plant samples picked up have been identified. In office studying, data supplied from land and identification of plants have been evaluated. Changes of vegetation, related to climatic factors, have been determined by drawing necessary maps and graphics. And also water balance values of the watershed have been calculated by Thornthwaite method and it has been drawn a water balance values graphic.

Especially, juniperus (*Juniperus* sp.) and oak (*Quercus* sp.) species have been grown where Mediterranian sea climate type was seen in the research area. In these places it is suitable to make oak breeding working. Fir (*Abies nordmanniana*), which is an element of East Blacksea plant society, has been grown together with scotch pine (*Pinus sylvestris*) in the northern part of watershed. It is important not to degrade this mixture for continuity of forestlands. So it is necessary to protect fir.

At the result of research, according to some priorities evaluated, it has been found that climate is one of the definite factors in the distribution and changes of vegetation, but it does not have priority. That is, there are another factors having been effective on vegetation changes. It can be easily said that edaphic factors and other ecological conditions can be affect. Because grazing pressure, smuggling have been observed in the research area. And also it has been seemed that there are quite clear differences between sides when the development of forest and species mixture have been examined.

Injuries of forest tree species by air pollution and their economic evaluation

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Keywords: air pollution, foliar analysis, economic evaluation

Air pollution in Slovakia is serious not only in the surroundings of all industrial centres but also in mountain regions. Regarding whole Europe worse forest conditions is only in the Czech Republic and Poland. With an increase of air pollutants loading also the loss of foliage increases what reflects also in diameter increment. Forests cover about 41% of the territory of the Slovak Republic what is about 20 thousand km^2. The proportion of commercial forests is 72%, of protective forest 14% and of special purpose forests 14%. The proportion of coniferous tree species is 42.7% (spruce 26.8%, pine 7.7%, fir 5%, larch 1.9%, dwarf pine 1.0% and others 0.1%) and the proportion of broadleves is 56% (namely beech 29.1%, oak 11.3%, others 16%). Health condition of the forests in Slovakia is deteriorated due to air pollutants impact. A region of the border of Slovakia, Poland and Czech Republic was declared the second black triangle in Europe. Main disturbances of forest ecosystems appear. They lead to their gradual degradation and decline. Due to long-lasting load by high concentrations of various air pollutants a mass dieback not only in the stands in the surroundings of the sources of air pollution also pollutants from remote transfer, particularly from Poland and Czech Republic are accumulated on our territory. Slovakia has compared with these countries very disadvatnageous location due to prevailing northern, northwestern and western air flows. Moreover, it should be taken into account that Slovakia is a country with broken relief and the altitude reaching 2632 m whereas the timber line with dwarf pine is extending to the altitude 1800 m. All these unfavourable circumstances together have caused that in the 90ies 85% of forests exhibited symptoms of damage. To characterize the condition of forest stands in Slovakia there were set 8 air pollutant deposition types (acidic with fly ash from coal combustion or combustion of heavy oils, with fluorine and chlorine, with organic substances and dense dust, alcaline -lime or magnezite and ammonia). These types determine main chemical components of air pollutants. In the year 1996 total emission from the sources of air pollution reached 224.2 thousand tons of sulphur dioxide, 139.5 thousand tons of nitrogen oxide, 373.3 thousand tons of carbon monoxide, 67 thousand tons of solid pollutants including heavy metals, 150.5 tons of fluorine, 2 256.3 tons of carbon sulfide, 937.3 tons of hydrogen sulfide, 86.7 tons of chlorine and 12.3 tons of mercury. Total emission of air pollutants in Slovakia has increased in the period 1970-1985 by about 25%. Since 1985 the level of emission has been stagnating.

With an increase of air pollutants loading also the defoliation increases what reflects also in diameter increment. Diameter increment has been gradually decreasing for spruce and fir with defoliation. For beech and oak increment is not decreasing up to 30% of defoliation. This increment is reduced by about 25% if the defoliation is for fir 20%, for spruce 40% and for beech and oak 60%.

The area of forest was 1, 987, 909 ha in 1996. Reduction of increment represents 327 mil. SKK. An annual amount of 1.5 thousand millions SKK (US=41 Sk) is needed for recovery measures. The poster demostrates the effect of air pollution on a model territory in Turcianska valley by means of foliar analyses and presents calculation of economic loss in forest stands due to air pollution.

Carbon exchange of forest at the ecosystem level: results over a three-year period from two contrasting ecosystems of the Italian Peninsula

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Keywords: carbon flux; energy exchange; carbon budget; Eddy covariance; Mediterranean forests; mountain forests

The question on global carbon cycle quantification and the role of carbon sequestration by vegetation has become increasingly important. Even if the uncertainties are decreasing, global estimates are, at the moment , unable to univocally assign the so called 'missing-sink' i.e. the uptake of a fraction of the CO_2 released in the atmosphere, to either the oceans or the biosphere. In the past the studies of exchange between vegetation and atmosphere have been carried out mainly by leaf, stem and soil level gas exchanges, within this decade, the developments in the eddy covariance theory and technique are starting to make routine the study of the interaction between vegetation and atmosphere at canopy and ecosystem level. The advantage of the technique is that it is possible to integrate the carbon fluxes at spatial scales of the order of ha to squared kilometers and at time scales of one or more seasons, allowing to determine the overall ecosystem fluxes and, finally the yearly carbon budget or Net Ecosystem Exchange (NEE), that is the amount of carbon stored in the ecosystem at the end of a year and can be considered as the terrestrial sink.

Within the framework of the project EUROFLUX, funded by the European Union, the carbon and energy exchanges by means of the eddy covariance technique have been monitored over 15 forest sites for the period 1996-1998. Two of those sites are located in Central Italy, where a Mediterranean evergreen oak forest (Castelporziano, 41º45’ N, 12º22’ E, 3 m a.s.l.) and a Apennine beech forest (Collelongo, 41º 45’ N 13º38 E, 1500 m a.s.I.) were studied.

At the first site, measurement started with the onset of the project (1996), while the beech forest is a long-term monitoring station, where our Department is performing ecological and silvicultural research since 1991. At this site, carbon fluxes are measured since 1993. Both sites are closed forest stands.

The result of the two sites will be presented and contrasted, with particular respect to the pronounced inter annual variability of carbon fluxes.

For the beech forest, profiting of different structural, micrometeorological and ecophysiological variables that have been concurrently measured with canopy fluxes, the ecosystem level measurements will be linked to leaf and canopy physiology and to microclimate, providing a frame of ecophysiological interpretation of canopy fluxes.

At both sites, the result of net ecosystem exchange obtained by canopy fluxes, will be compared to the productivity estimated with other techniques, like biomass growth (above and below ground), litter and soil organic matter decomposition.

Regional and yearly changes of flowering date in *Prunus yedoensis* studied for the observation by the Japan Meteorological Agency

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Keywords: cherry trees; flowering date; phenology; environmental change*; Prunus*; air temperature

We investigated the yearly changes of the flowering dates in Japanese cherry trees of Someiyosino *(Prunus yedoensis*) from 1953 to 1996 in Japan, using for the data recorded by Japan Meteorological Agency. Monitoring sites were located between 30^{o}4'N and 43^{o}3'N regions. Since Someiyoshino is the grafted garden species, monitored plants have hereditary unity. They will tend to react similarly under the same set of environmental changes. The flowering dates changed year by year at every monitoring site. The flowering dates of the normal year at the sites from 31^{o}N. to 35^{o}N on the Pacific coast were not different from each other, especially at the sites below 33^{o}N. At northern regions from 35^{o}N to 42^{o}N, the flowering dates got late as gain for latitude. And the flowering dates in the very mild winter (e.g. in 1978-79) were earlier than that in the normal year, especially from 36^o-38^{o}N. At southern regions, the flowering dates in this year were greatly later than that in the normal year. Especially, in Tanegashima island (the most southern site of 30^{o}4' N), the flowering date was about 19 days later than that in the normal year. It was almost the same time as the flowering dates at about 40^{o}N sites, for example at Miyako. So, the earliest regions for flowering from 31^{o}N to 43^{o}N were around 36^{o}N sites, for example at Choshi. In this year, on the cost of Japan Sea from 32^{o}N to 42^{o}N, the flowering dates got late as gain for latitude. Inland sites had intermediate patterns between the two seacoasts. Another, we investigated the effects of the winter chilling on the release for dormancy of flower buds in *Prunus yedoensis*. The temperature at the time of flowering started came down as gain for latitude. And there was a negative relationship between the numbers of "the chilling days (daily mean temperature below 10^{o}C)" and the daily mean temperature at flowering started. Thus, the temperature conditions of flowering started came down for going as far as to meet chilling stimulation. It is considered that the decrease for winter chilling stimulation may cause to come up the flowering possible temperature. It is exhibited on the delay of flowering started at Tanegashima site in the mild winter. So the earth getting warmer may cause to the flowering periods to be later than today at southern regions. But at northern regions, it may not be short for chilling stimulation in the mild winter. So the earth getting warmer may cause to the flowering periods to be earlier than today at northern regions.

Estimation of obtaining a "zero" carbon balance for the forest of European Russia

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Keywords: carbon budget; land-use change; afforestation; deforestation; forest cover

The forest area of the European Russia (ER) has decreased nearly by one third from 1695 to 1914, mainly because of transformation of privately owned forests into agricultural lands for cereal production. By end-17th century arable lands in the ER occupied nearly 8%, and forest - 50% of the total land area of the country. As human population grew, arable lands, hayfields and pastures extended, and forest lands decreased. According to historical chronicles and reports of the Ministry of Domain Properties (economic and statistical Atlas of ER development 1696-1914), the forest cover was 52.68% in 1696, 51.16% in 1725, 42.27% in 1861 and 35.16% in

1914. In 1998 forest were growing on 39.1% of the ER area.

During 300 years Northern regions of the ER practically kept their forest cover. By 1915 up to 91.8% of initial forests were conserved in (given present-day administrative units) Arkhangelsk and Vologda regions, and in the Republic of Komi; 80.6%-Perm R., 77.4%-in Novgorod, Pskov and St.-Peterburg R. In the beginning of 1998 the forest cover of the Arkhangelsk R. was 53.9%, Vologda R.

- 70.0%, Republic of Komi-72.1%, Perm R.-66.6%, Novgorod R.-64.1%, Pskov R.-38.1% and Leningrad R.-55.7%.

In Russia as a whole, relatively favourable climatic conditions for forest growth exist on 59% of land area, while in the ER 70% exists. Here, by end-20th century the spatial distribution of forests, agricultural lands and areas suitable for growing forests, but not agricultural crops, has been stabilised. Nevertheless, it needs to say that already since the first third of the 20th century ecological problems appeared in regions with low forest cover. In 1949 large-scale works begun on vast areas of the ER Southeast with the view of forest restoration and afforestation, in order to create artificial forests and forest belts able to maintain multiple natural functions: water protection, anti-erosion, sanitary, recreational, biological (preservation of wildlife habitats and biodiversity). This was called "State plan of nature transformation". Operations were done on working and reserved agricultural lands. By 1952 artificial forests were created in form of compact massifs and many kilometres long belts, their total area exceeded 1.2 million ha.

The results of this work are now especially important as we are searching for solution of the problem of establishing a "zero" balance for dynamics of atmospheric carbon accumulation in the system "emissions-sink". The forest planting should be considered as the most realistic possibility of a practical solution of this problem.

On the basis of methods worked out in All-Russian Research and Information Centre for Forest Resources (ARICFR) for determination of storage, average annual increment and carbon balance in Russian forest at the level of forest management units (leskhozes), a preliminary assessment of the carbon balance ws done for ER forests. The analyse shows that there is a large margin for forest restoration and growing in regions with "minus" carbon balance (Astrakhan, Volgograd, Veronezh, Lipetsk, Rostov Regions, Stavropol and Krasnodar Territories, republics of Ingushetia, Daguestan, Kalmykia-Khalm-Tangch). In order to achieve the "zero" carbon balance in these regions it needs to provide for an additional depositing of about 2 million tonnes of carbon per year. To do it, one must replant nearly 2.5 million ha. It is a difficult task, but its scale is comparable with work of 1950s. Moreover, it is necessary to reduce emissions into the atmosphere through improving forest protection (including measures of fire fighting, control of pests and diseases, of AAC, improving technologies of harvesting, processing and wise use of forest products, etc.), such as measures being well grounded by a preliminary evaluation of profit/expenses ratio for carbon sequestration deal.

A general equation of relationship between forest evapotranspiration and climatic factors

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Keywords: forests; actual evapotranspiration; model; climatic factors

Forest evapotranspiration (EPT) is one of the important components in the forest hydrological balance, taking 30-95% of precipitation. There has been a large amount of literature on this context. However, a general equation for calculating the actual EPT for forests under various natural conditions has not been available owing to multiple factors involved. Forests are such rough surfaces that the methods based on active surface characteristics, such as Penman-Monteith equation, are difficult to apply, because of the difficulties in obtaining aerodynamic parameters and other surface resistance parameters.

In this paper 65 samples of EPT data resulted from the differences between precipitation and runoff for the temperate forests, and 35 samples for the tropical forests have been collected and analyzed. The author found that when merely the EPT and precipitation are taken as the variables, no good relationships could be established. And there are no good relationships between the ratio of EPT over precipitation and the forest species, because that the ratio depends on the precipitation intensity.

However, when the evapotranspiration ratio (the ratio of EPT over precipitation) and precipitation were taken as the interdependent variables there was a relatively fine relationship. And further the dots for tropical forests and temperate forests were separately treated and two dots with extreme values are deleted, then much better relationships appeared. The two curves were separately fitted for the temperate forests and tropical forests as follows

Temperate forests: Y= 0.9734exp(-0.0004X) (R2=0.5187) Tropical forests: Y=1.4338exp(-0.0004X) (R2=0.741) in which Y is the ratio of actual EPT over rainfall, and X is rainfall in mm.

Good relationships existed between the rainfall and the ratio of EPT over rainfall. And the equation for the tropical forests is better than temperate forests. Further suggestions on improving this model have been proposed by the author. Finally the Turc equation were used to make comparisons with the calculated EPT in this model.

8.09.00 Human impacts on tropical rain forests with long term view

Comparison of canopy gap dynamics between unlogged and selective logged forests

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Keywords: Malaysia; gap dynamics; tropical rain forests; logged and unlogged forests; aerial pictures

A tropical rain forest is considered as a mosaic of patches of different developmental phases as seen in a temperate or boreal forest. When a tall canopy tree or an emergent tree falls down, a canopy gap is created. Seedlings or saplings of some species can grow only in such gaps, because they cannot even survive under closed understory where light intensity is extremely low. Therefore, gaps trigger the establishment and enable the regeneration of these species and analyzing the dynamics of canopy gaps is essential to understand the dynamics of the forest. Since the size distribution of standing trees is much different in logged forests and natural unlogged forest, it was expected that frequency, size distribution and other features of canopy gaps were also different between them.

In order to reveal such difference between unlogged and logged forests, we have analyzed the canopy gap dynamics in Pasoh Forest Reserve (State of Negeri Sembilan, Peninsular Malaysia) using aerial pictures taken above the forest. The analyzed unlogged forest is the eastern 38 ha of the core area (50 ha plot). For this area, aerial pictures were available both for May 1995 and February 1997.

Stereo-pair pictures were used to determine the canopy elevation. Then, canopy height was calculated by subtracting the ground elevation from the canopy elevation. Areas whose canopy height was below 15 m were regarded as canopy gaps and all the individual gaps larger than the minimum recognizable size (6.3 m^2 =1 cell) were followed. As a selective logged area, 6 ha plot south-west to the former area was analyzed. Aerial pictures were taken in 1998 for this area and the pictures were processed in the same manner.

In the unlogged forest, 509 gaps (= 13.4/ha) existed as of 1995 and the number of gaps decreased to 463 (= 12.2/ha) in 1997, which accounts for 7.9% and 6.9% of the whole area, respectively. Size distributions of gap were J-shaped with extreme aggregation in small size in both years. The mean gap size was 84.0 m^2 and 72.2 m^2 in 1995 and 1997, respectively, while the median size was 18.8 m^2 in both year. On the other hand, the logged forest found 28 gaps in 6 ha (= 4.7/ha), which was 5.5% of the whole area. Though the mean size was 119.4 m^2 because of one exceptionally large gap (1400 m^2), the median was 15.6 m^2, which is slightly smaller than that of the unlogged forest. If the largest gap was omitted, the mean and the median were 72.0 m^2 and 12.5 m^2, respectively.

Therefore, it is suggested that the logged forest has less number and area of canopy gaps than the unlogged natural forest. This may be ascribed to the difference in tree size compositions; logged forests have only immature and shorter trees than in unlogged forests. It is also predicted that the frequency of gap formation is much lower in logged forests. These difference of gap size, area, and frequency are expected to affect greatly the regeneration of whole tree species, not only light-requiring ones but also shade-tolerant ones, by altering the microenvironments in the forest.

Effects of tree falls on diversity of wood decay fungi

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Key words: biodiversity; rainforest; tree fall; wood decay fungi

In the previous studies, we revealed that florae of wood decay fungi on substrata are affected by diameter, tree species, and decay process of the substrata. Therefore, it is suggested that presence of various types of substrata may increase the diversity of wood decay fungi. In the Logged Plot with intensive logging in the past established in Pasoh Forest Reserve, a lowland rainforest of

the West Malaysia, diversity of wood decay fungi is lower than the diversity in the Unlogged Plot established in the same site. Less newly fallen trees with large diameter and old fallen trees exist in the Logged Plot, and few species restricted on large substrata and well-decomposed substrata are seen in the plot.

Here, we made a comparative study of the diversity of wood decay fungi between the areas with and without recent tree falls within the Ecological Plot 1 (EP1), situated in an unlogged area of Pasoh Forest Reserve. EP1 was divided into 200 subplots (10 x 10m). These subplots were classified according to the presence of tree falls accompanying gap formation on and after 1992 as follows:

subplots with tree falls on July 1995 (93G, 5 subplots); those on 1993-1995 (3 subplots); those on June 1995 (95G, 29 subplots); those with few effects of intensive tree falls (NG, 159 subplots). Occurrence and frequency of each wood decay fungi was recorded in each subplot on August 1995, December 1995, December 1996 and December 1997. Taxa of wood decay fungi examined here were Erythromyces crocicreas and Stereum ostrea in addition to all species of lignicolous polypores.

Total frequency of wood decay fungi specific on small twigs (ramicolae) was almost same in 95G and NG each year, and few fluctuation was observed in both of the subplots. On the other hand, total frequency of non-ramicolous fungi distinctly increased between August 1995 and December 1996 then slowly decreased after December 1996 in 95G while almost no fluctuation was seen in NG. Species number of wood decay fungi was also increased from August 1995 to December 1996 in 95G. It is suggested that diversity of wood decay fungi be maintained by occurrence of tree falls.

This suggests that high species diversity in unlogged areas is attributed to the presence of several non-ramicolous fungi in the parts with recent tree falls, and high species diversity is expected for some years after the tree falls. Because of the frequent tree falls, thereby creating a larger variety of woody substrates, high diversity of wood decay fungi can be maintained in unlogged forests. However, in logged forests with intensive logging in the past, fewer tree falls are expected because of the limited number of emergent trees and this reduction in the variety of woody substrates could result in the loss of some rare fungus species from the forests. Intensive logging may therefore induce a reduction in the diversity of decay fungi in the future although flushes of some fungi may occur just after logging.

Ecology of wind dispersal of fruits of dipterocarp species in Pasoh Forest Reserve

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Keywords: *Dipterocarpus;* regeneration; seed shadow; tropical rain forest; wind dispersal

We examined the effects of wind dispersal on the regeneration process in some dipterocarp species. Fruit dispersal provides an opportunity for terrestrial plants to "move" their living sites. To examine the ecological significance of wind dispersal of fruits during an early stage of tree regeneration in tropical rain forests, we estimated the fruit shadow for individual trees at the event of mass fruiting in 1996 in Pasoh Forest Reserve in Peninsular Malaysia.

We monitored the development of fruits and the wind speed at horizontal directions on a tower at a height of 51 m during the period of fruit dispersal in 1996. We determined the descending speed of fruits, which were manually released, from the height of 13 m on the tower. Based on these data we estimated the fruit shadow for individual mother trees.

We directly determined the dispersal area of fruits around individual mother trees that sporadically fruited in December 1997 and in September 1998. We also measured spatial variations in the diffuse site factor around the mother trees to assess the light conditions of germinated seedlings. We observed seedling establishment around the mother trees in 1998, 2 years after the mass fruiting.

It was suggested that the descending speed of fruits under little or no wind at horizontal directions was faster than that under strong winds. The size of the fruit shadow of a 40-m tree was approximately three times larger than that of a 30-m tree. Under a condition of the horizontal wind speed of 5 m/s, fruits dispersed from a 40 m height were expected to reach beyond the shadow of the canopy of a mother tree, where the light conditions for seedling growth were more likely better compared with the sites under the canopy. The 2 year-old seedlings were not always established well at the distance of the highest fruit density on the ground and the establishment was partly influenced by the local light conditions. We will also demonstrate the mechanism of wind dispersal of fruits and discuss the role of fruit dispersal for seedling establishment of dipterocarps.

Leaf gas exchange characteristics of pioneer and late successional species

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Keywords: photosynthesis; transpiration; stomatal conductance; water use efficiency

Seedlings raised under shaded and well-watered conditions in the nursery are susceptible to water stress when planted in the open because of their reduced ability to cope with drought. Thus, keeping transpiration low in order to avoid excessive water loss is important for survival of the transplants. However, closing stomata to reduce transpiration also may cause limiting photosynthesis, which is essential for growth. Therefore, information on stomatal gas exchange such as balance between the release of water vapour and uptake of CO_2 is important to assess adaptability of seedlings to drought. In this study, net photosynthetic rate (A) and stomatal conductance (G) were measured for 25 tropical tree species including both pioneer and late successional species. Diurnal changes of A, G, and transpiration rate (E) of leaves were also studied for seedlings of one dipterocarps, *Hopea odorata* and two pioneer species, *Acacia auriculiformis* and *Tectona grandis*, planted on sandy tin-tailings. Based on the results, gas exchange properties were compared among species in order to classify them according to the adaptability to drought. A was lower in the dipterocarps, generally known as late-successional species, than in the pioneer species, but water use efficiency (WUE, A/g) was not different between the dipterocarps and the pioneer species. Highest A was observed in A. mangium and *A. auriculiformis*, both well known as fast-growing pioneer species. Other fast-growing species like *Tectona grandis, Endospermum malaccensis, Cinnamomum iners*, and *Azadirachta excelsa* showed relatively high A. High A was also observed in the relatively fast-growing dipterocarps like *H. odorata* and *Shorea assamica*. High A in *S. assamica, T. grandis, A. mangium, E. malaccensis*, and *C. iners* was mainly due to high G, suggesting that these species may require large amount of water to maintain their rapid growth. When the seedlings planted on the sandy tin-tailings were exposed to direct sunlight during midday, both A and G decreased in all the species studied. Such midday depression of A and G was more remarkable in *Hopea odorata* than in *A. auriculiformis* and *T. grandis*. T. grandis maintained relatively high G even in the afternoon when vapour pressure deficit largely increased, resulting in extremely high Tr and visible wilting of the leaves. Such lack of drought avoidance of this species may cause frequent dieback of the seedlings planted on the sandy tin-tailings.

Edge effects on the nest predation and avian community in Pasoh Nature Reserve

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Key words: bird community; edge effect; predation pressure; artificial nest

Tropical lowland rainforest have drastically decreased and fragmented in last few decades in Peninsula Malaysia. Habitat fragmentation will increase the amount of edge relative to the amount of interior habitat, and will enable omnivorous predators to increase in numbers, and to disperse into the interior of habitat. In order to detect edge effects on avian community in the Pasoh Forest Reserve, monthly netting have been started at the core area since 1992 and at the boundaries since 1996. The Pasoh Forest Reserve is small isolated forest surrounded by oil palm plantations, though virgin forest is still remaining in the core area. Totally, mist-net operations were carried out for 4,319 net days, and 1,168 birds belonging to 93 species were captured during the study period.

All captured birds were measured and banded with a uniquely numbered aluminum ring, and released beside net site captured. The abundance of understory birds among study plots was almost identical, and the species diversity was dropped at forest edge. Insectivorous ground forager like babblers, Timaliidae, were decreasing from the core to the boundary of rainforest, and nectarivore and frugivore like sunbirds, Nectariniidae, and bulbuls, Pycnonotidae, were oppositely increasing at the boundary. If edge effects occur, higher predation pressure is expected in the peripheral area than core area of rainforest. In order to evaluate predation pressure, 862 experimental nests with a few quail eggs were set in the understorey. A couple of nest was set near netting sites, and was monitored until depredated for 4 days. An automatic triggered camera set was placed near the nest to confirm predators, when quail eggs were depredated. Proportions of experimental nest depredated became higher according to approaching to forest edge. This result showed that predation pressure was severer near forest edge than the core area. Automatic triggered camera set revealed that pig-tailed Macaque, common treeshrew and short-tailed mongoose were predominant predators In summary, species diversity of understorey birds in Pasoh will be gradually decreasing from the core to the boundary, because predation pressure on birds building the nest on the ground is increasing near forest edge. It might be a reason why ground foragers like babblers are decreasing from the core to the boundary.

Comparisons of tree species diversity, composition, and population structures between primary and regenerating forest plots in a hill dipterocarp forest

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Key words: hill dipterocarp forest; regenerating forest; species diversity

A large area of tropical rain forests in the southeastern Asia was already disturbed by logging, fires, and many other artificial activities. To manage and improve these disturbed forests was an important task for foresters. Logging is now continued in hill forests under the Selective Management System in Malaysia. However, regeneration success of timber trees was not confirmed and the impact of logging on the community and population levels was not fully investigated.

Species composition, diversity, and population structures of common tree species were compared between a 6-ha primary (natural forest) plot and a 4-ha regenerating (logged forest) plot in , Peninsular Malaysia. The primary plot was established in a hill dipterocarp forest in Semangkok Forest Reserve in 1993, and the regenerating plot was established in the selectively logged site neighbouring to the reserve in 1994. Logging was carried out in 1989. All young and mature trees larger than 5 cm d.b.h. (diameter at breast height) were tagged, identified and their g.b.h. (girth at breast height) were measured.

Total number of species was larger in the primary plot (464 species) than in the regenerating plot (421 species). In the primary plot, 170 of 464 species were specific to the plot, and 127 of 421 species were specific to the regenerating plot. Total numbers of families and genera were larger in the regenerating plot. In the primary plot, species richness (number of species) was as follows; gamma=464, alpha=26.7, and beta=0.12.

In the regenerating plot gamma=421, alpha=26.2, and beta=0.16 where gamma (total richness) = alpha (mean richness) x beta (turn over rate).

Species diversity H' was slightly larger in the primary plot (H'=5.28) than in the regenerating plot (H'=5.13). Species evenness J' was similar in the primary (0.86) and in the regenerating plots (0.85).

Although these species diversity indices were not largely different each other, the composition of common 30 tree species remarkably altered between the plots. *Shorea curtisii*, which is the most important timber tree in the hill forests, was dominated in the primary plot. *Macaranga triloba* was the only light demanding tree species among the 30 common species in the primary plot. On the other hand, pioneer or secondary tree species of families Euphorbiaceae, Verbenaceae, Melastomaceae, and Elaeocarpaceae occupied the half of 30 common tree species in the regenerating plot.

Size structures of emergent tree species (*Shorea curtisii*), canopy tree species (*Antidesma cuspidatum*) and typical light demanding tree species (*Macaranga triloba*) were compared between the two plots. Size structure of *Shorea curtisii* changed by selective cutting, but those of *Antidesma cuspidatum* and *Macaranga triloba* were not largely changed. Relative growth rate (RGR) of *Shorea curtisii* based on basal area at breast height in the regenerating plot was three times larger than that in the primary plot. On the other hand, RGR of Macaranga triloba was similar in both plots. These were results of short-term study during four years. We need a more long-term ecological study to predict the community dynamics of regenerating forest and to improve the management system in the hill forests.

Rainfall-runoff responses to storms at Bukit Tarek Experimental Watershed, Peninsular Malaysia.

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Keywords: tropical rain forest; rainfall-runoff responses; stormflow; soil moisture

Hydrological observations were conducted at Bukit Tarek Experimental Watershed in Peninsular Malaysia to investigate the relationship between rainfall-runoff responses and variation in soil moisture in a tropical rain forest. There was a distinct diurnal cycle in precipitation at Bukit Tarek, where about 60% of the rainfall occurred between 13:00 and 19:00h. The sine wave, which was decomposed by Fourier transform consisting of 24-h, 12-h, and 8-h cycles and applied to the observed data, was useful (r=0.97) in order to re-evaluate the diurnal cycle of precipitation. The amount of rainfall in each rain event ranged from 1.0 to 96.0mm with mean of 14.3mm. The rainfall was characterized by short duration and high intensity: about 55% of rain events fell within 1-hour periods, testifying to the predominantly convectional storms. There was a high positive correlation (r=0.95) between amount of rainfall in each rain event and maximum hourly rainfall intensity during rain event. The saturated hydraulic conductivity (Ks) decreased with increasing soil depth. The macro- and meso-porosity of the soil also decreased with increasing soil depth. The Ks values were higher than those reported for other tropical soils. The geometric means of the Ks values ranged from 4.69 x 10-3 (80 cm) to 4.07x10-2 cm/s (10cm). This suggests saturation overland flow may not be dominant but that subsurface flow must play an important role in stormflow generation. Stormflow depended strongly on the antecedent wetness as represented by the initial runoff rate.

Though heavy rains fell in almost every month, the soil moisture decreased when fair weather was sustained. The soil moisture depleted and became dry at 160 cm depth during occasional dry spells. During dry conditions, streamflow responded quickly to rain events but declined rapidly after the rain stopped, and the soil moisture of surface soil (<20 cm) increased but remained dry at lower depths (>80 cm). This suggests that the rainwater was mostly retained in the soil and only small proportions appeared as stormflow. As soil moisture conditions became wetter, the recession limb of the storm hydrograph was more gradual. Stormflow volume increased with increasing soil moisture. During wet conditions, the soil profile was moist at all parts of the slope. The hydraulic gradient was around 1.0 and there was downward soil water flux, which followed the pressure gradient. This suggests that subsurface flow from the upper part of the slope might also be important for streamflow production. The behavior of the subsurface flow might be an important determinant of stormflow.

Leaf dynamics of dipterocarp seedlings in a primary and secondary forest in relation to the effects of leaf herbivores and light conditions

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Keywords: dipterocarps; forest regeneration; leaf dynamics; light environment; Peninsular Malaysia

Logging is one of the major human disturbances to natural forests. Selective logging, in which only the large-sized trees are felled, is a typical logging treatment to obtain timber products. Selective logging causes significant changes in forest structure such as size distribution and species composition. For example, variances in tree size distribution tend to be decreased by the removal of large-sized trees. These changes in the forest structure affect physical and biological environments at the forest floor, where successful regeneration of tree species is to be expected.

During the process of regeneration of tree species in a forest, seedling establishment is a critical stage, because seedlings suffer high mortality risk in their life. Seedling survival and growth are affected by several abiotic and biotic factors. Improvement of light environment caused by canopy gaps has been particularly emphasized for regeneration of canopy tree species, because light intensity is a major limiting resource at a forest understorey. On the other hand, herbivory and disease frequently exert a major impact on seedling establishments. Leaf damage by herbivores and pathogen diseases reduce growth and survival of plants. To examine seedling regeneration, information on the leaf dynamics is essential, because their growth process is basically determined by the photosynthetic production of individual leaves. In this study, we examined leaf dynamics and damages of seedlings of six dipterocarp species growing in the understorey of selectively logged and primary forests to estimate the effects of selective logging on the regeneration processes of dipterocarp species.

Our study was conducted in a lowland rain forest at Pasoh in Negeri Sembilan, Peninsular Malaysia. Two ecological plots (2-ha each) established in a primary forest and a secondary forest which was logged in 1950's were used for the study. One hundred subplots (1 x 1 m) were set regularly in each 2-ha plot. In every subplot we marked individual leaves of seedlings of six dipterocarp species to estimate plant growth and leaf dynamics. We also determined light conditions at the 1.0 and 0.5 m height on the all plots by taking hemispherical photographs.

Firstly, we analysed the effects of logging on leaf dynamics (leaf production rates, leaf loss rates, and net leaf gain rates) and damages (percent of heavily damaged leaves for individual seedlings). While there were significant differences in leaf production and loss rates among the six species, net leaf gain rates were not significantly different among species. Effects of logging on leaf production and loss rates, and percentages of heavily damaged leaves were still detectable even more than 40 years after logging practice, while the trends of the effects of logging were significantly different among the six species.

Secondly, we compared understorey light environments between the logged and the primary forests. Estimated canopy openness and photosynthetically photon flux density indices of the logged forest were higher than those of the primary forest. Two slower-growing species showed significant relationships between leaf demographic parameters and light environments. This result may suggest that changes in light environments caused by logging would favor for the regeneration of slow-growing species, whereas fast-growing species would require large gaps which are produced more frequently in a primary forest than in a logged forest.

Effects of disturbance by selective logging on occurrence of termite species

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Key words: dead wood; termite; *Hospitalitermes; Macrotermes*; Selective logging

In order to know how the disturbance by selective logging affects occurrence of termites in tropical lowland rain forest, soldier individuals as well as worker ones of termites were collected from the dead wood both in the undisturbed and disturbed sites of the Pasoh Forest Reserve, Pahang, Malaysia. Free-ranging termites of the genus *Hospitalitermes* which walked in lines on the ground and foraged on living tree trunks in the morning were also censused and collected.

The total number of dead wood pieces searched was 73 and 43 in the undisturbed and the disturbed site, respectively. Termites were found from 34 and 25 wood pieces in the undisturbed and the disturbed site, respectively. In most of the other pieces from which no termites were collected, soil-fills constructed by termites were found. These results indicate that most of dead wood on the forest floor was utilized by termites. Termites collected from dead wood counted up to more than seven and six species in the undisturbed and the disturbed site, respectively. The fungus-growing termite *Macrotermes malaccensis* occurred predominantly both in the undisturbed and disturbed sites, but it was more predominant in the latter, thus lowering the diversity of termite fauna in dead wood at that site.

A total of 20 colonies of *Hospitalitermes* were found in the undisturbed site, while 12 colonies were found in the disturbed site. The number of colonies with observed foraging activity at one morning was generally higher in the undisturbed site than in the disturbed one. These census results show that the activity of *Hospitalitermes* termites was lower in the disturbed forest than in the undisturbed one. In the undisturbed site, the frequency distribution of tree diameters at breast height was compared between all trees and the trees where foraging of Hospitalitermes termites was observed. The frequency of foraging-site trees was the highest in the diameter range of <30 cm and the second highest in the ranges of 50-70 cm. The second-highest frequency was disproportionately higher compared with that of all trees. This indicates that Hospitalitermes prefers large trees that are rare in the forest as a feeding site. This preference may be one of the major reasons why the activity of

Hospitalitermes was lower in the disturbed forest where large trees had been logged.

Micrometeorology of a tropical rain forest at Pasoh, Peninsular Malaysia

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Keywords: tropical rain forest; micrometeorology; albedo; ENSO

Data sets on meteorology in a tropical rain forest are important not only as a background of ecological studies conducted there but also for understanding its influences on the environment at local and global scales. Micrometeorology was continuously monitored at a lowland mixed dipterocarp forest in the Pasoh Forest Reserve , which is located near Simpang Pertang in Negeri Sembilan about 140 km south east of Kuala Lumpur in Peninsular Malaysia. A 52 m observation tower was used for this monitoring. The continuous canopy height was about 35 m, although some emergent trees exceeded 45 m. The leaf area index (LAI) was 6.52. The climatic variables such as downward and upward solar radiation, net radiation, air temperature, humidity, wind velocity and direction, and rainfall have been measured at the top of the tower continuously since March 1995. Vertical distributions of air temperature, and humidity were also measured in a short period in 1995.

Vertical distributions of air temperature show that temperature differences within canopy were small and recorded a low near the forest floor in the daytime. This could be attributed to the complex and wide canopy structure. Vapor pressure decreased with elevation and this suggests that the latent heat seemed to be carried upward throughout a day.

Seasonal variations of climatic variables were monotonous under the climate of tropical rain forest. The albedo was about 0.12 and the seasonal variation was not clear. Wind velocity was weak except at the time just before a short and intense storm in the afternoon. Two rainfall seasons reflecting the southwest and northeast monsoons were found from March to May and from October to December, respectively. However, rainfall was remarkably large in the latter monsoon season whereas that in the former monsoon season was not prominent. This tendency caused a large solar radiation with high air temperature and dry humidity in the earlier half of each year and a small solar radiation with low air temperature and wet humidity at the end of each year. During the observation periods, the amount of rainfall was large only in the year of 1995, and it was small in each year of 1996, 1997 and 1998 compared to that in a common year. This result depended strongly on an ENSO episode which caused a huge forest fire in Indonesia. One of the effects of the fire on this site was recorded as decreasing of solar radiation caused by the haze in September 1997. The driest condition with large values of vapor pressure deficit was shown later in April 1998. The monitoring results suggest that this natural forest is maintained by a comparatively small amount of rainfall considering a climate of tropical rain forest with constant large radiation energy.

Logging effect for genetic diversity of Shorea ciurtisii forest in the hill dipterocarps forest of Peninsular Malaysia

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Keywords: dipterocarps; inbreeding; macrosatellite; mating system; regeneration

Tropical rain forests have been becoming fragmented into small patches or simplified in structure and composition by exploitation for timber. The resulted fragmentation may reduce the genetic diversity of future generation in each species. While plant have evolved the flower and inflorescence characters to attract particular animal pollinators which then convey pollen from flower to flower. If the pollinators can move between the small patches without hesitation due to the attractive flowers, the genetic diversity of the species may maintain for the future. The majority of tropical trees examined are insect pollinated and predominantly outcrossed. However, the mechanism for maintenance of relatively high genetic diversity in tropical tree species is not still clear.

Mating systems of some tropical tree species have been investigated using allozyme. These results indicated that the average outcrossing rate of tropical species are more than 80%. Murawski and Hamrick (1991) reported that positive correlation between outcrossing rate and flowering tree density for tropical tree species. They suggested that the synchronized mass-flowering which promoted the effective movement and development of pollinator population even in the secondary forest kept the same level of outcrossing event. These results suggested that the relationship between the density of flowering tree and pollinator behavior is much important for success of mating, however, there is no clear explanation for them. *Shorea curtisii* Dyer ex King is an emergent and canopy tree in the hill dipterpcarp forest of Peninsula Malaysia. In tropical region, selective logging has been conducting for the sustainable forestry, and this species also one of the targets in Malaysia for consumption as a construction timber. This kind of logging is making the fragmentation for this species. For low-density population such like selectively logged forest, therefore, key questions are how much genetic diversity still have kept in the forest and whether healthy regeneration of this species is expected. Recently, microsatellite DNA markers have applied to study the gene flow within forest because these markers can be determine the parental individual with a high probability. In this paper, we discuss for the outcrossing rate and disturbance effect for genetic diversity of *Shorea curtisii* in hill dipterocarpas forests from the results using microsatellite analysis. We also compared the genetic diversity, outcrossing rate and pollen flow between undisturbed and disturbed forests. Genetic diversity and outcrossing rate of *Shorea curtisii* (Dipterocarpaceae) were investigated in undisturbed and disturbed forests using the microsatellite analysis. The heterozygosity, the number of alleles per locus and the proportion of polymorphic loci were not different significantly between two forests. To estimate the outcrossing rate, seeds from 11 and five individuals were analyzed in undisturbed and disturbed plots, respectively. The average outcrossing rate of undisturbed forest was 87.7%, which was similar as the former reports of dipterocarps species with isozyme analysis. However, the disturbed forest was 40.9%, which was remarkably lower than that of undisturbed forest. This decline of outcrossing rate in disturbed plot was considered to be strongly affected by the density of flowering tree with four-fold difference and the behavior of main pollinator of this species.

PART 2:

Posters presented in poster/panel and group sessions

The summaries of the 'panel posters' are printed in the Proceedings volume of oral presentations within the respective Group Session.

1.09.00 Short rotation forestry for biomass production

A survey of short rotation willow growing in Sweden

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Sustainable Management of Abandoned Farm Lands for Energy Forestry Using Domestic Nitrogen-fixing Tree Species.

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A Study on the Pollen Morphology of Six Section in Subgenus *Salix* L. (*Salicaceae*)

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Turkish Energy Forestry for Sustainable Forest Management and Energy

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Comprehensive silviculture and development strategies for pulpwood plantation in China

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1.17.03 Tropical forest restoration

Underlying Causes of Deforestation and Forest Degradation and Constraints against Rehabilitation Efforts in Ghana

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Rehabilitation of degraded Tropical Rain Forest by enrichment planting of endemic species in a forest of Sabah, Malaysia.

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Participatory restoration of a degraded landscape in Kerala state, India with indigenous forest tree species of commercial potential

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Comparative ecological study of natural forest, man-made forests and grass lands for developing sustainable forestry in Sakaerat, Northeastern Thailand

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Transformation of degraded farmer forests into managed semi-natural forests in Eastern Parguay

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Restoration of the Native Understorey Vegetation in the Plantation Forests Areas of Chittagong University Experimental Plantaion Area

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The Potential Role of Plantations on the Rehabilitation of Native Forest Biodiversity in Degraded Hilly Areas of Bangladesh

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Seed and seedling demography of an alien tree species *Bischofia javanica* in a subtropical island forest of western Pacific

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Restoration of a Sri Lankan rain forest: An eight year review of experimental trials

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Forest restoration for biodiversity conservation in Northern Thailand

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Development of Wasteland Through Tree Plantation in Chattisgarh Region

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PART 3:

Posters displayed during sub-plenary sessions

A2 Sustainable Management of Natural Resources. Fire and Forests

Forest Fires in Russia

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Keywords: Russian forest fires; light forest; dark forest; succession

The area of the forest stock in Russia, including forests transferred to the permanent use, according to the calculation made in January 1, 1993 is 1180,9 million ha. Burned-out forests, cuttings, swamps and hayfields are also included into this territory. Forests proper take the area of 705,8 million ha; 507,7 million ha are covered by coniferous species: larch (52%), pine (22,5%), spruce and fir (17,8%), and cedar (7,7%). Acerous leaves (needles) and timber of these species contain essential oils and colophony, that is why they are too flammable (susceptible to fire). Russian forests have a multiple-aged structure: undergrowth-22%, middle-aged-33%, maturing-11%, mature and overmature-34%. Formation of such forest structure was influenced by industrial cuttings; but the main factor of taiga forests formation is forest fires. According to the official statistics their number varies from 13,4 thousand (1987) to 31,3 thousand (1997); the area of forests, subjected to fires -from 569 (1987) to 2450 (1998) thousand ha. Pine and larch forests of the North, Siberia and Far East, growing on the drained, rising grounds are mostly subjected to fires. The average temporal interval, during which these forests may undergo low fires is 30 years. In the course of this period the critical amount of combustibles, able to catch fire in hot dry weather and keep burning, is accumulated under the forest canopy. Spruce young growth, which is a constant competitor to pine and larch, burns out in low forest fires. Dark-colored spruce-fir forests grow on the low areas with damp (moist) soils close to subsoil waters. That is why fires can hardly occur in these forests even in the short-term periods of drought. In case of fierce droughts, occurring every 70-90 years, when caught by fire spruce-fir forests burn out completely, without any young growth left. Due to this reason their further reforestation goes, as a rule, through the change of species, that is, at first, the process of regeneration of cutover stands by broad-leaved species (birch and aspen) takes place, and only then young spruce and fir sprouts start growing. In the light-colored coniferous 30 year-old forests low fires, which do not cause damage to them, prevail. These fires play the role of thinnings, by means of taking away weakened trees and those falling behind in growth, providing the rest of trees with optimum light condition and space for roots development. In the permafrost region of light-colored coniferous forests low fires destroy the mossy cover, warming overburden layers. After fires the level of permafrost goes down, but the power of root layer increases, providing conditions for significant increment of trees. It is found out that successful reforestation of pine and larch can be possible only as a result of low fires, destroying thick mossy cover and debris layer. With the average interval between fires of 30 years and the mean age of mature and over-mature forest crops in the boreal forests of 150-200 years, every crop is subjected to low fire as many as 4-7 times during the period of its growth before it is completely replaced by young growth. Only top fires may happen on the areas covered by coniferous young growth, but they lead to the complete damage of the latter. By the way, pine undergrowth is mostly subjected to fires. Dead larch undergrowth cover burns out only in the periods of drought, accompanied by strong wind. Artificially planted even-aged coniferous crops seldom happen to grow till their natural decomposition. On the contrary, wild multiple-aged forests, formed by fire during millions of years, not only survive in the temporal fire weedings, but even improve, becoming more fire-resistible. We have a powerful overland and aviation forest service, which protects forest stock territory on the area of more than 700 million ha. With the help of aviation, tele-and infrared equipment, and data obtained from artificial Earth satellites, forest service detects and eliminates considerable number of forest fires in proper time. But we should admit, that these activities do not exert great influence upon the general amount of forest fires. On the contrary, eliminating forest fires we favor the accumulation of combustibles under the forest canopy, which may cause destruction of the crop in case of fire. Every year in two or three regions of the country fire passes through the area of 1-2 million ha. Coordinates of these regions, time of fires origin, their number and extent of the burned out territory are programmed by nature itself, but it is still beyond our capacity to make a prediction in advance. Specialists in the field of fire fighting assure, that fire behavior in the forest is unpredictable. It is necessary to carry out a thorough and detailed research of this natural phenomenon, to reconsider our hostile attitude to the fire and to start using it as an ally.

An analysis of forest fire behaviour based on estimation of wind direction and wind velocity at the time of the fire

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Keywords: forest fire; fire behavior; wind direction; wind velocity; stem-bark char

Wind direction and wind velocity data are necessary to analyze the behavior of forest fire and its propagation. It is possible to obtain prevailing wind data from weather stations but not the characteristics of fire whirlwind at the site of the forest fire unless we measure it at the time of the fire.

This paper presents a procedure of estimation of wind direction and wind velocity from the stem-bark char remained at the forest fire damaged area. In this investigation, in order to clarify the relation among the factors affecting fire-scar of stem, wind tunnel experiments were carried out. And in order to establish how to predict the forest fire behavior, field experiments were carried out using opportunities of prescribed fire.

In the wind tunnel experiments, it was observed that the height of stem-bark char registered at the windward face of a stem is smaller than that of the opposite face of a stem under all the experimental conditions. Therefore, an estimate of wind direction from the remaining stems in a burned field can easily be done.

Further it was found that, the height of stem-bark char of windward face of a stem decreased as the wind velocity increased. The height of stem-bark char of a stem opposite the windward direction increased as the diameter of the stem increased. It was derived from these results that the magnitude of the difference in height of stem-bark char of windward face and opposite face of a stem was an important factor for estimation of wind velocity. From a viewpoint of field application, stem-bark char ratio of both faces of a stem tends to be significant as well as the difference in height of stem-bark char of both faces, because of the dissimilarity of scale in wind tunnel experiment and actual phenomena in the field. Dimensional analysis was carried out for the factors affecting the stem-bark char using the observations mentioned above. Based on the results of the study, the equations for estimation of wind velocity were proposed when the stem partially burned.

In the field experiments, first, the wind velocity calculated by experimental equations was compared with wind velocity observed in two prescribed fire sites. It was observed that the wind velocity could be expressed with a high accuracy by the above-proposed equations.

When the fire behavior was an upslope fire, the fire whirlwind directions estimated from the stem-bark char showed a fixed direction. Fire whirlwind direction agreed approximately with slope azimuth, in spite of a prevailing opposite wind direction. Further relationship between fire whirlwind velocity estimated by experimental equations and maximum slope gradient was investigated.

Forest plantation fire: the SAFODA experience (Sabah Forestry Development Authority)

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Keywords: SAFODA; reforestation; afforestation; plantation fires

The Sabah Forestry Development Authority (SAFODA) was enacted in December 1976, its objectives are to convert wasteland and marginal agricultural land to a highly productive forest plantation and to uplift the living standard of inhabitants through employment in reforestation and afforestation work related to forest plantation establishment. SAFODA has allotted 118,756 ha. of land throughout the state of Sabah for that purpose. By the end of July 1998, SAFODA has planted about 31,417 ha. of trees mainly *Acacia mangium* and 8,356 ha. of rattan. Other than pest and disease problems, fire is still the most dangerous phenomenon due to its extensive negative impact toward certain ecosystems and has long been the major threat in forest plantation project. In 1983, it is recorded that about 5,565 ha. of the SAFODA forest plantation throughout the state of Sabah had been burnt and the latest occurrence was during El Nino 1998 period, which 3,818 ha. of plantation were totally burnt. The objectives of this paper are to highlight and share the experience of forest fire occurred in the Bengkoka Forest Plantation Project in Sabah, its also discuss the problems encountered, annual budget, fire fighting technique, material and equipment used as well as the future direction of research needs. Since 1983-1998 there were 124 fire cases in Bengkoka Forest Plantation Project caused by mainly farm burning, smokers, campfires and incendiary. Most of the fire occurred in March to October each year. It is also noted that one to five years old forest plantation is very severe to fire. Therefore, an effective forest fire management system is really needed to lessen these problems.

Effect of fire on soil properties in pine and natural forest in Sri Lanka

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Keywords: Sri Lanka fires; fire severity; soil properties

Forest fires have become regular events in Sri Lanka due to intentional burning by livestock owners and hunters and practice of slash and burn agriculture (shifting cultivation). The foresters as a tool to eliminate undesirable weeds or dominant species in forests also use burning. In Sri Lanka other than the natural forest, part of the hill country is reforested using exotic species as *Pinus* and *Eucalyptus*. Much information is available on the regeneration of forests and regarding the change of the composition of vegetation after forest fires, its effect on soil properties have not been studied in detail. Studying the effect of forest fires on soil properties will help in understanding forest regeneration patterns and help in efficient management of natural and plantation forests. Therefore the objective of this study was to study the effects of fires on soil physical and chemical properties in a natural and pinus forest in Sri Lanka. These were studied at three stages, namely before the occurrence of fire, one day after fire, one and three months after fire.

This study was conducted in adjoining pinus and natural forest in the mid country of Sri Lanka. The soil profiles of the two sites were described using the FAO guidelines and the major soil horizons were identified. Soil properties as soil texture, acidity, total nitrogen, available phosphorus, organic matter and aggregate stability were measured. The area were burnt as usually done at the end of the dry season before the rains and similar measurements were conducted for soil samples obtained one day and three months burning.

More emphasis in this study was given to the determining of dry and wet soil aggregate stability, as soil erosion is one of the major problems in these sloppy lands. The dry aggregate stability was determined using dry sieving with a nest of sieves. The mean weight diameter and log standard deviation was obtained as aggregate indexes reflecting resistant to erosion by wind. Wet aggregate stability was determined by wet sieving using a single sieve technique. The percentage of the initial sample remaining after 18 minutes of sieving was used as the index showing the resistance to erosion by water.

The results showed that the soil pH increased just after burning and again decreased to the original value after about three months. The increase was higher in the pinus plantation than in the natural forest. The increase was from 4.6 to 5.1 and is mainly due the basic nature of ash remaining after burning. Afterwards these bases are easily leached due to rainfall and the soil becomes strongly acidic as before. The soil organic matter content nitrogen decreased with burning which the most damaging effect related to the loss of biomass to the atmosphere. The available phosphorus increased significantly in the surface layers of natural forest due to burning. The available P increase from 40 to 62 ppm in just after burning and decreased to 50 ppm after three months. The change in available P in pinus plantation was not significant.

The dry aggregate stability and wet aggregate stability decreased in the pinus forest with burning. In the natural forest the decrease in soil aggregate stability? were not significant. These aggregates developed to the original size after three months of burning. This shows the vulnerability to soil erosion by wind and water in the pinus plantations during the first three months of burning. This study shows how the soil property change after burning in natural and pinus forests in the mid country of Sri Lanka. In both forest types the chemical properties changed significantly after burning. In natural forest the properties attain the pre-burning values in three months after burning while in pinus forest it took longer times. In the pinus forest the susceptibility to soil erosion increased during the first three months after burning when compared with the natural forest.

Impact of fire on forest insect species diversity - a study in the Silent Valley National Park, India

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Keywords: Western Ghats; India; biodiversity; fire impacts; succession

The Western Ghats of India, which is the most imposing, but extremely threatened topographical, floristic and faunistic feature of the Indian subcontinent is one of the 18 biodiversity 'hotspots' of the world. Spread over an area of 175,000 sq.km. in six States, this mountain range extends more or less parallel to the west coast of Indian Peninsula from Kerala to Gujarat traversing a length of 1600 km.

The Silent Valley National Park is situated in the Palghat District of Kerala State, between latitudes 1103' and 11015'N and longitudes 76023' and 76030'E. As per the world classification of Udvardy, the area falls under the Malabar Rainforest Realm.

The total area of this forest is 90 sq.km. and accessibility to this area is restricted due to the steep slopes on all sides. The region is characterised by heavy summer rains and the mean annual rainfall is 4400mm. The major forest disturbance is fire which ferequently occurs during the summer season in the grasslands and spreads to the adjacent natural forests. As a result, several patches of natural forests get degraded leading to disappearance of many evergreen species. The 'gaps' thus formed in the forest due to burning are subsequently colonised by various secondary species that are found in the adjacent moist deciduous forests and grasslands.

The impact of fire on insect species diversity was studied in representative plots. Altogether. eight plots were taken along a transect in such a way that four plots were in the fire affected zone and the remaining in the unaffected forest patch. Plot size was fixed as 625 m^2 and the distance between plots was 25 m. Data on vegetation and insects were collected from all the plots and from this, the species composition as well as the indices of diversity, dominance, evennes, species richness etc., were computed separately for plots in the fire affected and unaffected zones.

There were 3951 plants belonging to 130 species in the study area, of which 1608 plants belonging to 81 species were found in the undisturbed area and 2343 plants belonging to 109 species in the disturbed area. The diversity index for the undisturbed area was 3.66 and the value for the disturbed area was 3.55.

The floral composition in the disturbed and undisturbed areas was also interesting. While the undisturbed areas had good representation of primary species like *Palquium ellipticum, Aglaia* sp., *Myristica dactyloides, Mesua ferrea, Cullenia exarillata, Holigarna arnottiana, Casearia bourdiloni* and *Persea macrantha*, the disturbed areas had only poor represention of these species. More over, there was an invasion of various secondary species like *Olea dioica, Scolopia crenata, Macaranga peltata, Zizyphus rugosa, Walsura trifolia, Celtis sp., Albizia chinensis* and weeds like *Clerodendron viscosum, Mikania micrantha* and *Lantana* sp.

Altogether. 10451 insects belonging to 578 species under 13 Orders and 67 families were collected from the study area. Of these, 5781 insects belonging to 449 species were from the undisturbed area and 4670 species belonging to 417 species from the disturbed area. Thirteen Orders and 61 families were represented in the undisturbed area and 12 Orders and 60 families in the disturbed area. The species diversity index was 4.76 in the former and 4.65 in the latter.

Consequent to the changes in plant composition following forest disturbance, there was a higher representation of arboreal feeding insect families (Geometridae, Saturnidae, Cossidae etc.) in the undisturbed area where as herbaceous feeding families like Pyralidae, Noctuidae, Chrysomelidae etc., were very abundantly found in the disturbed area. The Orders Diptera, Lepidoptera, Coleoptera and Hymenoptera were the most dominant groups in both the areas.

Natural regeneration of *Tectona grandis* and *Gmelina arborea* after fire in Ikrogon Forest Reserve, Cross River State, Nigeria

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Keywords: Nigeria; plantation fires; regeneration; fire severity and timing

Ikrigon Forest Reserve is a dry lowland rainforest, surrounded by a Derived Savannah and located between latitude 6.17 degrees north and longitude 8.36 degrees east. The total forest reserve area is about 600 ha.

The soil is loam to loamy sand with rock composition of mainly granite, quartzo-feldspathic biotite and hornblends-bearing gneisses, schists and magmites (Wright et al 1985).

Since the forest reserve is within a derived savannah, there is yearly fire occurrence which affects the natural and artificial forest in the area. At the plantation forest edge, bordering the savannah where *principally Gemlina arborea* (Gmelina) and *Tectona grandis* (Teak) are the planted reserve boundary species, there is annual seed dropping on the forest floor and the adjoining savannah area. This annual seed dropping has led to the natural establishment of seedlings of these plantation species on the frontiers of the adjoinging savannah woodland. Over the years, the seedlings have grown under the strong competition induced by annual fire, spatial distribution of seedlings, nutrients, soil, water and sunlight.

The result of this situation is natural selection in which some seedlings have grown to poles and trees while others remain stunted as perpetual understorey species due to lack of adequate sunlight and persistent annual fire. The litter drop of *T. grandis* is heavier than that of *G. arborea* and the leaves of the former wider in area than the latter. The leaves of *G. arborea* decay faster than those of *T. grandis*. The result is that there are *more G. arborea* seedlings on the forest floor than those of *T. grandis*. The perpetual persistent litter of Teak does not support profuse seedling production in Teak.

Data collected in mini-quadrats of 10 m by 10 m show an average spread of about 8,900 seedlings perha in Teak and 8,547 in Gmelina. There are also 494 trees established in one ha of Teak and 567 in Gmelina. This means that the trees naturally establish themselves at an average espacement of 4.5 m by 4.5 m for Teak and 4.2 m by 4.2 m for Gmelina. It is also deduced that in Teak area, over 8,406 seedlings lose the competition battle due to annual fire, heavy leaf litter, root competition, and canopy closure of dominant trees. The maturity survival percentage of the species under natural and untended conditions is 5.6%. Similarly, in the Gmelina area 7,980 seedlings lose the attainment of mechartable size due to fire, competition for nutrients, sunlight, and weeds.

The maturity survival percentage of Gmelina in the area is 6.6%. The heavy litter and canopy in the Teak area neither permits weed growth nor speedy development of seedlings. In the Gmelina area however, canopy is almost open thereby allowing for more Gmelina seedlings and weed growth. This is proved by the tree survival in the two plots assessed. The Teak plot does not therefore allow for encroachment of many indigenous species while the Gmelina plot does - especially weeds (*Cromolena odorata*)

Recruitment and survival is therefore based on the annual severity and time of occurrence of fires, competition for nutrients, sunlight, weeds, and canopy effects. Natural espacements for Teak and Gmelina seedlings on the forest floor are 1.06 m by 1.06 m and 1.2 m by 1.2 m, respectively. Also natural espacement for mature teak and Gmelina are 4.5 m by 4.5 m and 4.2 m by 4.2 m, respectively. The espacements exhibited by these tree species can scientifically influence espacement decision in plantation silviculture.

Seedling survival, mortality and regeneration after fire in a tropical high forest in Ghana

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Keywords: Ghana tropical forest; regeneration; early/late burning

Tropical high forests were previously thought to be immune to fire. However, studies and empirical evidence have suggested that fire might have played an important role in their evolution. Following the extensive bush fires throughout the tropics in 1982-3, fire has become a major issue impacting on the management of dry semi deciduous forest types of the tropical high forest of Ghana. Several ha of intact forest have been degraded due to the combined effects of recurrent fires and logging.

Studies including prescribed burning have been conducted elsewhere with the aim of reducing the detrimental effects of fire on the forest, whilst promoting re-growth of woody vegetation. However, most of these studies have focused more on the savanna woodlands and transition zones and least on the tropical high forest itself. At present, data is not available for a systematic study of the influence of fire on seedling survival, regeneration and tree mortality following fire in the tropical high forest.

This study attempts to quantify the effects of early and late burning on the survival and mortality of seedlings and trees and regeneration after fire in a tropical high forest in Ghana. It has been observed that tree seedling survival and mortality and regeneration thereafter are greatly influenced by the time of burning. Early or late burning is rather subjective and is determined by the prevailing weather conditions at the time of burning.

The implications for forest management in the dry zone of the tropical high forests are discussed.

Growth and development of a maritime pine stand after fire

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Keywords: Portugal fires; regeneration; growth rates

Three permanent plots, each with 1000 m^2 were laid out in 1989 in a State managed pine forest in the northwest of Portugal. The plots, installed in 1989, are located on a natural regenerated pure evenaged stand of maritime Pine (*Pinus pinaster* Ait.), after a forest fire in 1975. To decide about the most appropriate degree of thinning for this kind of stands two degrees of intermediate thinning were performed in 1992. In August 1993 a forest fire attained the three plots but it was decided to keep it to evaluate the impact of the fire on tree vigour, tree mortality, tree growth and yield and the occurrence of natural regeneration of maritime pine and other forest tree species.

At the first measurement, in 1989, each plot contained six tree rows, approximately four meters apart. Diameter measurements, at 1,3 meters above ground level, were collected for all trees within each plot, by taking the average of two calliper measurements. Tree height measurements were performed for sample trees only, ca. 40 in each plot, using an extending measuring pole. At the second measurement in 1992 tree height and breast height diameter were measured in the same manner. The height of the beginning of the crown was measured for all sample trees using a pole. The crown was considered to begin at the point on the tree stem where the first two green branches were detected. Furthermore, for all trees within the central four rows of each plot, four crown radii measurements, considering the greatest extension of tree crown, were made at approximately 90 degrees to each other. The overall plot dimensions and the spatial arrangement of the trees within each plot were measured using a extending tape. The corrected distance measurements, for the slope, together with crown radii measurements were utilised to construct crown maps of each plot. In 1994, 1996 and 1998 tree height, breast height diameter and the height of the beginning of the crown were measured in the same manner, all the trees were examined in relation with the occurrence of pests or diseases and classified according their vigour. In 1998 new crown maps were realised and the natural regeneration was identified and counted in ten square plots randomly located , each with 1 m^2, in each plot.

The effect of fire on all the above-described parameters and their evolution in the last five years are reported in the poster.

Sustainable Management of Natural Resources: fire and forests

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Keywords: Indian forest fires; economic impact; sustainability; fire research

Forests are not merely an economic resource but constitute an essential life support system, especially for the people living in mountainous or rural areas, Recurring forests fires cause considerable damage and degradation to forests and environment every year and more so in a cycle of four to five years. Ministry of Environment and Forest, Govt. of India, appointed a committee to assess the damage from forest fires in Uttar Pradesh (U.P.) and Himanchal Pradesh (H.P.) in 1995. This committee assessed direct economic losses to the tune of 139.3 million rupees, in U.P. alone during the Fire season of 1995. It also recommended that studies to make a scientific and comprehensive assessment of damage resulting from forest fires should immediately be undertaken by the Indian Council of Forestry Research & Education (ICFRE) and then the result of those studies applied in all states in evaluating the loss from the fire damage. These recommendations clearly reveal that research on forest fires has seriously been neglected.

It is paradoxical that fire protection was one of the first tools of scientific forest management in India, yet research in forest fires has been a neglected field in this country. Although research on two other injurious agencies off forest viz. diseases and insect pests started a long time ago, limited studies have been made on forest fires so far.

To estimate the true extent of fire losses, quantitative value has to be assigned to various impacts of forest fires. Forest fires are known to bring down considerably the various values e.g. productive, wild life, aesthetic-recreational grazing, socio-economic & others. It is also essential to have a reliable data base to generate the desired type of information. Expenditure on fire control can be justified only up to an amount representing the savings or loss reduction, which results from that expenditure. The more valuable the forest, the greater is the amount that it is worth spending to control fires. Research has to encompass all aspects of forest fire from pre suppression, prevention, detection, control, reporting, quantification and monitoring of losses. In the Himalayan region specific research is required towards cost effective & environment friendly hazard reduction methods e.g. some economically viable use for chir pine needles or some process to hasten its rate off decomposition. A modest beginning towards forest fire research has been made during the past two decades by adopting fire danger rating system for different type of forests, evaluating direct fire losses, designing statistical format for fire reporting for subsequent use in fire damage analysis. In view of the importance of the forests in Himalayan eco-system forest fire problems of this area need prioritisation in the Forestry research agenda.

About necessity of new approach to pyrological estimation of forests

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Keywords: Russian far east; 1998 fires; biodiversity; protection strategies

Principles of forest protection from fires, the evaluation of their consequences and their elimination, as has been shown by the catastrophic fires 1998 in Khabarovsk Territory, Russia, are no longer the matter of any separate country or any of its regions alone. Catastrophic forest fires periodically appear in this or that region and not only in Russia. No atrocious forest exploitation can be compared with the pyrogenic consequences, because only due to fires in a very short period are possible irreversible disturbances and destructions of formed many centuries ecological connections and trophic chains on the vast territories. Besides, as a result of fires, the indirect consequences are possible which it is impossible to take into account immediately. For example, soils destruction on mountain slopes in the result of burned stand decomposition which could happen after 10 or more years after the fire.

Experience shows that no country having large forest volumes located in insufficiently accesible areas (due to weakly developed road networks) is indemnified from the development of fires up to catastrophic sizes with all ensuing global ecological consequences. The world community is not so much worried by the loss of raw potential of the forest lands as by those ecological consequences which follow mass deforestation of the territories. Among the most meaningful ecological consequences are soil erosion, low river water, the loss for a long period carbon sequestration functions and, as a consequence, contravention of climatic situation on the planet. Evidently, it is necessary to improve all facilities of forest protection from fires - from their forecast and inventory to elimination of their consequences.

One of the important aspects is the determination of fire cause needed both for current and retrospective analysis of succession dynamics. If earlier it had a specifically administrative meaning, then today the role of cause in determination of priorities in pyrologic territory organization, prophylactic work with the population, improvement of legislative and regulatory bases becomes more actual.

It is evident, that both physically and economically there are no possibilities to fight all forest fires. In other words, it must be discriminatory relating territory and relating the value of forests. Such experience has been accumulated, particularly, by Canada. For Russian conditions, with its mammoth and hardly accessible territories, it is necessary to zone areas on a new basis - first of all according to forests ecological value, not only formally stated in the regulatory documents, but also actual, for example, according to carbon sequestration ability. The last could be estimated on green mass production and not only by the stand, but forest cenosis on the whole. According to these signs, the territory must be differentiated by zones according to prioritization of fire control active methods use under mass ignitions, similar to fires 1998, and according to the necessary expenditures for prophylactic measures.

Fire occurrence in relation to weather conditions

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This paper presents and evaluates the effects of fine fuel moisture content of forest floor fuels on fire occurrence in mediterranean ecosystems of Turkey. Fine fuel moisture contents were measured in an even-aged, fully stocked red pine (*Pinus brutia*) stand near Izmir. Three fuel samples were taken daily in the early fire season in june and once or twice a week thereafter. Fuel samples were weighed and oven-dried at 100°C for 12 hours or until no change in weight was attained. Moisture contents were determined based on the weight difference between before and after oven-drying.

Weather measurements were taken daily at noon local standard time from a nearby weather station located at Menderes Interantional airport. Measurements included temperature, relative humidity, wind speed and direction, and precipitation. Fire occurrence data during the study period was obtained from the Regional Forest Directorate in Izmir. Analyses showed that a close relationship exists between weather conditions and fire occurrence. Indexes generated from this study should be invaluable for fire managers in the region and other places having similar conditions.

Wildfire occurrence in a forest district and other Brazilian protected areas

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Keywords: fire danger rating; fire occurrence prediction; Brazil fires

Wildfire is a permanent threat to native and planted forests in most part of the Brazilian territory. Periodical dry seasons and abnormal weather conditions have induced to large and destructive fires from time to time. In 1998, for instance, an extremely large fire burned about 13,000 km^2 of tropical forest and savanna vegetation in the State of Roraima, located in the amazonian region.

Despite the preoccupation with the tropical forests, data on fire occurrence in that ecosystem are not sufficient to make a good description of fire occurrence in Brazil. This paper presents the history of fire occurrence in the Agudos region, State of Sao Paulo, southeastern Brazil, from 1984 to 1995 and other protected areas throughout the country. The center of the forest district area is located approximately at 22^{o}28'S 48^{o}59'W and 526 m above sea level. The fire season in the region goes from June to November. There was statistical difference among the months of the year for both, number of fires and burned area. August, with 21.60%, presented the higher number of occurrences, and 76.36% of the fires occurred from June to November. September presented the largest burned area (28.49%), and 80.41% of the total area affected by wildfires burned from August to November. There was no statistical difference in the number of fires or burned areas among the days of the months and the weekdays, although sunday, with 17.36% of the occurrences and monday, with 24.86% of the total burned areas had presented the highest numerical values. However, significant difference was observed both, in the number of fires and burned areas, among the hour of the day. About 85.17% of the fires and 91.97% of the burned areas were recorded between 10:00 AM and 06:00 PM. The hour that presented the highest occurrence was 02:00 PM, with 17.20% of the recorded fires. Precipitation was the weather variable that presented the best correlation with fire occurrence. About 42.1% of the annual precipitation and 82.41% of the recorded fires occurred between April and October. August was the month with lower precipitation and higher number of fires. Data collected from protected areas in the Brazilian territory in 1994 and 1995 presents similar results showing that the history of forest fire occurrence is similar all over the country.

September, with almost 30% of the recorded fires, was the leading month in fire occurrence, and 84.61% of the fires and 97.85% of the burned area were observed between July and October. Arson (41.40% of the fires and 11.81% of the burned area), Debris burning (32.26% of the fires and 79.55% of the burned areas), and Smoking (10.21% of the fires and 1.13% of the burned area) were the leading causes of forest fires.

Performance of the Monte Alegre formula on fire danger evaluation in different regions of Brazil

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Keywords: fire occurrence; fire causes; Brazilian tropical forest/savannas

The occurrence of forest fires is highly influenced by weather conditions. For that reason, fire danger rating indices based on meteorological variables are important tools to aid in planning and supervising fire control activities in fire protection units. Besides presenting a good performance, an index must be adapted to the local conditions, mainly to the available data for its calculation. That is why sophisticated indices that require data that is not easy to obtain cannot be used in developing countries, where meteorological and other necessary information are seldom available. The "Monte Alegre" formula (MAF) was developed in 1972 using meteorological and fire occurrence data of the central part of the State of Paraná, and has since been used by most forest institutions and companies in Brazil and other South American countries to predict fire danger. It uses only three variables: relative humidity (directly), number of days without rain and amount of precipitation (both indirectly), and can be easily calculated every day through the following equation:

MAF = 100 SUM FROM { n=1 } TO { n } 1 OVER H

where n is the number of days without rain and H is the relative humidity measured at 1:00 PM. The performance of the MAF was evaluated in three deferent forest districts in the southeastern and southern regions of Brazil. Firstly, using a data set from the region where the index was developed (Cfa climate, according to Koppen's classification), its performance was checked. Results showed that 52.5% of the fires registered in that period occurred when the index indicated a very high danger; 31.7% when the danger was high; 13.8% when the danger was medium; 2.0% when the danger was low; and no fire was recorded when the index indicated no danger. Secondly, using data from a forest district in the southern State of Santa Catarina (Cfb climate), the MAF was compared to the locally used index, developed by the South Carolina State Department of Forestry, USA, (SCI) in the 1960s. By the MAF, 13.0% and 87.0% of the recorded fires occurred when the index indicated high and very high danger, respectively. When the SCI was used, 43.5% of the fires occurred when the danger was low, 26.1% when the danger was medium, and 30.4% when the danger was high; and no fire was recorded when the index was very high. Thirdly, using data from a forest district in the central region of the southeastern State of Sao Paulo (Cwa climate) the performance of the MAF was compared to three other indices: Nesterov, Tellysin, and the Canadian Fire Weather Index (FWI). Three methodologies were used to test the efficiency of the indices: Mahalanobis distance, Friedman's test, and distribution of the occurrences through the danger scale of the indices. According to the Mahalanobis distance and Friedman's test, the FWI was more efficient but when the distribution of the occurrences through the danger scales was used, the MAF was more efficient in estimating the fire danger of the region.

Monitoring and assessing forest fires using NOAA-AVHRR data with special emphasis on Borneo

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Keywords: Indonesian fires; remote sensing; smoke/haze; fire management

Forests are managed not only for the production of wood, but also as a safeguard for environment. One of the main factors effecting forest degradation is forest fires and uncontrolled burning. Asean countries especially Malaysia and Indonesia were most affected by forest fires during July-November, 1997. The worst haze occurred in Sarawak, Malaysia when the Air Pollution Index (API) reached 800, exceeded the 500 danger level. Consequently the state was declared emergency by the government. This paper will highlight the capabilities of satellite image (NOAA-AVHRR and SPOT image) in monitoring forest fires. Observation and studies showed that the haze was caused by fires and burning. This paper also assessed the burned forest areas and the relationship between the number of hot spots and the severity of haze occurrence i.e. affected areas. The causes of forest fires were highlighted and management plan of forest fire control was proposed.

Influence of bush fires on the dynamics of dry forest: case of degraded forests in North-Benin

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Keywords: Benin; bushfires; early fires; late fires; regeneration; dry forests; natural forests; forest management.

The North-Benin is in the dry part of the country where dry season covers 6 to 7 months of the year with a rainy season of 5 to 6 months. The average temperature is about 27°C with the rainfall oscillating between 900 and 1200mm annually. The vegetation is savannah type with low density of large trees. The main activities are agriculture, breeding and hunting. In this part of the country, bush fires are widely used by farmers, breeders and hunters for their activities. So, every year, many ha of forests are burnt with consequence of gradual degradation of forestland. This attitude of populations has a sociological foundation, which is not easy to overcome. In order to appreciate the real impact of fires on natural regeneration of forest, an experiment was initiated in 1990 with objective to determinate the appropriate periods for fires use as a tool for forest management. For this purpose, five treatments have been applied on six different sites as following: a) use of "Early fires" (EF) on 11 November and 11 December; b) use of "Late fires" (LF) on 11 January and 11 February; c) no fire use (NF) as control. After some years of observation, the tests have been evaluated in 1996 and 1997 in order to appreciate the evolution of plots. The results appear that the LF is very damaging for young regeneration with about 95% seedling burnt causing in fact progressive genetic erosion and the destabilization of soil. On the other hand, the EF of 11 November stimulated more the natural regeneration with appearance of new species in the experimental plots. With this treatment, it has been observed a natural pruning of trees with best development of trunk. Concerning the protected plots, grass has grown with high concurrence to young regeneration and natural sowing and seedling. On these plots, it also appeared that the renewal of grass is low comparing to EF, the trees have developed large crown with big branches and the high accumulation of dead vegetation. The conclusion is that, fire is a real tool for forest management in dry regions when its use is well analyzed. For now, fire appears as the best tool to fight against the risks of uncontrolled bush fires in dry regions in regard to the context of socio-economic conditions of the populations concerned. The EF applied just at the beginning of dry season has a positive influence on natural regeneration and the reconstitution of dry forests for wood and fodder production as well for biodiversity conservation.

Prognosis of emergency situations under wildland fires

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Keywords: Russian fires; climate change; vegetation mapping; fire behavior

It is proved that climate changes occur with extreme declination of seasonal weather variations and may cause large scale fire emergency situations (Stocks, 1993; Wein, Groot, 1996; Fosberg, Stocks, Linham, 1996). In the last years climate changes are vividly seen in the South of Siberia and the Far East and they are the cause of intensified spring and summer droughts. Due to these droughts such emergency situations often occur when forest and steppe fires become dangerous for inhabited localities and even inflict casualties. This work analyses the peculiarities of dangerous wildland fire development, the forecasting and possibilities of prevention emergency situations on the basis of vegetation fuel maps. Emergency situations take place when a strong fire threatens an inhabited locality or some valuable object.

The dangerous fire intensity depends on the mass of vegetation fuel burning down in flame regime in time unit per long meter (but not per square meter!) of fire edge. This mass depends on two factors: a) the stock of such vegetation fuel per unit of area and b) the speed of fire edge spread. If the speed of spread is large, the intensity of fire can be very high even under small stock of vegetation fuel. The presence of considerable stock of vegetation fuel burning down in the regime of smoldering (litter, peat, duff) decreases the intensity of flame burning. Fires become of high intensity and, therefore, of danger if they reach the so called ‘phase of self development’. Firstly, it happens at the expense of their speed increase under ‘potted’ spread with throwing about burning particles in front of the fire front. It is especially characteristic of ‘explosive’ fires.

Ignitions in inhabited localities and industrial objects occur because of burning particles which are thrown about in front of a strong forest or steppe fire front. This usually happens in dry windy weather, therefore, ignition of separate dwelling houses and industrial buildings can spread over other buildings and objects. Burning particles can spread up to 500 meters distance and more. Due to this, strong vegetation fires can get over the rivers, unburned bogs and other obstacles.

The main way of protection objects against an approaching strong fire is preliminary backfiring. The history of very large forest fires (for example, fires in the Northern China in 1987) shows that such fires are able to spread freely over the area for a long time destroying inhabited localities and crossing the rives and roads which could be the best initial line for preliminary backfiring. The list of problems on prevention of loss under the emergency situations, connected with wildland fires close to inhabited localities and others valuable objects, includes the following tasks: 1) showing up of inhabited localities which can be damaged under wildland fire (forest, steppe and so on); 2) elaboration of prophylactic measures on protection of such objects from wildland fires; 3) prognosis of possibility of wildland fire dangerous development, active near the inhabited locality or near the industrial object; 4) prompt, safe and reliable stoppage of dangerous fires with the least expense of strength and means.

The solution of enumerated tasks is possible on the basis of vegetation fuel maps usage and method on vegetation fires behavior prediction. Technology of vegetation fuel maps creation on the basis of forest inventory data and air-space information and method of fire behavior prediction are elaborated (Volokitina, Klimushin, Sofronov, 1995).

Assessment of forest fire impacts in East Kalimantan using satellite remotely sensed data

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Keywords: Indonesia; Landsat TM; JERS-1 OPS; NDVI; GIS

It is difficult to assess and get general view of large scale forest fire with ground survey alone. Satellite remote sensing technique, which enable monitoring over a large area multi-temporally, were employed to map the extent and degree of the large scale forest fire occurred in East Kalimantan Province, Indonesia, between mid 1997 and early 1998. According to the report of Indonesian government, this fire damaged more than 520,000ha of forest in this Province. Southern part of Samarinda, the capital city of East Kalimantan Province, was selected as a study site. The study site covers 24,1000ha, including Bukit Soeharto Education Forest (BSEF) and Sungai Wain Protection Forest (SWPF). Although BSEF and SWPF are both protection forests, they have different degree of protection level and different types of vegetation management.

Two change detection analysis methods, Normalized Difference Vegetation Index (NDVI) analysis method and Change Vector Analysis (CVA) method, were introduced to map vegetation cover changes caused by the forest fire, using 5 scenes of Landsat TM data (acquired on 1997/4/13, 1997/8/3, 1998/1/26, 1998/2/11, and 1998/3/31) and 3 scenes of JERS-1 OPS VNIR data (acquired on 1996/9/27, 1997/8/1, and 1998/6/5). Maps of detected change derived from NDVI analysis represented suitable results compared to CVA when using limited ground information, and were adopted as the maps of vegetation cover change in this study. From this satellite remote sensing data analyses, 26.8% of land area in the study area showed vegetation decrease from February to March 1998, which probably caused by the forest fire, and 11.8% showed vegetation increase from March to June 1998 by regeneration of vegetation after the forest fire.

A GIS database of this study area was newly constructed to find out the relationship between human activities and forest loss due to the fire. The database comprises spatial data such as 1) slope model, 2) basin/ridge model, 3) buffer zones representing human activity area, 4) boundary of the BSEF and SWPF, and 5) land cover map of the study area before the forest fire obtained from RS data classification. By overlaying vegetation cover change layers with other GIS layers, it was possible to assess the scale and degree of the forest fire in relation to human impact and vegetation management condition.

From February to March 1998, 54.8% of forest area in BSEF, where protection of vegetation by university had been not carried out sufficiently, showed vegetation decrease caused by the forest fire. While in SWPF, where sufficient vegetation protection by Indonesian Government had been carried out, 31.5% of forest area showed vegetation decrease in the same period. Furthermore, SWPF showed 6.1 times large vegetation regeneration area compared with BSEF after forest fire, from March to June 1998. By using 1 kilometer buffer zone of human activity area, where human impact to vegetation environment thought to be large, 65.1% in BSEF and 50.2% in SWPF showed vegetation decrease from February to March 1998. They suggest that the vegetation change of the study site caused by forest fire have strong relation to the conditions of vegetation management.

A3 Sustainable Management of Natural Resources. Management and Conservation of Forest Gene Resources

Conservation of Endangered Genetic Resources in Forests of Cuba

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Key words: conservation, genetic, endangered species.

There are 820 plant species (626 native and 173 foreign) associated with forests in Cuba. A significant number of species (109) are at risk of extinction as a result of human presence and evoluties factors. The Forestry Research Institute has been working on conservation, management and rescue of endangered species in different forestry ecosystems in Cuba through a combination of *in situ* and *ex situ* studies. Studies were conducted on forestry species in the natural conditions to characterize phenotypic and anatomical variation and on seedling/clonal regeneration. To restore or augment endangered populations, seedlings were planted in natural area for *in situ* conservation and at other suitable locations for *ex situ* conservation.

Recommendations for post-planting management were developed. *In situ* and *ex situ* conservation planting is important techniques to ensure recovery of certain species in forest ecosystems.

Contemporary Approaches to the Ex situ Conservation of Malaysia Rain Forest Tree Seed Germplasm

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This presentation explores the contribution that contemporary research methods (i.e. biotehnology, in vitro conservation, molecular biology, cryopreservation and bioinformatics) can make in the conservation of Malaysian Rain Forest tree seed genetic resources. Research has included: preliminary assessments of phenological studies , which may be used to assist seed germplasm collection; pre-storage seed evaluation and the control of phytosanitary and moisture content status; seed storage characterization; zygotic embryo rescue and in vitro culture; rapid screaming of cryopreservation protocols; cryogenic storage; molecular stability characterization , and the application of statistics for the improvement of conservation experiment design.

The significance of these contemporary, multidisciplinary approaches for the improvement of conservation strategies for Malaysian Rain Forest tree seed germplasm will be presented, a key factor to their success will be their integration with sustainable management programmes and their complementary use in conjunction with other ex situ and in situ conservation regimes.

Reproductive Biology and Genetic Diversity of Selected Rain Forest Species of Sri Lanka: Implications for Management

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Reproductive phenology, floral biology, mating systems and genetic diversity of selected rain forest plant species of traditional economic importance were examined in Sinharaja World heritage site and the surrounding forests of South-western Sri Lanka. Dipterocarps belonging to the local group Beraliya whose seeds are edible, flower supra-annually often coinciding with maior El-Nino events while the Thiniya-Yakahalu-Dun group flowers annually. They are pollinated by *Apis* species and the fruits are dispersed by gravity and wind. The dioecious medicinal vine, *Coscinium fenestratum* (Menispermaceae) is an annually flowering species. Its likely pollinator is a dipteran and the fruits are dispersed by the Ceylon Fruit Bat (*Rousettus* sp.) and the arboreal palm civet (*Paradoxurus* sp.). The herbaceous wild cardamom Elettaria cardamomum var. major is an out-breeding species pollinated by an Amegilla species.

Mating system studies on dipterocarps have revealed a predominantly out-breeding system for *S. congestiflora* (tm = 0.87) and a mixed mating system for both S. trapezifolia (tm = 52 - 62%) and *S. megistophylla* (tm = 0.74). The average single-locus out-crossing rate for *S. megistophylla* was significantly lower than the multi-locus rate in the selectively logged forest but not in the adjacent unlogged forest indicating a greater level of biparental inbreeding (kin mating) in thinned populations. The fixation index for adult individuals of all three species was lower than that of the progeny suggesting a considerable selection against selfed progeny in them while reaching adulthood.

Genetic variation parameters were calculated for 10 populations of S. trapezifolia separated by 8-45 km from each other. The proportion of polymorphic loci, effective number of alleles per locus and the observed and expected heterozygosity were lowest in a small relict forest, a likely result of forest fragmentation, degradation and consequent genetic isolation. The highest genetic variation was observed for populations outside the Sinharaja protected area which had 18% of the total alleles sampled exclusive to them. 89% of the genetic variation was found within populations indicating a relatively low genetic differentiation among populations sampled. UPGMA cluster analysis and a correlation analysis however, failed to recognize any geographical pattern of population differentiation..

This serves as a bench-mark study in population genetics of Sri Lankan dipterocarps particularly for monitoring long-term effects of forest fragmentation and degradation on population genetic structures of incumbent species. It strongly recommends setting aside of larger areas of contiguous forests or clusters of forests linked through 'gene-bridges' such as riverine forests, ridge top forests etc. for conservation of genetic diversity of out-breeding species. Furthermore, it also advocates that the distribution of genetic diversity of at least some key species should be taken into consideration in protected area design and management.

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Biodiversity and exploitation of cedars (*Cedrus* spp.) in Mediterranean region

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We have started to develop the necessary genetic and population data and methodologies to allow the identification of cedar genotypes and their distributions within populations, between populations and across countries. These approaches are being used to define the underlying structures of the remnant forests in Lebanon along with the more extensive and exploitable ones in Turkey and Morocco.

The genus *Cedrus* includes four species which have geographically distinct origins. These are: *C. libani* A. Rich in Lebanon, Syria and Turkey; *C. atlantica* Manetti in Algeria and Morocco; *C. brevifolia* Henry in Cyprus; and *C. deodara* Loudon in Afghanistan and India. Some of these species, however, are difficult to distinguish phenotypically which led some authorities to regard them as a single species.

Cedar forests are among the oldest forests in the Mediterranean basin and have a significant economic role in many countries of the Mediterranean basin, both as a source of highly valued timber but also as ornamental trees. Currently most cedar forests are facing serious problems of degradation and mismanagement partly as result of the lack of an efficient regeneration system. The remaining natural sites have been under intensive human pressure due to demographic increases, the absence of other resources of timber with similar or better quality than cedar and simple “mismanagement”, arising from a lack of reliable information. In Lebanon, for example, there are several forest stands of Cedars extending from Kammoua in the North to the Shouf in the South. But, as a result of previous reforestation efforts, some of the Lebanese stands now include, in addition to native C. libani, C. atlantica, C. brevifolia, and/or C. deodara.

It was, therefore, perceived to be imperative that the genetic diversity of the natural stands was determined in order to assess the available genetic base and hence to determine necessary procedures for further reforestation. This is allowing not only the specification of protocols to preserve the genetic diversity but also the identification and encouragement of sustainable exploitation. Alongside the increase in the basic information on diversity it was essential that an effective and efficient propagation system was developed which would facilitate planned plantings and sensitive development to proceed.

Results will be presented from our current programme which has been combining modern biotechnological approaches, made available by the rapid development of molecular marker technology, with conventional methods, but undeveloped for cedar, for propagation and screening.

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Strategies for Genetic-Resource Conservation of Commercial Tropical Timber Species in Asia Pacific Region

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The tropical rainforests in Asia-Pacific region are considered among the most complex eco-system in the world. These forest provide multiple benefits to its host countries, both in socio-economic development and environmental services. In the 80’s, the rate of deforestation for the region was one of the highest in the world. Deforestation, however, is still a major problem in some countries in the region due to unsustainable practices of logging operations and continued land-use conversation. The region is a major source of supply for the tropical timber products, contributing about seventy five percent of all tropical timber products traded in the international market. As timber are produced mostly from the region’s natural forests, the conservation of genetic timber resources becomes very critical. This paper highlights the outcomes of an ITTO funded study carried out in five countries in Southeast Asia on in-situ and ex-situ conservation. The paper review the current status of in-situ and ex-situ genetic conservation of timber species in those countries and proposes measures to be undertaken to further strengthen it’s the conservation. New sets of guidelines for in-situ and ex-situ conservation to be adopted for Asia-Pacific region are also discussed.

Mating System Parameters of *Dryobalanops aromatica* Gaertn. f. (Dipterocarpaceae) in an undisturbed natural population, a logged over natural population and two planted populations

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The mating system of Kapur (*Dryobalanops aromatica* Gaertn. f.) from Peninsular Malaysia was quantified by allozyme analysis of progeny arrays using a mixed-mating model. Four populations were compared: an undisturbed natural population, a logged over natural population, a multi-species planted population and a mono-species planted population. The undisturbed natural population had the highest multilocus outcrossing rate (tm = 0.92), followed by logged over natural population (tm = 0.77) and multi-species planted population (tm = 0.67) with mono-species planted

population showing the lowest (tm = 0.55). This finding may indicate that reduction in population density of *Dryobalanops aromatica* following logging activities and changing in population structure under plantation condition can significantly levitate the proportion of seeds produced through inbreeding. It could also be attributed to differences among populations in genetic compositions and environmental conditions. Only the progenies from mono-species planted population showed evidence of biparental inbreeding (tm – ts = 0.12), suggesting that the population was established using related seed sources.

Management and Conservation of Forest Genetic Resources in Uruguay: Role of the National Reseach Institutions.

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Keywords: Forest genetic resources; Management; Conservation; Research institutions; Uruguay.

The present work aims to an analysis of the role of the Uruguayan national research institutions in the management and conservation of forest genetic resources field through:

a presentation of the forest genetic resources current state in the country,

an analysis of the actions of the national research institutions,

and a proposal for an effective implementation of a national research strategy.

The study of the forest genetic resources present state will be developed in the conceptual framework of biological diversity, highlighting the tree forest genetic resources component and considering the regional and global trends in their scientific and political dimensions. The peculiar features of Uruguayan natural environment and their relationship with the management and conservation of forest genetic resources will be presented.

The actions of the national research institutions will be analysed at the scientific, technical and institutional levels, emphasising the contribution of the National Agriculture Research Institute (INIA) and his National Forestry Program.

The proposal of an effective implementation of a national research strategy in management and conservation of forest genetic resources will describe both home and abroad Uruguay's policies and long - term actions required for strengthening this area.

The delimitation of the role of the national research institutions is of a strategic importance in the present stage of forestry development in Uruguay. In fact, during the 1987-1999 period, an overwhelming plantation program of fast growing species has taken place in four main suitable soil zones of the country, favoured by a highly structured state policy with an exceptional package of incentives. At the same time, this forestry state policy has been based on regulations protecting the natural native forests. The public opinion has also a great sensibility to environmental topics, including the biodiversity one. Uruguay has at present 3.6 million hectares of soils suitable for forestry. There exist 670 thousand hectares of natural forests and 450 thousand hectares of plantations, almost all them installed during the 1992-1999 period, with an annual plantation rate of 40.000 ha/year.

A5 Sustainable Management of Natural Resources. Sustainable Forest Management and Productivity

Under-Canopy and Preliminary Forest Cultures as a System of Forest Growing in Conditions of Smooth Natural Generation Change in the Boreal Forests of Russia

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Natural spruce forests of the boreal taiga are usually presented by multiple-aged forest stands. Spruce reforestation under the canopy of such crops is a natural process, corresponding to the natural peculiarities of the zonal (area) forests. However, in the considerable area of the exploitable crops of the European part of Russian boreal forests it is quite difficult to run a forestry, orientated to the conservation and further utilization of the young growth during the cutting of the mature forest stand.

During the last 35 years in the north-western and central parts of Russia there were probated new methods of planting and conditions of artificial growing of spruce and other shade-requiring species under the canopy. Depending on their purpose these cultures are subdivided into preliminary and under-canopy.

Common to both types is the fact they are planted under already existing (growing) canopy; while the difference is that preliminary cultures are planted under the canopy of maturing and mature crops (approximately 10-12 years before cutting), but under-canopy cultures- under the canopy of open undergrowth(I-II age class).

The technological system of preliminary cultures provides for preventing unfavorable succession of spruce species and gradual(progressive) replacement of old generations by young, ecologically stable forests. Planting and growing of preliminary cultures, unlike the clear cutting forestry management and further reforestation, has a number of technological, ecologically-silvicultural and economic advantages. The purpose of under-canopy cultures is slightly different and consists in planting structurally and compositionally complex forest crops on the basis of open unsuccessful or damaged forest stands.

Young spruce growth in the open cutting usually suffers greatly because of the late frosts and sun burns. Besides, its growth is greatly restrained by grassy vegetation and broad-leaved sprouting. Microclimatic conditions are much softer and more favorable for survival and growth of young plants under the parent canopy. In particular, there is no competitive pressure on the crops from grassy vegetation and broad-leaved sprouting, the fact that greatly decreases care costs.

Moreover, under the canopy of forest crops the processes of bogging are weakened as here, in contrast to clear cuttings, water regime(condition) is regulated by growing forest crops.

We can’t help mentioning a most important ecological effect of the under-canopy reforestation system, that is reduction of the amount of open forests peculiar to clear cutting forestry.

Nowadays, when forests suffer immensely from air emissions and other technogenic (industrial) pollutions, under-canopy “covered” system of forest growing considerably reduces the probability and degree of salvage.

The under-canopy system of forest growing essentially reduces and prevents CO2 release into atmosphere owing to unproductive temporal interval (10-15 years), until the territory of cutting is planted by new crops.

The long-tem researches of the stationary plots showed that during the processes of planting and growing of preliminary cultures. The latter accelerate their growth abruptly when the upper canopy is cut or thinned. Their biometric parameters and productivity become similar to those of the cultures planted earlier in the open areas.

In all its technological and forestry components the under-canopy system of reforestation and forest growing will favor ecologolization of the forestry management system in the boreal forests.

Tropical forests management based on tree populations dynamics: the example of moabi in the Dja forest (Cameroon)

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Though Central African rain forests contain a wide diversity of tree species, present logging practices are extensive and mining, and focus on a relatively restricted range of valuable timber species Considering the complexity of management practices aimed at controlling global stand dynamics, we propose an approach based on ecological characteristics and demography of particular timber species and we assume that forest management mainly consists in the management of timber tree populations living in their natural environment. This approach is illustrated with the example of moabi (*Baillonella toxisperma* Pierre, *Sapotaceae*), a timber species from Cameroon.

For two and a half years (1994-1997), we measured survival, growth, fecundity and spatial distribution of every class of seedlings and trees of this species in permanent plots covering 347 ha, located in the Réserve de Faune du Dja and in the adjoining logging concession (South-East Cameroon).

After a description of the Dja’s floristic diversity (chapter 1), we present the phenology and germination of moabi (chapter 2), seed dispersal and predation by mammals as well as impact of hunting on its natural regeneration (chapter 3), and then seedling growth in the understorey related to light availability (chapter 4) and finally the demographic parameters of its adult population: diametrical structure, growth, mortality and spatial distribution (chapter 5). Moabi start fruiting from 70 cm DBH, some individuals reach 280 cm DBH as maximum size and trees are cut over the legal limit diameter which is 100 cm. The density of adult trees is 0.1 stem/hectare. The specific growth curve is calculated by mean of three different methods: measurement of 273 living individuals for a period of 2,5 years analysed with both Gompertz’s model and a polynomial model; annual growth rings counting for 10 trees; and carbon dating for 4 trees.

On the basis of these observed values of fecundity, survival and growth, we build a matrix model (Lefkovitch 1965, Usher 1966, Favrichon 1995) which reproduces the evolution of class sizes of moabi over a period of time (chapter 6). This demographic model is a management tool which can be used for predictive simulations.

On the one hand (chapter 7), we quantify the impact of the present logging practices on moabi population dynamics. Thirty years after first logging, moabi population will recover 27% of the initial number of adult stems and this reconstitution level will be 83% after 300 years.

On the other hand (chapter 8), the matrix model enables to assess the impact of forest management scenarios designed by changing management parameters. We successively simulate (1) the elevation of limit diameter from 100 to 130 and 160 cm, (2) the lenghtening of rotation period from 30 to 60 years; (3) the reduction of impact of logging from 10 to 5% of the ground area and (4) the increase of growth speed due to the implementation of selective thinning. These simulations enables to compare the cumulative timber production yielded over a period of 480 years by the present logging practice *vs* an extremely conservative management scenario (limit diameter = 160 cm; rotation time = 60 years; reduced impact logging; selective thinning).

This approach based on tree population dynamics with regard to their natural regeneration logically fits into the classical scheme of natural forest management plans in Central Africa baesd on selection system. It enables quantitative recommandations for long term timber production from these forests to be formulated and, consequently, contributes to their sustainability.

Modelling Norway spruce young stand development based on IUFRO international stem number experiment

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There is an expectation of new plantation and regeneration on abandoned agricultural land in Europe. These new plantations should be ecologically stable and sound. The models for regeneration and young stand development are sought as one of the tool to reach the above given goals.

The presented model is based on the IUFRO international stem number experiment for Norway spruce where radical reduction of the number of trees per hectare in the juvenile stage has been done. The experiment was established in 1971 in eight years old spruce thicket originated from planting in regular spacing with density 2500 trees per hectare. The series consists of five obligatory treatments with two replications. The stand is situated on previously cultivated agricultural land in 5th (spruce-beech) vegetation degree on elevation of 600 m above sea level. The pattern of experiment includes control plot 1 without thinning. All other programmes are based on first heavy thinning (top height 10 m). Thinning regime 2 represents heavy treatment in young age (top height 12.5 and 15 m). The regimes 3 and 4 (fully mechanised selection) are similar treatments planned later when the stands achieve top height 20 and 22.5 m. Thinning along with treatment 5 (commercial thinning) is to be done only when 80 m3 of stem wood can be removed on trees with DBH over 12 cm excluded 400 crop trees.

The data set gives detailed information on every tree growth including the stem and crown shape and the position of the tree within the stand. The data are recorded since 1971 and represent high quality long time period for juvenile growth stand. The higher volume of stem wood (474.7 m^3 per hectare) is accumulated (last survey in 1998) in the control stands 1, but total production (together with volume removed by thinning) is the highest on plot 2 (541,1 m^3) as well as the volume of selected trees - 217.5 m^3. Various thinning programmes affected stability of experimental stands in favour of tended stands.

The model could help with the formulation of the growth process of young Spruce stands under very new silviculture regimes which should create the stable stems with low value of stem sliminess coefficient and long and vital crowns. It is expected that these silvicultural regimes could increase the vitality of the stands suffering in Central Europe by the air pollution and other climate stress.

Nutrient Management Guidance for Enhancing Sustainable Forest Productivity

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Guidance on the nutrient management requirements to support enhanced productivity goals for new plantations of loblolly pine (*Pinus taeda*) in the southeastern United States or of Douglas-fir (*Pseudotsuga menziesii*) in the northwestern United States is developed. Sustainable forest management with enhanced productivity is needed on commercial forestland as opportunities for timber harvests from public forests declines in the United States. A suite of Excel spreadsheet "models", derived by simplification of simulation models, is provided at two Internet websites for use by the Forest Industry in their stand management planning. A three-step procedure is designed for use with personal computer systems.

First, the productivity goal for a new plantation is estimated for the specific soil and climate conditions of a field site to be planted with selected planting stock and managed with practices that enhance productivity (e.g., planting density, vegetation control, fertilization, thinning). The target biomass projection for each year of the new plantation is determined from growth and yield models available to the forest company or from the 3PG spreadsheet model calibrated for plantation growth. The 3PG model was developed by Landsberg and Waring (1997, Forest Ecol. and Manage. 95:209-228).

The nutrients required to support the target growth are next estimated with the REMSS spreadsheet model. This code determines nutrient requirements from empirical relationships established from the nutrient content of stems, branches, foliage and roots of the two tree species. These calculations determine the time course of nutrient requirements for the target plantation growth.

In the third step, the soil supply of nutrients for the specific soil and climate characteristics of a selected site is determined with the NuCSS spreadsheet model. Soil data from forest company measurements or from estimates provided from soil databases are used to determine the annual nutrient supply from the soil to the vegetation. The difference between the REMSS vegetation nutrient demand and the NuCSS soil nutrient supply provides guidance on the fertilizer requirements to meet the target productivity.

Repeated simulations with the spreadsheet models provide insight on the nutrient management requirements for sustaining enhanced forest productivity through several rotations. The procedures also estimate changes in soil carbon sequestration due to nutrient management.

Supplemental features are included at the Internet websites. The nutrient status at a field site may be evaluated prior to planting by foliar vector analysis with the DIAGNOSIS spreadsheet model. This analysis can be made if foliar mass and nutrient data are available from the previous forest stand. Further, the Crystal Ball software may be used with all Excel spreadsheet models for conducting sensitivity and uncertainty analyses. Sensitivity analysis shows the important variables that contribute significantly to the outputs at each step. Sensitive variables need to be accurately determined. However, variability (uncertainty) of soil, climate and vegetation attributes is often large at field sites. If this variability is known, uncertainty analysis may be undertaken with Crystal Ball to estimate plantation nutrient requirements with statistical confidence intervals.

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Détermination de la productivité des jachères dans cinq régions du Mali

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La filière bois-énergie au Mali permet de couvrir 91 % des besoins énergétiques natinaux. Le bois est issu des formations naturelles et des formations "hors forêt" ou diffuses des espaces agro-sylvo-pastoraux. Pour mettre en place une gestion durable et raisonnée de la ressource ligneuse, le Mali s'est doté d'une politique énergétique : la Stratégie Energie Domestique.

La production de la biomasse ligneuse des formations forestières est connue, alors que celles des jachères (formations forestières diffuses) sont tout à fait empiriques.

Pour mieux appréhender sa production, la Cellule Combustibles Ligneux (volet offre de la Stratégie Energie Domestique) en liaison avec l'Institut Polytechnique Rural de Katibougou, a installé des sites d'étude dans cinq régions du Mali d'Ouest en Est : Négala, Ouéllésebougou, Fana, Cinzana et Koutiala. Les sites choisis doivent permettre une meilleure connaissance des formations "hors forêt" du pays.

L'inventaire des arbres (de jachères et de parc), de la régénération, le cubage par classes (0- 5 ans, 6-10 ans, 11-15 ans, 16-20 ans et plus de vingt ans) ont été réalisés dans ces sites. La répartition par classes d'âge a été obtenue par enquêtes auprès des paysans exploitants de ces jachères.

La productivité annuelle de ces formations est fortement liée à l'anthropisation, elle varie de 0,06 m3/ha/an à Koutiala (fortes occupations des terres pour la production du coton) à plus de 0,25 m3/ha/an dans les régions de Fana et Négala. Ces résultats n'incluent pas les arbres dits de "parc" tel que Vitellaria paradoxa, Parkia biglosa, et Lannea spp..

Les essences caractéristiques de ces formations "hors forêt" sont pour l'étage dominant les arbres de parcs cités au pargraphe précédent, pour l'étage dominé: *Combretum nigricans, Acacia macrostachya, Combretum glutinosum* ; la régénération est caractérisée par des espèces pionnières : *Piliostigma reticulatum, Acacia macrostachya, Guiera senegalensis*.

Ces données partielles seront utilisées pour la réactualisation des Schémas Directeurs d'Approvisionnement des principales villes du Mali (Bamako, Ségou, Mopti et Koutiala).

Growth Models Control Sustainability of Forests in Transition

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Keywords: *Dauerwald* management, Individual tree growth models, permanent forest inventory

In Central Europe there is an increasing trend to convert even-aged to uneven-aged forests, aiming at a *Dauerwald* (permanent forest) forest management system. Under this situation the former age class methods, derived from the “normal forest model”, or from the dbh-class models based on de Liocourt’s negative exponential dbh-class distribution, are appropriate to both, determine and control sustainable annual cut with respect to age classes or dbh-classes and the way how to best approach the *Dauerwald*-structure of the forests.

Two developments in European forest science help this situation: (i) individual tree growth models have been developed, aiming at the substitution of classical yield tables, and (ii) forest inventory designs have shifted to permanent sampling methods in order to more accurately identify changes in forest structures and damage.

This presentation will demonstrate that combining both, permanent inventories based on angle count sampling and the distance independent individual tree growth model PROGNAUS, will enable foresters to choose harvesting strategies, appropriate to achieve both high value sustainable yield and uneven-aged forest structures.

The example presented is a forest management area of 1270 ha, where more than 40 years ago the clear cut system was abandoned and replaced by target diameter harvest. In 1988 permanent plots were established. Sample trees were selected using Bitterlich’s angle count method with a basal area factor of 4 m²/ha. The first re-measurement in 1998 served to calibrate the growth model PROGNAUS. With the calibrated model, different harvesting scenarios are calculated for a 40-year period. Stocking volume, dbh- and stem quality distributions are compared.

Using forest inventory, remote sensing, GIS and growth models to monitor some sustainability indicators at management level

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Criteria and indicators for the sustainable management of forests have emerged as a central element of international and domestic forest policy discussions. The Third Ministerial Conference on the Protection of Forests in Europe, that took place in Lisbon, Portugal, in June 1998, adopted the six Pan-European criteria for sustainable forest management. The European countries involved in this conference committed themselves to promote the development and implementation of national criteria and indicators, taking into account specific country conditions, as well as to improve the quality and promote the necessary adaptations of national data collection systems, to fulfill the needs of information to assess sustainable forest management. In Portugal, the definition and implementation of adequate indicators to be used at a practical level in the assessment and monitoring of forest management sustainability at management area level have attracted particular interest since then. The implementation, in practice, of the proposed indicators strongly rely on the availability of forest inventory and mapping of forest resources over time, seldom available in Portugal at the management area level. In this context, a management area is a forest area, subdivided into management units (stands) that is subject to the same management plan. The objective of this poster is to analyse alternative methodologies of up dating forest resources information, including spatially specified information. Data from the continuous forest inventory of the National Forest of Leiria are the basis for this study. The National Forest of Leiria is a state property with an area of 11,000 ha located in the coastal dunes of Marinha Grande in central Portugal. Most of the area (8,700 ha) is made up of pure maritime pine stands managed for high quality timber production. A relative small percentage along the coast is protection forest with the maritime pine as dominant species (2,000 ha) and a little more than 300 ha are devoted to other land uses. The forest is subdivided into 342 management units approximately rectangular that are sometimes subdivided into 2 or more stands. For management purposes, a continuous forest inventory systematically covers the forest since 1979 with an intensity of one 500-1,000 m2 plot per ha (two plots per ha till 1988) and a periodicity of 5 years. Alternative methodologies of up-dating forest information were simulated on the basis of these data, including the use of traditional forest inventories of different intensity, combined or not with the use of growth models, as well as the use of remotely sensed information and other ancillary data available in a GIS system that is available for the area.

The application of growth and yield models for yield regulation and to assess indicators of sustainable forest management for mixed tropical forests.

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Yield regulation has been identified as a key constraint to sustainable management of natural tropical forests. Growth and yield simulation models are being developed as tools for growth prediction and yield regulation using data from permanent sample plots and forest inventory. This paper illustrates the application of an individual-based (single-tree spatial) model for simulation of the growth and yield of moist tropical forest systems. SYMFOR is a modelling framework that has been principally designed to study and predict the effects of different silvicultural treatments for sustainable yield management of natural Dipterocarp forests in Indonesia.

The current version of SYMFOR has been applied to illustrate the utility of both empirical and process-based growth and yield models for three applications: (1) growth and yield prediction, (2) evaluation of alternative silvicultural systems and (3) evaluation of indicators of sustainable forest management. Predictions of growth and yield are presented for an area of lowland dipterocarp forest in East Kalimantan (Indonesian Borneo). These predictions are used to describe and predict the recovery of the forest following logging compared to its pre-logging condition. This analysis is then extended for the same dataset to determine the effect of altering the silvicultural system applied to the forest through alterations in either diameter cutting limits or length of cutting cycle. These results are then further analysed to illustrate simple indicators of sustainable forest management. The analysis of these simulation runs demonstrated the importance of appropriate statistical analysis of model simulations

The paper concludes that growth and yield models will become an increasingly important tool for the management for sustained yield of tropical forests and can be further applied to develop and implement effective criteria and indicators for sustainable forest management. These applications will require the development of appropriate analytical procedures to utilise output from simulation models and to make their results readily available for application by forest managers.

The Determinants of Silvicultural Investment in British Columbia: An Economic and Policy Perspective

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Being a key link in the chain of sustainable forest management practices, silviculture occupies an important place in British Columbia's forest policy considerations. This poster aims at providing an economic and policy analysis of the silvicultural investment in BC's public forestlands. First, a brief historical overview of the Province's silviculture programs is presented to outline the institutional context in which the silviculture sector has evolved. Next, silvicultural activities and expenditures are reviewed statistically. Then, a regression analysis is undertaken in an attempt to reveal the effects of several explanatory variables such as harvest areas, timber prices, non-timber values and government stumpage revenues on the levels of silvicultural investment. Finally, the policy implications of the research findings are discussed from the perspective of sustainable forestry. The paper ends with a comment on the emerging trends of BC's forest policy regarding silvicultural operations in the Province.

B4 Forest and Society Needs. Evaluation of Technologies for Society Needs

Fulfilling Societal Needs through Participatory Silviculture - An Evaluation

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A revolutionary development in forest management took place in India in the late 1980s, when participation of local, forest-dependent communities was sought for the management and protection of State forests under the umbrella of the Joint Forest Management (JFM) program. This new approach has now been adopted by 21 of the 25 Indian States. Approximately 3.5 million ha of forestland have been regenerated by more than 35,000 forest protection groups in different parts of the country. This has been accomplished through indigenous and innovative methods and approaches. The Latest Report on the State of Indian Forests (in 1997) shows that, although the amount of new forest cover is small in regions where JFM has been implemented, there have been marked increases in biodiversity, biomass productivity, tree basal area, and other ecological parameters in these areas.

As the phenomenon of JFM has strongly taken root, managers have realized that classical silvicultural systems and operations are not adequately equipped to address the newly emerging needs and demands of the society. The JFM program considers the dependence of local, forest-dwelling communities as well as those living on the forest fringes. Thus, intermittent yields of locally valuable, multiple forest products become critical to the sustainability of this co-management concept. This also conforms to the emerging global consensus regarding the vital role of forests in facilitating the anti-poverty crusade, which is high on national agendas around the world.

Forest management is now recognized as being more than just protection. The local community should be involved in the manipulation of trees and other forest vegetation if total and effective co-management is to be achieved. Thus has evolved the practice of Participatory Silviculture, which is the new thrust area in the JFM-practicing States of India. The techniques and operations implemented under Participatory Silviculture incorporate local knowledge and use perceptions, temporal and spatial dimensions of local needs, and institutional setup. Additional factors include aspects of a wider socio-economic environment apart from forest types, the history of forest management, and other vegetation-related characters. Beginning with species selection and through to silvicultural operations, local needs and aspirations are considered supreme. These silvicultural methods, though simpler, are evolved jointly and continuously by the technically skilled foresters and the forest-dependent community. Local communities now conduct their own operations, such as lopping for fodder and fuelwood, rotational blocking for NTFP collection, multiple shoot (MS) cutting, stump dressing, pruning, etc.

This poster attempts to answer the following questions regarding the potential role of Participatory Silviculture in the sustainable management of community forests:

Are community forests being managed effectively to respond to the needs of the user groups?

What kind of silvicultural manipulations are being carried out by the forest user groups, and how do both scientific and local knowledge come into play in determining such practices?

Is there any need and/or scope for further strengthening and improvement of these silvicultural interventions to address both social and environmental needs?

The poster highlights and analyzes the results obtained from field studies in Central India (Harda Forest Division), Bihar (Singhbhum Forest Division), West Bengal (Bankura Forest Division), and Nepal (Kavre Forest District). Ecological factors have been re-examined that limit natural forest recovery on degraded areas under co-management. The studies also evaluated various management options and the socio-economic and policy issues that influence silvicultural decisions for restoring and rehabilitating degraded natural forests.

Transfer of Timber Harvesting Technology to Societies in Economic Transition – The Taiga Model Forest Project in Northwestern Russia

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A dramatic economic transition in Russia has caused difficulties for Russian forest industries. Annual cuts have been drastically decreased, and numerous sawmills and pulp mills are experiencing hardships because of a shortage of raw material. At the same time, exports of roundwood make up the core of forestry income. Reliance on earlier timber-harvesting systems has been very difficult, because Russia's own machine production is also struggling in the transition. Therefore, redesigning the harvesting systems is proposed as a solution. Western machine manufacturers consider Russia a potentially strong market, but the lack of capital hinders transactions. In addition, unemployment is a serious problem among forest workers.

A Taiga Model Forest (TMF) project was launched to establish a model forest area for demonstration and experimental purposes. One objective of this project was to find profitable and cost-effective technological applications for forest operations in northwestern Russia. Technology transfer within the project itself was mainly an exchange of scientific knowledge among scientists. Nevertheless, one purpose of the project was to demonstrate Scandinavian timber harvesting and to compare it with local Russian methods in a large thinning experiment. Shortcomings of this approach included the Russian counterparts' lack of knowledge in the actual planning of forest operations, as well as the unstable situation in Russian society. Both of these situations have caused serious problems with the realization of the TMF project's goals. In this paper, the TMF project was analyzed in a Samli's framework of technology transfer. One aim was to examine international transfer of forest technology by observing an on-going case. The Samli's model used in this study was improved upon by attaching outside motives to the framework. These outside motives (from non-governmental environmental organizations) had been one of the driving forces when the TMF project was established.

Comparative studies based on unit-cost calculations indicate that, economically, an intermediate technology would be the most profitable method in this case. This is because of a low level of salary in relation to the price of advanced technology. An intermediate timber-harvesting technology would also be more profitable for the economics of northwestern Russia because of its positive influence on employment and its smaller demand for foreign currency when procuring harvesting equipment.

The best results from the TMF were obtained in the training and advising of forest workers, who quickly adopted the principles of the new methods. In the TMF, Scandinavian forest road-construction methods also were demonstrated in cooperation with Russian road-construction companies. The local machinery labor was suitable for forest-road construction when the Scandinavian methods were used.

Intermediate technology practices in timber harvesting seem to be the most promising way to help northwestern Russian forestry in this difficult situation. However, because the current need for forest worker education is so great, the transition to more cost-effective Scandinavian systems may be slow.

Using the Delphi Method to Forecast Priorities in Forest-Engineering Technology

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Key words: effective measures for realization; forest-engineering technology forecast; forecasted realization

Forest engineering technology must be promoted as a pivotal component in sound management of Japan's forests. Using the Delphi method, we conducted a technology-forecast survey to gain a long-term perspective on the future of forest engineering. Survey results were consolidated through two questionnaires. We selected respondents who were experts with extensive knowledge of forest engineering: 20% from the forestry sector, 19% in machine manufacturing, 26% university-related, 29% in public research institutes, and 6% in other areas. For the first part of the survey, we sent questionnaires to 79 respondents, of whom 50 were then sent the second questionnaire. We excluded those who withdrew from the survey after the first questionnaire. The rate of response was 63% for the first part and 90% for the second.

The preliminary questionnaire was used to determine the forecast topics. We divided forest-engineering technology into four categories: machinery, operations, ergonomics, and roads. Within each category, the respondents were asked to state topics of concern that could be addressed, or ”realized”, in Japan by 2030. Predictions for the technological stage of fulfillment for each topic were made with one of three phrases: ‘in development’, ‘in practical use’, or ‘in widespread use’. The respondents proposed more than 100 topics. After all topics were prioritized according to importance and generality, 37 were selected for special consideration (14 in machinery, 13 in operations, 5 in ergonomics, and 5 in roads).

The respondents forecast the time for realization of half the topics by 2010, 90% by 2015. The earliest two topics forecasted (in 2007) were ”Widespread use of the instruction manual of forest operations for voluntary workers” and ”Widespread use of non-clear cutting operations using mobile tower yarders”. The topic ”Development of unmanned harvesting machines” was forecasted for realization after 2020.

Based on results from the second survey, an importance index was calculated for each topic; the overall average was 59.7. The topics with the three highest indexes (all >80) were related to environmentally aware technology: ”Widespread use of the evaluation and management methods of environmental conservation in forestry”, ”Widespread use of near-natural road construction methods”, and ”Widespread use of the accurate predicting methods of environmental impact through forest operations”. We also asked for ‘Effective measures the government should adopt for realization’ of each topic. Among the choices, ”Increase in government funding for research” was most frequent (average 50.5%). ”Personal exchange between the industrial, academic and government sectors” was chosen in 39.9% of the replies.

The forecasted realization time for each topic will be referred to during development of technology strategies in the forestry sector. Environmental concerns should be emphasized more in the future as R&D is promoted in the field of forest engineering technology. In particular, financial support for R&D and collaboration between industry, university, and government are expected to be considered when forest technology policies are proposed.

Impacts of Forest Harvesting Operations on Soil Properties

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Key words: forest operations; impacts on soil properties; regeneration quality.

Forest operations in northeastern China include planning for harvest systems, logging, transport, road-network design and construction, slash disposal, and planting after harvesting. These activities are significantly correlated with soil disturbance, which can be measured in terms of the degree of break and compaction as well as the loss of soil nutrients. Four sub-projects were conducted to study the effects of forest operations on physical and chemical soil properties at the operation sites. The study variables included such factors as cutting system, skidding traffic, layout and construction of forest-road networks, and slash disposal. In general, the degree to which soil physical properties were affected was closely related to the level of energy input, i.e., how much timber was removed from the forest, during operations at the harvest site.

Three cutting systems were employed: selective cutting, thinning, and small-area clear-cutting. Of these, selective cutting has been the most commonly used system over the past 10 years, and will probably be the best harvesting method in the near future. However, soil physical properties were affected most significantly by this method, as measured by the degree of disturbance associated with the volume of timber removed per ha. This is because more movements and greater energy inputs were required for executing the operations on each tree. Clear-cutting and thinning were ranked second and third, respectively. In terms of disturbance per unit area, however, the clear-cutting system had the most significant impact on both physical and chemical properties of soil, accounting for approximately 15% of the variation. This was because of the more-concentrated operations involved with this system.

Timber was moved from the site by tracked crawler, wheeled skidder, cable-yarding, or animal skidding. During the winter, ground-skidding traffic did not significantly influence soil physical properties, even after six to eight passes by the machinery. However, the opposite was true when the ground was not frozen. The wheeled skidder then had a greater impact than did any other means of log transport. Field investigations showed good natural regeneration in the areas disturbed by crawlers, but not at the landings or in the main skidding-track ruts. Animal skidding was an environmentally sound technique, with moderate operating costs. Because no soil damage is inflicted during winter operations and only slight amounts during the other seasons, the use of animals has increased to about 90% of all the skidding done in the last 5 years.

Three slash-disposal methods -- burning, piling, and spreading -- have been employed during the last 10 years of harvesting. Although the burning method has impacted the soil more because of nutrient losses, it has been beneficial in improving soil acidification. The other two slash methods have had moderate influences.

A well-planned forest-road network can reduce soil erosion. To lessen the impact of forest-road construction on soil properties, we are presenting a new mathematical model for optimal layout of forest roads. Both economical and ecological benefits are considered in this plan.

A Practical Approach to Prioritizing Forestry Research Projects

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Key words: forestry; prioritization; research programs; step-by-step procedures.

Various approaches have been proposed for prioritizing forestry research programs. Evaluating the merits and demerits of each approach may provide a means for ranking individual programs. Unfortunately, all of the current methods are rooted in agricultural environments, with the primary focus only on prioritizing particular species in annual crops. In contrast, the man-made models that are designed for studying natural systems in forestry consider species to be but one of many components in the system. Therefore, a practical approach is needed, which is applicable to the unique requirements of forestry. Our proposed method comprises two phases: Phase I -- prioritization of forestry projects; and Phase II -- prioritization of research programs. This approach reduces subjectivity by introducing objective questions whenever judgments must be made.

The process of Phase I begins by identifying the relevant issues in forest management, viz., Geographical Cover of forests; Conservation of Bio-diversity; Protection of forest resources from all kinds of destabilizing factors; Restoration of the degraded forests; Production of material goods; and Extension of forestry for practice by the public. These are the primary objectives in tropical forest management. Forests are categorized, based on both biotic and abiotic characteristics, by the amount of ground they cover. At this stage, judgments are made according to the relevance or importance of each objective in various forest categories. Grades are assigned as Absent, Poor, Low, High, and Highest.

The subjectivity inherent with making judgments can be reduced by using objective questions. The graded judgments carry scalar values of 0, 1, 3, 6, or 10. Direct or inverse weights are introduced that account for the extent to which a forest is impacted by each objective. The total scores earned by the various combinations of forests and objectives are ranked in descending order. Rankings are improved by introducing the level of impact that each objective has on Economic, Environmental, Political, and Sociological aspects. The final ranking, which includes the improved, combined scores, provides the priority for forestry projects.

Phase II commences with identifying the chief components involved in technological activities. These components are ranked according to their contributions toward fulfilling forestry objectives. The technological activities are assigned to one of five levels: 0, 1, 2, 3, or 4, with 'Level 0' referring to rudimentary or absent, meaningful technology; and 'Level 4' indicating the highest level of technology that is feasible for a particular component. Technological Levels are scored as 0, 10, 30, 60, or 100%, respectively.

The goal of all research programs is to progress from some lower level to higher technological levels. Each upgrade is a gain toward fulfillment of the objectives. The gains from technological upgrade are estimated for all the components of Prioritized Forestry Programs. This is followed by an estimate of the final score, which is the product of both the expected gains from the technological upgrade and the score of the Prioritized Forestry Programs that was estimated under Phase I. Using this method results in the identification of Prioritized Forestry Research Programs, with final scores listed in descending order.

The Historical Development of Forest Operations in China and a Look Ahead 10 Years

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Key words: forest operations in China; historical development; 21st century; 10-year look ahead.

The history of forest operations in China since ancient times (more than 2000 years ago) has included developments in operation technology, equipment, organization, and professional education. We used the Entropy Growing Analysis method for studying the dynamics of these developments, particularly with regard to the interaction between human society and forest ecosystems in a given region. In China, the deforestation rate is highly correlated with an increasing population rate i.e., each era of great population explosion has resulted in large-scale deforestation.

Forestry activities have changed greatly in the last century because of the fast development of science and new technology, unbelievable population growth, and rapidly changing social structures and market systems. In the first half of the 20th century, large forests were destroyed during continuous wars, mad land-grabbing by invaders, and unanticipated establishment of farms by immigrants. The main goal of forest operations during that period was to extract as much timber and farmland from the forest as possible. Machinery, such as a forest railway transportation system powered by steam engines, significantly improved operational efficiency. Unfortunately, this new trend toward mechanization increased the capacity for human interference in the forest. However, the rest of the work was done manually, and contracted teams were a popular means for organizing forest operations.

Since 1949, and particularly in the past 20 years, forest operations in China have been greatly modified. Not only have the science and technology of forest operations been developed significantly; the environmental aspects, profitability, and economic efficiency have also been emphasized. Forests are now recognized as important suppliers of non-wood forest products such as water and soil protection, climate adjustment, and an assortment of flora and wildlife. These factors are considered when decisions are made about harvesting, timber extraction, and civil engineering in forests. In integrated forestry, planning is done from the viewpoint of sustainability for both timber and non-timber forest products. All activities, e.g., forest resource surveying and harvesting planning, road planning and construction, harvesting, post-harvest site disposal, and planting and protection must now serve these key purposes. As well, forest-operations technology and techniques have been converted from manual- to machine-driven, and are now part of an environmentally sound complex. Planning and organization has been changed from that of small, manual working groups to large-machinery operations. The working system now involves many contracted groups at different levels.

"The Natural Forest Conservation Project", begun in 1998, identified the challenges and opportunities in Chinese forest operations. The market for small- and mid-sized machines, with multi-functions, will be the most dominant in the near future, depending on the forest resources available in China. Environmentally sound, low-cost, and highly efficient forestry technology and techniques will be in the spotlight of both research and practice in the next 10 years. Forest operations will also play quite an important role in the management of sustainable forestry

C3 Changes in Environment and Society. Interaction between Environment and Society

Forest and Land-use Structure in the Urban Landscape in Tokorozawa, Japan

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Key words**:** urban forests, agricultural land, land-use change, spatial analysis, Japan.

Forests in urbanized and suburban areas have a wide range of functions, ranging from contributing to human daily life to providing habitats for wildlife. On the other hand, forests are source of real estates for urban development. Thus, it is important to examine the actual and historical situation of forests and land-use when developing a forest management plan in urban and suburban areas. This study aims to show the historical change and actual situation of the forest and land structure in the urban landscape of Tokorozawa, Japan.

Tokorozawa is a city about 30 km north from the Tokyo metropolitan area, located in the middle of the Kanto planes. Its area is about 7,200 ha and topologically gentle, except for the southwestern part. The population dramatically increased from 57,000 in 1960 to 303,000 in 1990.

Base data used were the actual vegetation map of Tokorozawa city in 1956 (26 categories) and in 1985 (54 categories). These were converted for digital data and re-categorized for land-use maps. Analysis was done using ARC/INFO and Arcview 3.

According to the overlay analysis of land-use maps, Tokorozawa had 1,940 ha (26.7%) of forests and 4,038 ha (55.7%) of agricultural fields in 1956. But in 1985, these had rapidly decreased to 1,150 ha (15.9%) of forest and 2,343 ha (32.3%) of agricultural field. In contrast, the urban area had increased from 367 ha (5.1%) to 2,046 ha (28.2%). According to the overlay analysis of actual vegetation between 1956 and 1985, over 80% of total area had changed, and mainly from forest and agricultural vegetation to urban areas.

In addition, structural changes occurred in forest and agricultural vegetation. Most of agricultural vegetation in 1956 consisted of a field weed community, and some of these were changed to a tea garden in 1985. At the same time, part of the forests' structure also changed. Coniferous communities (*Pinus densiflora* community, *Cryptomeria japonica*, *Chamaecyparis ovtusa* plantation) were succeeded by a deciduous substitutional community (*Quercus serrata* forest).

The structure of Tokorozawa's landuse dramatically changed from a forest and agricultural town to a satellite city of Tokyo. Accordingly, the forest and agricultural vegetation also changed.

Eco-Design In Nature-Based Parks: A Precondition Of Accomodation Facilities

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Malaysia is blessed with naturalness features in combination with varieties of flora and fauna. It is of the country's advantage to use these resources to the benefit of the country's population and economy. The opportunity for people to enjoy the nature-based activities should be expanded with minimum impact upon the natural environment. Sustainable development and eco-design development concept should be considered which include the contributions from nature resources.

All of the factors or variables associated with a built structure should be interrelated with one another and co-existed within a symbiotic environment. In general, the development of eco-design structures involved the analysis of the site, infrastructure, and related activities. These include evaluation on visitors, flora, fauna, environment, government aspiration, local population needs and their culture and relationship with the surrounding facilities. This paper discusses on the concept of eco-design with respect to studies carried out in Taman Negara, Kuala Tahan, Pahang and Pantai Kerachut, Penang. Basically, this paper focuses on accommodation facilities within the selected sites which are nature-based recreational areas.

The eco-design concept of building structures in Taman Negara Resort, Kuala Tahan, Pahang was carried out to evaluate the ecological consciousness of specific features of the buildings, especially the accommodation facilities. The study was divided into two aspects; namely, the assessment of human responses toward lighting comfort, thermal comfort and outdoor vegetation, and the investigation of building design. The features that have being investigated include the aspect of building design, the orientation, shape and form, materials of building, energy efficiency and waste disposal. Analysis of variance on the thermal comfort during daytime between respondents staying in shaded and non-shaded accommodation facilities showed that there is a significant differences ($p < 0.0001$) between the two variables. Analysis of variance of lighting comfort between respondents staying in shaded and non-shaded accommodation facilities showed significant differences ($p < 0.0001$) in glare sensation during daytime. Most of the accommodation facilities were oriented with the long axis in north-south plain and elongated in shape, which was unfavourable in reducing solar radiation. The materials of chalets and chalet suites were of lightweight and suitable in tropics. In the aspect of energy efficiency, costs and benefits analysis of replacement of incandescent lamp to fluorescent lamp has shown that the savings on electricity were able to cover the additional cost within a year of payback period. The sewage treatment and waste disposal practised in the resort were of conventional method whereby recycling of waste was minimally practised. Replanting of shade trees was practised but provided little shading to the accommodation facilities. The evaluation of ecologically conscious building features in Taman Negara Resort revealed that the resort design was minimally manipulated to blend with the natural features. Over dependence on mechanical systems to alter the interior climate has signified inappropriate design, disassociation from the environment, and non-sustainable use of resources.

The demand for eco-tourism or nature based tourism has increased drastically during these few years. This has caused the rush for development of more accommodation facilities in natural areas to cater for the demand. These developments usually do not give enough considerations to the impacts that it will impose on the natural environment. The study in Pantai Keracut was to develop a design of ecologically conscious accommodation structure based on the local and natural settings of the area. This study also consisted of two major phases. In the first phase, data gathering and analysis were carried out and plans indicating features within the study site was produced to determine the nature features and settings of the study site. It was used in the selection of the best area for siting the accommodation structure. The second phase of the study involved conceptualization of the ecologically conscious design for the accommodation structure. The ecologically conscious accommodation structure design consisted of three major features namely passive design feature, energy conservation feature (photovoltaic) and waste treatment feature. The incorporation of various naturally operated systems into an accommodation structure has demonstrated the potential of natural features to be utilized and could replaced the conventional power oriented system in many tourism areas. The low scale built environment proposed in Pantai Keracut Recreational Forest emphasized ecologically conscious features such as natural daylighting, natural ventilation and photovoltaic systems as an alternative towards a „clean and green“ tourism in the future, especially in the context of local environment.

D1 Cultural Diversity in Forest Management. Agroforestry

Performance of ginger as an understorey crop in *Ailanthus triphysa* stands grown at different densities and fertiliser regimes in Kerala, India

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Keywords: Understorey production, PAR, Soil fertility

Ginger (*Zingiber officinale*) is an important spice crop of the humid Indian tropics. Being a shade-loving plant, ginger is grown in association with an array of tree species. *Ailanthus triphysa*, a fast growing multipurpose tree, is common in the ginger-based agroforestry systems of Kerala. Owing to its compact crown, moderate root spread and deep rooting tendency, *Ailanthus* is thought to be less competitive with associated field crops.

A split plot experiment with *Ailanthus triphysa* was initiated at Vellanikkara, Kerala, India in June 1991. Objectives included assessing the productivity and quality of understorey crops in agrisilviculture systems involving different *Ailanthus* densities and fertiliser regimes, besides analysing the growth and productivity of *Ailanthus* trees and the partitioning of solar radiation among the different components of the system. Main plot treatments consisted of four densities of *Ailanthus* (3333, 2500, 1600 and 1111 trees ha^{-1}) with three replications. Four fertiliser levels (0:0:0, 50:25:25, 100:50:50 and 150:75:75 kg ha^{-1} N, P_2O_5 and K_2O) formed the sub plot treatments. Ginger was planted as an understorey crop in this experiment in May 1994. There were six beds in all plots. Three monospecific ginger plots were established in the contiguous area. They, however, did not form part of the replicated experiment, and the mean was compared with other treatments using the ‘paired t test’.

Until four years after establishment of the experiment (when the current observations were made), there was no significant difference in *Ailanthus* growth and/or foliar chemical composition owing to tree density or fertiliser regime. Ginger grown in the interspaces of *Ailanthus* exhibited better growth as compared to the sole crop. In general 2500 trees ha^{-1} registered better growth of ginger. Fresh and dry rhizome yield of ginger was highest at this density.

Availability of photosynthetically active radiation (PAR) was inversely proportional to stand density. Available PAR ranged from 35-72% and 40-75% of that in the open, at 50 and 150 cm above ground level respectively in four-year-old stands. A strong relationship, however, was not established either between PAR and foliar nitrogen content of the tree or between PAR and rhizome yield of ginger.

Foliar N, P and K contents of ginger increased as growth progressed, but declined after reaching a maximum value at around two months after planting. Although monospecific plots recorded higher initial nitrogen levels, intercropping, particularly in the denser treatments recorded higher nitrogen levels subsequently. P and K followed a similar trend. Higher foliar nutrient concentrations observed in the high density treatments may be due to elevated physiological activity of the leaves, as they remained greener for a longer period. Ginger LAI/LAD was higher in the denser treatments. This in turn re-confirms the fact that optimal levels of shade may promote growth of the understorey ginger crop. Fertilisers applied to the tree component of the system did not influence the growth and yield of ginger. Essential oil and oleoresin contents of ginger also were unaffected by tree density and fertiliser regime, although the sole crop of ginger recorded the highest values for essential oil (0.98%) and oleoresin (3.98%) contents.

Three years of *Ailanthus* growth resulted in a noticeable reduction in site nutrient capital. Soil nutrient availability declined with increasing tree density. Control plots recorded higher values for mineral elements and organic C. Reduction in soil nutrient levels at higher densities can be explained by rapid nutrient removal by trees. *Ailanthus* being a fast growing tree may absorb nutrients rapidly, especially during the initial years, although this may be compensated by nutrient cycling later. Reduction in soil pH can be rationalised by litter decomposition and the consequent release of organic acids. Fertiliser application to *Ailanthus* altered soil mineral nutrient status, except N. Residual soil fertility (organic C, N and K levels) after the ginger crop was higher than before, presumably because of green manure and/or nutrient addition to the ginger crop.

The potential of *Albizia saman* (Jacq.) F.Muell (SAMAN) in silvopastoral Systems in Venezuela

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Keywords: *Albizia saman*, Agroforestry, Silvopastoral, Llanos, Venezuela

Saman *(Albízia saman)* is a multipurpose leguminous tree widely used in Venezuelan agroforestry systems as permanent shade in coffee and cocoa plantations, in small banana lots, homegardens and as live fences. Its main and most important use is as shade, shelter, and fodder in silvopastoral systems in Venezuelan savannas (llanos) and in the south and western areas around Lake Maracaibo. The high protein content of the fruits (15-18%), and significant pod production during the dry season in the savannas, makes this tree a key component of silvopastoral systems in the llanos of Venezuela.

Formerly known as *Samanea saman* (Jacq. Merr.) or *Pithecellobium saman* (Jacq. Benth), the species is found mainly in tropical dry forest, from 0 to 700 m above sea level, and also in tropical moist forest with 2200 mm annual rainfall, and can tolerate dry periods of up to 5–6 months. The tree has a wide crown, up to 30 m wide, providing good shade and shelter to animals in grazing lots, fodder (pods and leaves), wood for crafts, timber for construction and it also fixes nitrogen, so improving soil properties. Average total wood volume per tree has been estimated between 1.2 and 3 m^3 for individuals more than 50 years old and more than 100 cm in diameter, and total wood volume values (including the main and secondary branches) are up to 9 m^3 per tree.

A study conducted in Portuguesa State (Venezuela) showed the beneficial effect of saman canopy on soil properties and on pasture growing under the tree. Nitrogen, phosphorus and organic matter were found to decrease with distance from the tree stem (under the canopy) toward the open grassland.

Research done in llanos in Apure State, where trees were selected at random in grazing lots, allowed quantification of fruit production per tree during the dry season from February to May. Production ranged between 53 and 806 kg $tree^{-1}$, and average production was estimated at 219 kg $tree^{-1}$ during 110 days of fruit production. In the same study fruit protein content was determined at between 15.6 and 16.5%, during the dry season, with an average of 16% protein content during the four months of production.

Grazing lots with the highest percentage of saman shade (55-64%) had an average of 5 trees ha^{-1} which means that average fruit production can be estimated around 1095 kg ha^{-1} with 175 kg ha^{-1} of protein. The carrying capacity of Venezuelan llanos is very low, 3 to 5 ha Animal $Unit^{-1}$ depending on the season. Livestock farms with silvopastoral systems based on saman trees have the potential to supply 3000 kg of fruit AU^{-1}. Venezuela has 20 million ha of savannas, Colombia has also millions of ha in the southeastern llanos of the country, and more generally in seasonally dry pastures in Latin America, saman has a great potential to be the key component in silvopastoral systems of the livestock raising areas.

Participative Construction of Forest Farmers`Concepts and Expectations in the Philippines

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Keywords: Participative construction, Forest farmers, Concepts, Expectations, Philippines

This study was conducted in a village setting in the Philippines to: (1) picture the concept that forest farmers have of their collective and individual farms, trees and other forest resources and the extent of depletion and replenishment of forest resources; (2) determine forest farmers' expectations of their farm, what they will do and what they expect from outside intervention; and (3) explore forest farmers' concepts of environmental issues in relation to farm sustainability, the laws governing forests and community concerns over their farming systems.

The department of forestry of the Visayas State College of Agriculture (ViSCA) had a record of about 98 households farming in the ViSCA Forest Reserve. During interviews, 78 village households were identified as forest farmers occupying the Forest Reserve. Preliminary visits to respondents were done for a week. This enabled the researchers to introduce themselves, present the objectives of the study to the farmers and familiarize themselves with the forest farmers' domain and lifestyle, especially the forest farming cycle. Final data gathering was made through a series of personal and group interviews. During the interviews, no written questionnaire was used to allow respondents to freely express their ideas. There was unlimited time for interactions, and the seeking of information was conducted either individually or participatively in groups anywhere in the household, neighbourhood or in the farming area. When conducted in the residence, household members shared their thoughts and ideas. After interviews, farmers' responses were immediately reconstructed and recorded. Anecdotal recording was done after each visit to each respondent. Presentation of data is descriptive. Conclusive statements about respondents' concepts were based on consensus. Respondents were encouraged to reinforce their ideas with diagrams on paper or with stones, leaves and sticks on the ground.

Forest farmers have encountered various problems in their farming system within the Forest Reserve due to its terrain (steep slopes), the distance between their farms and their homes and prohibition of forest occupancy. They have told many times not to cut trees, to stop making 'swidden cultivation', and have eventually been asked to leave their farms by law enforcers. Most of the respondents said that they would continue to cultivate the farm they presently have because it was inherited from their ancestors. Other respondents said they would continue cultivating their farm because this was their primary source of livelihood.

Respondents said that having trees in the farm is good because they provide protection from strong winds and minimize surface runoff. Trees also serve as shade when they relax after work. However, the numbers of trees in the farm are already depleted and farmers perceive that it is necessary to replenish the area by planting fruit trees. The respondents preferred fruit trees because according to them this would serve two purposes: protecting their area from natural damage and providing income from their fruits.

The farms have become the main source of livelihood of the respondents. Despite the laws prohibiting the cultivation of forest areas for farming, respondents stand firm in their decision to continue planting in their farms. Respondents would like assistance from individuals, groups or agencies, either government or non-government, provided that this is not conditional on them being evicted from the farm they presently cultivate.

The respondents freely shared their knowledge, ideas, concepts and expectations related to their farming system. Results of the study should help development workers understand better the forest farmers' way of life and seek ways to alleviate marginal living among forest farmers.

Agroforestry Models in Karnataka: A Field Level Analysis

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Keywords: Agroforestry, Block plantation, Random planting, Species diversity, Social forestry range

Agroforestry is an integrated approach to develop land for growing food, fodder and fuelwood on the farm. Rainfed areas with large areas currently under wastelands could be brought under vegetation cover by adopting agroforestry techniques. This paper, based on a study conducted in different parts of Karnataka State, India, deals with the tree species on the farm under different agroforestry models, farmers' tendency to take up either block plantations or agroforestry and the various models of tree planting followed under different situations.

The study was conducted by selecting two social forestry ranges from each of the 20 districts in Karnataka State; thus a total of 1407 farmers were selected for the study. Out of this 39% had taken up block plantations, 54% random planting (planting of trees without any regular spacing or pattern, wherever there is space on the farm) and 7% both.

The important models under agroforestry are block plantations, bund planting, hedge planting, row/inter cropping and stream/river bank planting. Under block plantation, species diversity is limited as *Eucalyptus* hybrids and *Casaurina equisetifolia* are the dominant species but under random planting models, in addition to these two species, other species like silver oak (*Grevillea robusta*), subabul (*Leucaena leucocephala*), and *Acacia auriculiformis* are also planted.

Yakihata-zorin (Taungya) reforestation method as practiced in northern Japan: a perspective of this method in the Sampoku region

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Keywords: Taungya, Yakihata-zorin, Red turnip, Reforestation, *Cryptomeria japonica*

The taungya method is usually defined as a reforestation method in which tree seedlings and agricultural crops are simultaneously planted at the initial stage of reforestation until the amount of crop harvest decreases due to crown closure. After that only the trees are left, with the final aim to establish man-made forests. The reforestation method 'yakihata-zorin' or 'yakihata-ringyo' in Japan is virtually the same as the taungya method and dates back to the early 1700s. Many of the present well established forestry areas, where mainly the timbers of sugi (*Cryptomeria japonica*) have been produced, have their origin in yakihata-zorin. This method, however, is not currently being practised except in Sampoku, located (38° 30'N, 139° 30' E) in Niigata Prefecture facing the Japan Sea, and most reforestation elsewhere now involves tree planting without crop cultivation. The present conditions of areas using the yakihata-zorin method in the Sampoku region are examined here.

The main reason why this method is still used in this area is that crop cultivation after burning in newly logged area has been specialized for red turnip (*Brassica campestris* var. *glabra*), which is then processed into pickles with the brand name of 'Atumi-kabu' which is highly regarded as a delicious and natural food. Due to the popularity of natural foods, the demand for turnip cultivated in the burnt areas of yakihata-zorin is great and the market price has been increasing. The yield of red turnip is about 10 tons ha^{-1}. Red turnip can sell at a price of 160 Yen kg^{-1} and this profit goes to the cultivator. Repeated cultivation (continuous cropping) of red turnip in the same area, however, is not usually practised because of replant failure and in the second year azuki bean (*Vigna angularis*) is cultivated: after this no further crops are grown. At present, seedlings of sugi are provided by landowners and wages for planting are paid. According to estimates, about 840,000 Yen (approximately U.S. $8,000) are needed, including insurance, annuities, etc., both for land preparation and planting seedlings in the first year. Planting density is 2,500 trees ha^{-1} and cost of seedlings (2 years nursery grown) is 99 Yen. When landowners permit cultivation of turnip they can save at least 400,000 Yen (approximately U.S. $3,600) in expenses for land preparation. The expenses for weeding (approximately 120,000 Yen) in the second year are also saved due to azuki been cultivation. These economies in expenditure are the landowner's profits. The reduced cost of land preparation and tending with a shortening of the weeding period is the main factor contributing to the continuation of this method. In addition, activity in the marketing of turnip by the Forest Cooperative in this village is also highly regarded. The yakihata-zorin method has potential for improvement of taungya in tropical countries, mainly in southeast Asia.

The suitability of the Shamba system to forest plantation establishment in Kiambu district, Kenya: an evaluation of socio-economic issues

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Keywords: Forest plantations, Shamba system, Socio-economics, Community participation

A socio-economic evaluation of the suitability of the shamba system in plantation establishment and improving the wellbeing of participating farmers was conducted in Kiambu district, Kenya. The study evaluated the development of the shamba system in Kenya through literature review and conducted evaluations of the current system through interviews with farmers using a questionnaire and interview with forest department (FD) officers using a prepared checklist.

The Kenya forest sector is characterised by the problem that the rate of forest estate clear fell does not match the rate of replanting, giving rise to backlogs in plantation establishment. Timely replanting of harvested plantation areas is a prerequisite to a sustainable plantation programme. Forest plantations are also facing increasing competition from other land-uses, mainly agriculture and settlements.

The FD has been establishing forest plantations using the shamba system since 1910. In its basic application, the shamba (shamba is a Kiswahili word for a small plot for cultivating crops) system can be considered as a temporal contact between a prospective farmer and the FD. The FD, as the owner of the land, is interested in the establishment of plantations at a low cost. It invites the farmer to assist in this process in exchange for allowing him/her to cultivate crops in the forest. The farmer clears the allocated forest area and cultivates subsistence crops for 18 months, after which the FD plants trees in the plot. The farmer takes care of the planted trees while cultivating crops for the next three years or until the tree canopy closes.

There have been changes in the management of the shamba system from its inception, including a period between 1987 and 1994 when the system was banned. These changes have had direct impacts in terms of delay in plantation establishment, as well as in the success and failure of these plantations.

The shamba system is critical to plantation establishment as shown by the consequences of backlogs in plantation establishment that followed its ban in 1987. It ensures low costs in plantation establishment and high survival of planted seedlings. The shamba system gives participating farmers high returns, in the range of US $1700 per hectare per year. It creates employment for farmers and ensures food security. Farmers valued shambas highly, stating that an empty shamba was worth US $61 and a shamba with crops US $1560. This means that farmers have economic motivation to own a shamba. However, it was also found that the methods used in shamba allocation are unfair and this can affect the commitment of farmers to forestry. Problems faced by farmers include: game damage, short periods of cultivation before trees are planted, lack of finances, poor roads and unstable market prices. The FD face the problem of damage of seedlings by farmers and management problems. The regulations in the shamba system are difficult to enforce without the farmer's participation.

The way forward for the shamba system is to consider it a form of Joint Forest Management (JFM), where the communities will get shamba and in return participate in forest protection. JFM allows establishment of joint management agreements that allow FD staff to redefine their relationship with the community and eventually to regain the trust and confidence of the villagers. The establishment of forest village committees in areas with shambas can act as a forum where the FD and farmers can discuss and solve various problems faced in the system before they get out of control. This will ensure a sustainable system of shamba, which will benefit the farmer and the FD.

The shamba system has a great potential to be developed as one form of JFM involving communities in forest management. Participation will ensure sustainability of forest plantations.

Agroforestry Systems and Their Bioeconomic productivity In North-Western Himalayan Region of India

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Keywords: Biological yield, Co-efficient of variation, Lowlands, Operational land holdings, System type, Uplands

Productivity appraisal studies were carried out on existing agroforestry systems (AFS) in two agroclimatic zones, namely subtropical sub montane low hills (up to 914 m a.s.l.) (zone 1) and subtemperate subhumid mid hills (915-1523 m a.s.l.) (zone 2) in the North Western Himalayan region of India. The purpose of the study was to identify the existing AFS and to determine their bio-economic productivity.

A three-stage random sampling technique was used to select the sample area in both zones. Based on the size of their operational land holdings, farmers were divided into four social groups: marginal (<1 ha land), small (1-2 ha), medium (2-5 ha) and large (>5 ha). In zone 1 the sample area was sub-divided into uplands and lowlands based on topography. AFS were classified based on their structure and function. However, stratified classification of agroforestry practices was used to indicate the system types and the system units. Biological yield was calculated based on the harvested biomass from each system type whereas net returns were estimated on the cost of cultivation. Co-efficient of variation (C.V.) values which could explain the stability or the extent of system sustainability were also calculated.

In zone 1, a total of five AFS types, namely agri-silviculture, agri-silvi-horticulture, pastoral-silviculture, pastoral-horti-silviculture and pastoral-silvi-horticulture were found in uplands. In the marginal group agri-silvi-horticulture was practised by about 90% of the households. Its mean biological yield per farm and net returns were 7.8 t and US $97, respectively. The C.V. values for biological yield and net returns were 86.7% and 143.8% respectively (n=21). In the small farmers group also, agri-silvi-horticulture gave the highest mean biological yield and net returns. There were only two AFS in the medium group: agri-silvi-horticulture and pastoral-silviculture, each having only one system unit. None of the households fell into the large category.

Lowlands had the same five AFS as present in uplands. Marginal group farmers practised all five, small group farmers four and medium group farmers only three system types. Agri-silvi-horticulture gave the maximum mean biological yield (15.3 t) and net returns (US $371) per farm in the marginal group. The C.V. values were 53 and 152% (n=11), respectively. This AFS dominated the yield and net returns in the small and medium groups too. Uplands and lowlands had three AFS types, agri-silviculture, agri-silvi-horticulture and pastoral-silviculture, in common among the different social groups of farmers. Co-efficients of variation for biological yield and net returns for these systems were more or less of equal magnitude although in lowlands the variation in net returns was higher.

In zone 2, seven AFS types were found: agri-silviculture, agri-horti-silviculture, agri-silvi-horticulture, pastoral-silviculture pastoral-silvi-horticulture, pastoral-horti-silviculture and agri-horticulture. Farmers in the marginal group practised all seven, and in the small group all except agri-horticulture. Farmers in the medium and large groups each practised only two, agri-horti-silviculture and pastoral-silviculture by the medium group and agri-silvi-horticulture and pastoral-silvi-horticulture by the large group. In the marginal group agri-silvi-horticulture gave the maximum mean biological yield (11.6 t) and net returns (US $535) per farm with C.V. values of 76 and 124% (n=19), respectively. In the small group also agri-horti-silviculture gave the maximum mean biological yield (19.5 t) and net returns (US $ 961) with C.V. values of 40 % (n=3) in each case. Other system types behaved similar to those above for their yield, net returns and variability in both of these parameters.

Agri-silvi-horticulture in zone 1 and agri-horti-silviculture in zone 2 were found to be the most productive system types although biological yield and net returns accrued from these presently were found to be little more unstable.

Effect of tree prunings as a source of nitrogen on a rice-wheat cropping sequence

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Keywords: Agroforestry, N uptake, Sustainable practices, Rice yield, Wheat yield

High fertilizer costs, decreasing soil organic matter, and an increased awareness that more sustainable production practices are needed have renewed interest in providing N for crops through agroforestry practices. This study was undertaken to quantify yield responses and the amount of N taken up by rice (*Oryza sativa* L.) and subsequent wheat (*Triticum aestivum* L.) crops from prunings of two perennial legume tree species (*Dalbergia sissoo* and *Albizia saman*). Rice and wheat crops were grown between hedgerows of trees in an alley cropping system on a medium high silt loam soil in Bangladesh. There were three treatments for upland rice, two of which had tree prunings from either *D. sissoo* or *A. saman* equivalent to 80 kg N ha^{-1} along with 20 kg N ha^{-1} from ^{15}N-labelled ammonium sulphate (10% a.e.) and the remaining treatment having no tree prunings but supplied with 100kg N ha^{-1} through ^{15}N-labelled ammonium sulphate (1% a.e.). Straw and grain yields and yield components were measured for the rice crop and the fraction of ^{15}N accumulated by the crop was determined. Wheat was then grown in the same plots during the rabi season to determine the residual effects of the ^{15}N fertilizer and tree prunings. In this case, the treatments which received tree prunings during the rice crop were fertilized with non-labelled N fertilizer at 75 kg N ha^{-1} while the treatment without tree prunings received 100 kg N ha^{-1}. The effect of any residual N contribution from tree prunings on wheat was estimated by comparing the values in treatments with and without tree prunings in the previous rice crop.

Yield of both grain (max. 4.39 t ha^{-1}) and straw (max. 6.72 t ha^{-1}) were significantly improved by the application of tree prunings, with the effect on both grain and straw being more pronounced for *A. saman* (42% higher for grain and 23% for straw) than *D. sissoo* (35% higher for grain and 17% for straw). Application of leaf litter substantially increased N uptake (61-92 kg ha^{-1}) of the rice crop by 42-50%. Fertilizer N recovery in rice was low, being 17 to 19% while the N contribution from leaf litter to rice yield was 49-55%. Residual effects on the wheat crop were not significant, although yields were increased where prunings had been applied to the previous rice crop even though less fertilizer N (75 kg ha^{-1}) was applied compared to plots receiving the full dose of N (100 kg ha^{-1}). Both the content and uptake (89-110 kg ha^{-1}) of N in wheat were also substantially higher in leaf litter treated plots. Residual ^{15}N in wheat was low (2.1-2.5% in pruning treated plots and 5.2% in untreated plots) but followed the trend of that in rice. The residual N contribution of tree prunings to wheat yield ranged from 19 to 24%. Incorporation of legume tree clippings increased total N and organic C content in soil determined at harvest of both crops.

It was concluded that N and organic matter applied through the tree prunings improved soil conditions and resulted in higher production of both rice and wheat. Therefore, applying tree prunings from *A. saman* and *D. sissoo* are recommended for soil enrichment and sustained productivity.

Biomass studies on Populus deltoides Marsh under different land use systems

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Keywords: *Populus deltoides*, Biomass, Land use

The present investigations were carried out in the two experimental areas of the Department of Silviculture and Agroforestry of Solan district of Himachal Pradesh (India), which lies between 30°50′ N latitude and 70°11′E longitude. The objective was to evaluate and compare the growth and biomass production of *Populus deltoides* Marsh under different land use systems. The experimental areas, located at an elevation of 1200 m above mean sea level, embody moist sub-temperate climate and are characterised by undulating topography with similar climatic and edaphic conditions. The study was undertaken in agri-silvicultural and silvopastoral systems consisting of 15-year-old pure even-aged plantations of *Populus deltoides* at a spacing of 4 m x 5 m with three replications.

The biomass production of *Populus deltoides* Marsh was greater in the agri-silvicultural system (75.2 t ha^{-1}) than in the silvopastoral system (47.4 t ha^{-1}) under a similar set of environmental conditions. Diameter at breast height under the agri-silvicultural and silvopastoral systems varied from 22 to 28 cm and 12 to 19 cm respectively.

Height ranged from 20.4 to 23.9 m in the agri-silvicultural system compared with 13.8 to 15.1 m in the silvopastoral system.

Specific gravity, which greatly influences the yield and quality of wood products, although strongly controlled by genotype, varied considerably within in the two systems. Also it varied from trees of lower diameter class to higher diameter class and with the location of wood within the tree, i.e. from the base to the top. On average, specific gravity varied from 0.420 to 0.436 in the agri-silvicultural system and 0.404 to 0.410 in the silvopastoral system.

Such differences in growth parameters are the manifestations of the type of land use and thereby the management practices traditionally followed in them. In the agri-silvicultural system, wheat (*Triticum aestivum*) and tuberous crops (*Zingiber officinale* - ginger, *Curcuma longa* - turmeric and *Colocasia esculenta*) were raised and thus standard tillage practices along with application of irrigation and fertilizer were followed, whereas in the silvopastoral system, natural grasses viz. *Chrysopogon montanus*, *C. gryllus*, *Heteropogon contortus* and *Themeda anathera* grew between the trees and were not given inputs in the form of fertilizer and irrigation. The grasses were harvested every year during October - November. Thus, the trees showed better performance with agri-silvicultural land use compared to silvopastoral land use.

Data on nutrient content of leaf tissue of *P. deltoides* indicated that N, P and K contents were higher in larger diameter classes of tree in the agri-silvicultural system, while in the silvopastoral system the reverse pattern occurred (except for K), but there was no consistent variation in concentration with an increase in diameter. Considering the biomass production potential it is concluded that for poplar grown in similar edapho-climatic conditions, the agri-silvicultural system is a more viable proposition than the silvopastoral land use system.

Canopy management impact on root characteristics, water use efficiency, photosynthesis and biomass production potential in agroforestry tree species

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Keywords: Coppicing, Foliage and branchwood biomass, Pollarding, Resource capture, Yield advantage

In agroforestry systems, trees are grown in close proximity to crops and pastures. Trees and crops compete with each other for critical resources. The reasons why certain trees and crops are compatible while others are not need to be understood clearly. Substantial and reliable information is required before biomass production/yield advantage can be improved. Canopy architecture is an important character which influences resource capturing and sharing. The objective of the present investigation was to underline the impacts of canopy management practices like coppicing and pollarding on root characteristics, water use efficiency (WUE), photosynthetic rates and foliage and branchwood production in important agroforestry trees of the temperate region.

Coppicing (to 0.5 m height) and pollarding (to 1.0, 1.5 and 2.0 m) treatments were imposed on four-year-old plants of *Grewia optiva*, *Celtis australis*, *Bauhinia variegata* and *Morus alba* M-5 (2666 stumps ha^{-1}) planted at spacing of 1.5 m (plant to plant) x 2.5 m (row to row). Stump height was maintained at the same level by removing new shoots every year. Observations were made three years after imposing treatments.

During the present investigation, coppicing and pollarding significantly affected the number of lateral roots. Pollarded plants of *M. alba*, *G. optiva* and *C. australis* produced a significantly higher number of roots than *B. variegata*. Diameter growth of proximal and lateral roots was higher in pollarded than coppiced plants. In *M. alba* and *G. optiva*, 66-84% of the total roots were found distributed in the 90° quadrant between east and north.

Irrespective of cutting height, higher WUE was observed in *M.. alba* and *G. optiva* as compared to *C. australis* and *B. variegata* under similar growing conditions. WUE was comparatively higher from May to August in all four species. A close relationship between WUE and total biomass production indicated that even if WUE *per se* was less for all the trees, the available water was used economically for growth processes associated with the production of biomass.

The biomass production potential of tree species, indeed, depends on the ability to maintain higher photosynthetic rates. The data indicated that higher photosynthetic rates from May to August in *M. alba*, *G. optiva* and *B. variegata* resulted in higher total biomass production (t ha $^{-1}$) in these tree species.

Coppicing and pollarding significantly affected foliage as well as branchwood biomass production in all four species, with a maximum total biomass (12 t ha $^{-1}$) in *M. alba* followed by *G. optiva* (8 t ha $^{-1}$) pollarded at 2.0 m. Pollarding at 2.0 m cutting height is recommended as the best canopy management practice for producing higher total biomass in *M. alba* and *G. optiva* under rainfed conditions. The lower total biomass in *C. australis* is probably the result of inability of this tree species to withstand coppicing and pollarding over successive years.

Evaluating N-fixing Living Stakes for Organic Tomato (Lycopersicon esculentum) Production in Costa Rica

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Keywords: Biomass, Diseases, *Erythrina poeppigiana*, *Gliricidia sepium*, Nutrient concentration, Yield

Conventional tomato production on hillside farms in Costa Rica is costly to farmers and to human and ecosystem health. This cost could be reduced with the incorporation of soil improving leguminous shrubs into tomato farms and the concomitant reduction in use of agrochemicals, the main cost factor. Additionally, the output of tomato with an organic label is likely to appeal to health conscious consumers. A study was initiated in 1998 to evaluate two common N-fixing tree species as living stakes for tomato produced without applications of mineral fertilisers and insecticides, in an alley-crop arrangement of shrub and crop components. *Erythrina poeppigiana* seemed to influence a more favourable environment for higher foliar biomass and fruit yield in tomato than *Gliricidia sepium*. Tomato diseases which attacked in tandem were differentially favoured by the leguminous species. Growing tomato plants in *Gliricidia* plots had higher mortality from infection with *Pseudomonas solanacaerum* than in *Erythrina* plots. Fruiting tomato plants suffered higher fruit loss and plant mortality rates from infection with *Phytophthora infestans* in *Erythrina* plots than in *Gliricidia* plots. Support age and by implication the shading effect influenced the severity of *Phytophthora* infection. Tomato staked to eight-year-old *Erythrina*, compared to two-year-old stakes, were more affected by this disease. The mitigation of the favourable microclimatic conditions for *Phytophthora* and the reduction of competition for light is considered to be the most efficient approach, in order to optimise the crop production in an organic management system. Thus, a study was initiated in 1999 to evaluate the shoot pruning management of the leguminous living stakes with the specific aim to re-evaluate the variables mentioned above and to quantify the concomitant below-ground effects of shoot pruning of the two woody species. This study is currently supported by the International Foundation for Science. The biophysical interaction of two common leguminous species for organic tomato production in an agroforestry arrangement in the humid tropics is discussed.

Intercropping Trials in Bamboo Plantations

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Keywords: Bamboo plantations, *Bambusa bambos*, Intercropping, Pigeon pea, Growth, Yield, Land equivalent ratio (LER), Economics, Litter production, Nutrient return

Agroforestry is the practice of agriculture and forestry on the same piece of land. Bamboo (*Bambusa bambos*) is a household species and is the best friend of the farmers. The present crisis in sustained availability of bamboo can be resolved only by raising elaborate bamboo plantations. In India normally bamboo plantations are grown at a spacing of 6 x 6 m to meet the increasing demand for bamboo products. Research has increased rapidly in recent years to cultivate agricultural crops in the interspaces of bamboo plantations. This paper presents the results of intercropping trials with pigeon pea (*Cajanus cajan)* in bamboo plantations. The sampling area (4 ha) was a five-year-old plantation of pure bamboo. Throughout this area, bamboo culms in their fourth and fifth years were harvested. Pruning was done of the remaining culms. One ha of this plantation was kept as a control. In the other three ha, bamboo was intercropped with pigeon pea (ICPL-88034) with 1:1 rows. In another trial sole pigeon pea was cultivated. The density of pigeon pea was 278 plants ha^{-1} and the grain yield obtained was 600 kg ha^{-1} (intercropped stand) and 700 kg ha^{-1} (pure stand). For bamboo, an average of 11 culms were produced in the intercropped stand compared with 19 culms in pure stands. The profitability of pure bamboo stands would be in the order of Rs. 24,900 (US $600), whereas the profitability of the intercropped bamboo stand would be in the order of Rs. 21,800 (US $510), which is slightly lower due to underground competition for nutrients and water in the intercropped stand. The profit obtained from the intercropped agricultural crop is Rs. 7,900 (US $190), whereas the net income from the pure pigeon pea crop is Rs. 13,000 (US $300).

The land equivalent ratio (LER) of bamboo producing culms (dry weight) with a pigeon pea intercrop showed:

Sole pigeon pea	Sole bamboo	Intercropping
0.7 t ha^{-1}	2.2 t ha^{-1}	0.6 t ha^{-1} grain + 0.9 t ha^{-1} culms

The land equivalent ratio of the system =

$$\frac{0.6}{0.7} + \frac{0.9}{2.2} = 1.2$$

This means that the productivity of 1 ha under intercropping is equivalent to that of 1.2 ha under the sole system. The bamboo plantations intercropped with pigeon pea produced a higher quantity of litter than pure bamboo stands. Litter fall followed a bimodal pattern with a principal peak in the winter and another in the late summer. Of the total annual litter production, leaf litter accounted for 58% and twig litter 42%. The annual litter production was 13.5 t ha^{-1} in the pure bamboo stand and 15.7 t ha^{-1} in the intercropped stand. With regard to nutrients, the highest concentration of N, P, Ca and Mg was in leaf litter. In twig litter, the maximum concentration of K was observed. On an annual basis 89, 6, 78, 42 and 49 kg ha^{-1} (pure bamboo stand) and 113, 9, 106, 52 and 60 kg ha^{-1} (intercropped stand) of N, P, K, Ca and Mg respectively was returned through leaf litter. The results from these studies can be used as a guideline for improvement of productivity in agroforestry models.

Economic Evaluation of Tea Based Agroforestry

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Keywords: Economic evaluation; Tea-based agroforestry; Linear programming; Returns-over-variable-cost; Employment generation

The present paper analyses the economics of tea-based agroforestry systems in the tea-growing pockets of Kangra and Mandi districts of Himachal Pradesh (India). Himachal tea, commercially famous as *Kangra Tea*, is known for its strong flavour and is often in demand for blending with Assam tea. The study was based on survey information obtained from 34 randomly selected agroforesters, spread over 12 villages in the Palampur tea-growing region of the state.

Tea productivity of the area is substantially lower than that of other tea-growing areas in the country. The reasons for this are the geographically distant and infrastructurally underdeveloped area, distant markets, lack of trained labour and legal restrictions on changing the land use pattern of the tea gardens. Forest tree harvesting rules also contribute towards this, as at times harmful shade trees like *Pinus roxburghii* cannot be easily removed from the gardens. The surveyed farmers, on average, had a large number of trees (226) in tea gardens, pasture lands (189) and on the bunds of agricultural holdings (30).

The linear programming technique was used for formal analysis of the data. The existing agroforestry system on the sample farms was compared with two variants, one involving the re-allocation of existing resources under existing technology (Plan-I), and the second incorporating the use of technology recommended by the local agricultural extension institutions (Plan-II). The systems were analysed in terms of their different components (real activities) like forest trees, tea gardens, pasture lands, livestock and agricultural crops. The model thus consisted of 39 real activities and 34 constraints. The economic advantage of a system was measured in terms of the net returns-over-variable-cost.

Under the existing management pattern, the average sample farm generated US$ 4232.02 per annum, of which the contribution of tea was nearly 86%. Tea was followed by forest trees, which had a contribution of about 5%. Under Plan-I, there was a significant change in the suggested physical levels of various real activities. The Plan-I activity levels, however, did not change in Plan-II. However, use of recommended technology under Plan-II improved returns over variable cost considerably. Plan-I suggested significant change in the composition of forest trees, with *Grewia optiva* (an excellent fodder tree) on field bunds and 238 trees of *Albizia chinensis* (a good shade tree) in tea gardens. Returns-over-variable-cost increased by 48.54% in Plan-II as compared to the returns-over-variable-cost under the existing management plan and 40.64% as compared to Plan-I. Similarly, employment generation potential under Plan-II increased by 36.91% over Plan-I and 46.14% over the existing farm management pattern. All this was linked to the additional capital requirement of US$ 95.04 per farm under Plan-I and US$ 594.31 for the shift from Plan-I to Plan-II.

The study revealed that the use of improved technology can improve the profitability and employment generation capacity of existing tea-based agroforestry systems. Thus efforts to build farmers' confidence through various incentives can go a long way in improving the health of tea-based farming systems in the region.

Product Quality Affected by Associated Plants in Agroforestry: Case Studies with Coffee and Timber from Costa Rica

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Keywords: Agroforestry, Aroma, Bean size, Coffee, *Cordia alliodora*, Costa Rica, *Erythrina*, Tasting, Timber

The evaluation of agroforestry associations has traditionally focussed primarily on the quantities of the crops and trees produced. Quality attributes, of increasing importance for emerging specialty markets such as gourmet coffee, have generally been neglected. In this paper, the possible effects of agroforestry associations on the quality of products are reviewed and illustrated with studies on the quality of coffee and timber from plants grown in agroforestry associations or in pure plantations.

In low-elevation, sub-optimal environments for coffee in Costa Rica, increasing shade intensity from 0% to more than 80% under unpruned shade trees (*Erythrina poeppigiana)* increased bean size of *Coffea arabica* significantly. While the large beans (diameter > 17/64ths of an inch (6.75 mm)) accounted for 49 and 43% of the coffee from sun-grown Caturra and Catimor, respectively, these proportions increased to 69 and 72% under dense permanent shade. Blind tasting experiments showed consistent shade-induced improvements in appearance of green and roasted coffee as well as in acidity and body of the brew. The higher quality under shade demonstrated the power of tree facilitation under sub-optimal low-elevation conditions.

Preliminary results on timber quality of 12-year-old *Cordia alliodora*, a high-value timber species from Costa Rica, showed increased cracking of centerpiece boards and significantly reduced branchless bole lengths from the trees that grew fastest. These were the trees grown in agroforestry associations where they benefitted from weeding and fertilization of the associated crops. Pure plantation timber had less defects. Detailed information on structural and stability attributes of the timber will be available by the end of 1999. The study of quality aspects and determinant environmental controls deserves increasing attention in the future.

Root and Water Dynamics in a Water-limited Agroforestry System

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Keywords: *Senna spectabilis*, Maize, Bean, Roots, Soil moisture

Investigations were conducted on a water-limited sandy-loam soil in Machakos, Kenya with *Senna spectabilis* (DC.) Irwin & Barneby (senna) grown as a standard tree or a hedge (pruned to 0.5 m) and planted as single rows in combination with *Zea mays* L. (maize) in April to July 1997 and *Phaseolus vulgaris* L. (beans) from October 1997 to January 1998. The effects of shoot pruning of senna on root turnover and soil moisture distribution were investigated. Soil moisture between 35 and 175 cm depth was monitored weekly using a Wallingford neutron probe. Soil moisture characteristics were determined using the filter paper method. Root sampling in the top 50 cm soil horizon was done at three time scales: every 14 days using minirhizotron tubes in conjunction with photography, every 30 days using coring and every 150 days using trenching.

Trenching was the most destructive method, but it yielded the most continuous spatial information for senna root distribution, whereas coring and minirhizotrons were prone to discontinuity and random differences due to sampling from discrete locations. Senna root presence over time in the two dimensional plane from minirhizotrons was poorly related to that in three-dimensional soil volumes from coring, possibly because measurements were started too soon after installation of the minirhizotrons. Nevertheless, the ability of minirhizotrons to detect root turnover over a short time scale is strongly supported by the self-explanatory nature of data they generated. This could not be observed from coring alone.

If minirhizotrons are to be used on their own, they are best suited for qualitative studies such as diagnosis of pathogenic activity or abnormal growth in roots, but not for quantitative root demography. Coring provided the best compromise, yielding reasonably quantitative information on spatial root distribution at a reasonable sampling frequency.

Maize and bean root length density were greatest in regions with low senna root length density and were higher in the hedge system than in the standard tree treatment. The synchrony of tree standard and hedge root dynamics observed from minirhizotrons implied that root death and growth were driven more by below-ground conditions than by the stage of development of the crown structures. Contrary to what others have observed, root turnover was lower in the pruned system. Root quantities estimated from trenching were similar in both senna treatments in February and September, 1997, showing that by the end of the dry season, pruning effects had been overtaken by the effects of limitation in water availability. Total root length density was poorly correlated with soil moisture, especially when soil water potentials were higher than -100 kPa because the drying effect of roots was quickly neutralised by equilibration of water within the soil matrix.

Architectural Variation in Tree Roots of Populus Deltoides Planted Under an Agrisilviculture System

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Keywords: Biomass, Root distribution, Fine roots, Coarse roots, *Populus deltoides*, Agroforestry system

Agroforestry involves matching trees and crops so that they complement one another and share the available resources effectively in order to attain maximum productivity. A knowledge of biomass production and the distribution of root systems therefore has considerable practical value. Above-ground and below-ground biomass production and the distribution of coarse and fine roots were studied in 9-year-old *Populus deltoides*. The roots were excavated by the skeleton method (dry excavation), digging along the course followed by the roots in the soil mass. An area of about 4 m radius around each tree was excavated up to 1.3 m depth. The roots were classified into fine (<2 mm) and coarse (>2 mm) roots. Tree densities were 2250, 531 and 208 per hectare in stands of 2 m x 2 m, 4 m x 4 m and 6 m x 6 m spacing, respectively. The total biomass (both above- and below- ground) varied from 71.50 tons ha^{-1} to 251.50 tons ha^{-1}, depending on tree density. Among the different tree components, stemwood contributed the maximum biomass (66.3-71.3 %), the biomass was in the order of stem > root > branches > leaves.

Patterns of root distribution showed that most of the coarse roots were distributed in the top 30 cm of soil, whereas fine roots were concentrated in the top 15 cm. Coarse root biomass decreased with an increase in spacing from 29.8 tons ha^{-1} in the stand of 2 m x 2 m to 5.6 tons ha^{-1} in the stand of 6 x 6 m. In contrast fine root biomass increased significantly (P>0.05) from 13.8 to 23.0 tons ha^{-1} in the stands of 2 m x 2 m and 6 m x 6 m, respectively. No significant difference was observed in the horizontal distribution of fine roots at different distances from the tree rows at a particular depth in any of the stands. Total below-ground biomass was equal in the stands of 4 m x 4 m and 6 m x 6 m, although the former had twice as much above-ground biomass as the latter. The shoot:root ratio decreased with an increase in spacing. The study indicates that the bulk of the roots of poplar are found near the surface, and hence there may be root competition with agricultural crops. The architectural variation data reveals that the general notion that under agroforestry system tree roots go deep and do not compete with crops is refuted at least in the case of *P. deltoides*-based agrisilviculture systems.

Evaluation and species selection for efficient agroforestry systems in central dry zone of Karnataka, India

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Keywords: Agroforestry systems, Light interception, Dryland, Central dry zone, Finger millet, Spacing trials

A study in tree species selection for efficient agroforestry systems was conducted in the sixth year of an ongoing agroforestry trial at the Zonal Research Station, Tiptur, in Karnataka State of India under rainfed conditions with a mean annual rainfall of 585 mm. The trial included nine treatment combinations of three fruit tree species (jack (*Artocarpus heterophyllus*), mango (*Mangifera indica*) and tamarind (*Tamarindus indica*)) at three spacings (8 x 8 m, 12 x 8 m and 16 x 8 m) with finger millet (*Elusine coracana L.* Gaertn.) grown between the trees during the rainy season. There was also a control treatment with finger millet grown without trees. The plot size for each treatment including the control was 48 x 24 m. The experiment was laid out in a randomized block design with two replications. The soil was red sandy loam in texture, slightly acidic in reaction (pH 6.5) and medium in available nitrogen (329 kg ha^{-1}), phosphorus (32.5 kg ha^{-1}) and potassium (425 kg ha^{-1}). Observations were made of tree growth, light intercepted by trees and crop and yield of finger millet at different distances from the trees. Data were analysed using analysis of variance.

Jack trees had significantly larger height (5.73 m), collar diameter (18.19 cm) and crown width (4.74 m) than mango (2.36 m, 11.7 cm and 3.04 m respectively) and tamarind (4.4 m, 11.64 cm and 3.59 m respectively). Diameter at breast height was significantly higher in jack (15.52 cm) than tamarind (11.08 cm), while that of mango could not be recorded as it had branches from the base of the tree. Jack intercepted more light (38.3%) compared with mango (23.4%) and tamarind (22%). Jack intercepted light up to 4 m from the tree compared with only 2 m in the case of mango and tamarind. Closer spacing of 8 x 8 m greatly reduced the availability of light to finger millet compared to wider spacing due to more canopy area of trees, as the number of trees were more in 8 x 8m spacing (156 trees ha^{-1}) compared to 12 x 8 m (104 trees ha^{-1}) and 16 x 8 m spacing (78 trees ha^{-1}). The grain and straw yield of finger millet were reduced in agroforestry compared to control. The reduction was more in plots grown with jack and at closer spacing. Significant reduction in yield was observed up to 2 m from trees in all the species (over 40% in jack, 28% in mango and 18% in tamarind). However, at distances of 4-6 m and 6-8 m there were higher grain yields than in the control in both mango- and tamarind-based agroforestry systems. Considering the total economics of the system as a whole, mango and tamarind species are better suited to agroforestry involving finger millet.

Insect pests and their impacts on forest Agroforest trees in the Western Himalayas

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Keywords: *Diorhabda lusca*, *Ectropis deodarae*, *Dioryctria abietella*, *Curculio sikkimensis*, *Hypsipyla robusta*, *Apriona cinerea*

The incidence, extent of damage and impact of insect pests was studied in the last few years on some economically important forest and agroforest trees in the Western Himalayan region of India. Among the coleopterans, *Diorhabda lusca* Maulik was recorded as a serious pest of *Celtis australis*, a common summer fodder tree that grows naturally in the traditional agro-ecosystems of the middle and lower Himalayan region. Impact evaluation studies on the pest carried out during 1990-91 revealed that three larval instars and adult beetles caused 15.9, 37.5, 67.0 and 71.6% defoliation of the trees, respectively. The overall average foliage damage during May, June, July and August was recorded to be 34.9, 46.6, 50.7 and 53.6%, respectively. Similar damage symptoms were inflicted by other chrysomelid beetles like *Chrysomela populi* Linn. and *Plagiodera versicolora* Laich. on Populus and Salix foliage.

The bioecology of *Curculio sikkimensis* Heller, a pest of oak (*Quercus leucotrichophora*) acorns, was studied during 1996-97. The maximum infestation (81.6%) was observed at Kandaghat as compared to two other sites, one each at lower and higher elevation. The infested acorns did not germinate as the pest ate away the endosperm. Thus, natural regeneration was adversely affected as a result of pest attack. Shrinking of oak forests in the western Himalayan region in recent years can be attributed to pest attack besides over-exploitation of the species by the increasing population. The poplar stem borer, *Apriona cinerea*

Chever., is a serious pest of poplar (*Populus deltoides*) trees in the region. It is a well established pest in the Kashmir valley and also attacked poplar trees in Himachal Pradesh and the Tarai area of Uttar Pradesh where poplars are grown in social forestry and agroforestry plantations. Young trees (2-5 years old) are more prone to attack and 25% mortality of such trees occurs due to stem borers in establishing plantations.

Lepidopteran pests were the other important group infesting various tree species. In the deodar (*Cedrus deodara*) forests in Himachal Pradesh, *Ectropis deodarae* Prout appeared in epidemic form in the beginning of the 1990s. It caused complete defoliation of the trees in several localities, as a result of which the affected forest looked brown towards the end of June. The affected trees in such forests were found to show die-back symptoms. *Dioryctria abietella* Denis and Schiff. is another serious pest of all the conifers in this region. In addition to acting as a shoot borer, it is a serious pest of cones and seeds. Variable damage to cones of different conifers was recorded in 1992 and 1993 during June and August with respect to different crown levels of trees and locational aspects. The lower crown and southern aspect had higher levels of cone infestation as compared to the top and middle crown and northern aspect. However, in the case of chilgoza pine, *Pinus gerardiana*, cone infestation was higher in the middle crown as compared to the bottom and top levels. Seed infestation averaged 69.6, 26.3, 3.2, 62.3 and 16.9% in chilgoza pine, blue pine (*P. wallichiana*), chir pine (*P. roxburghii*), *Cedrus deodara* and spruce *(Picea smithiana*), respectively. *Hypsipyla robusta* Moore is a serious pest of Toona ciliata which caused very high shoot (62.5%) and sapling (93.3%) damage during 1994-95 in 2-3 m tall trees. The pest also caused as much as 44.4% fruit infestation and adversely affected seed germination by up to 20%. Infestation also resulted in deformation of apical growth and development of stag-headed, forked and crooked, branched boles unsuitable for timber, besides affecting natural regeneration by affecting seed germination. The poplar shoot borer, *Eucosma glaciata* Meyrick also caused similar type of damage on *poplar (Populus ciliata*) seedlings and saplings.

PART 4:

Posters displayed in task force sessions

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Reactions of changed water and nutrient supply on a forest ecosystem

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The effects of environmental parameters on individual reactions in forest ecosystems can be best investigated under laboratory conditions. Here it is possible to modify single factors while other variables are kept constant. However, the transfer of the results thus obtained to the ecosystem, is problematic. The roof project in Solling, FRG is a long-term experiment, where the impact of manipulated enviromental conditons can be observed for all compartments of a forest ecosystem. With this interdisciplinary experiment the important question should be answered, wether a strongly reduced acid and nitrogen input can improve the health of forest ecosystems.

The experimental site is a 60-year-old Norway spruce stand in the Solling mountains (51°46',09"N;9°34' 52" E), about 500 m above sea level, characterized by a cool humid climate and a high input of SO_2-pollution during winter months. The large scale experiment concentrates on two basic environmental changes, which were simulated by quantitative and qualitative manipulation of element inputs. The effects of an improved immission quality which can be expected as a result of implementation of air protection measures, were investigated in a de-acidification experiment („clean rain experiment“). The effects of long periods of drought phases were tested in a drying out experiment. Three transparent roofs of 300 m^2 each were constructed under the canopy of the 25 m high Norway spruce stand. In order to carry out the measurements in the crown area, a crane 30 m high was installed in the center of the roofed area. With this method regular physiological measurements of the carbon budget (photosynthesis, respiration) and the water budget (transpiration, xylem water potential, osmotic potential) as well as the shoot elongation were carried out. In addition each year needle samples were taken for element analyses and also an assessment of the condition by visual observation of the needle losses and needle chlorosis. The radial growth of the trees was determined at monthly resolutions by permanently fixed circumference measuring bands around the trees. The numerous, different results after 8 years show, that there are clear reactions of the trees in terms of vitality, nutrient supply, growth and physiological processes that underline the necessity of a persistent enviroment policy.

Ecological imperatives and remote sensing of rural tree decline in Australia

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'*Eucalypt* dieback' is the term used to describe the progressive dying of tree canopies. Possible causal agents include insects, pathogens, drought and changes in the properties of soil or groundwater. Rural dieback is a dramatic manifestation of tree decline, and is characterised by a widespread, relatively recent upsurge of premature dieback and death of trees on farm.

The main contributor to the dieback problem may have been the impact of human settlement and resulting numerous changes in the ecosystem. *Eucalypt*s affected by dieback are indigenous to the area and dieback seems to be more widespread where livestock grazing is a major activity. The nutrient enrichment caused by the redistribution of nutrients by livestock may be a key factor contributing to the abundance of defoliating insects, and hence rural dieback, in remnants of woodland used by livestock.

Eucalypt dieback is not restricted to native woodland alone in Australia. It now represents a serious threat to the conservation of important commercial *eucalypt* forests of eastern and western Australia. The control of the problem provides benefits through environment conservation and ecological restoration.

The problem of *eucalypt* dieback has been a major concern of botanists and other scientists in various parts of Australia although there has been very little research done since 1990. Ecological research no doubt has an important role in the long term for the enhancement of healthy vegetation in rural Australia to reverse the problem of land clearance. Meanwhile, *eucalypt* dieback and the resultant decline of native woodland in rural areas create more atmospheric carbon (CO2), and the spread of dieback has caused some greenhouse concern.

Land uses change and forestry contributes roughly 23 percent of the greenhouse emissions in Australia. Forests absorb carbon dioxide while dead trees slowly give off vast amounts of carbon dioxide as they decay, so fewer forest means more greenhouse gases. Australia's future efforts in reducing greenhouse emission levels largely depend on the health of its forest cover. Conversely, the spread of dieback may speed up the rate of land clearance.

If Australia's emission reduction and sink enhancement programs were to reach an internationally credible standard, data on Australia's carbon pools will have to be verified by satellite monitoring and audited by on-ground sampling procedures. This form of carbon accounting, which has been adopted by Intergovernmental Panel on Climate Change (IPCC), will enable Australia to benefit from full 'carbon value' of its sink development initiatives.

In the above atmosphere, a research was undertaken with the aims of: (a) identifying without-leaf cover biomass affected by dieback in Australian forests and woodland using satellite sensors; (b) verifying data on dieback on the net carbon pools by satellite monitoring; (c) estimating decay rates and the effect of dieback on the net carbon change for greenhouse modelling and (d) suggesting conservation and ecological restoration of remnants affected by dieback.

The research includes a scoping study and an expert analysis and estimates of regional dieback, a survey of the affected regions according to agro ecological zones, and case studies of affected woodland and forest areas quantified according to the area of occurrence.

Dieback is an important component in the decay and dead wood component in the greenhouse model. As the effect of dieback on the emission level is measured, the results indicate whether the CO2 is increasing due to dieback (decay), or decreasing as a result of regeneration (recovery). The research highlights the declining condition of fragmented vegetation in rural areas and forest environments, and the increasing emission levels of atmospheric carbon from premature death of trees and associated clearing.

Indicators of nitrogen status nitrate leaching and effects of deposition in European forests

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The paper will synthesize the analysis of several regional and European wide data sets on N cycling in forests. In a database on nitrogen (N) input, cycling and leaching compiled from more than 75 temperate forest ecosystems in Europe, N concentration in vegetation and forest floor compartments increased with increasing input. At c. 60% of the included sites nitrate leaching was above 5 kg N/ha/yr. There were, however, a considerable spread in the N retention. Sites at relative low deposition leached all inputs whereas some sites at high deposition still retained a considerable fraction of the input. It appeared that for conifers N concentration in needles, N flux in throughfall + litterfall and forest floor C/N ratio were good indicators of N status and were correlated with nitrate leaching. Especially C/N ratio of the forest floor was strongly related to nitrate leaching. At C/N ratios below 25 all sites leached considerable amounts of nitrate and at C/N ratios above 30 no sites leached.

In the paper these findings will be explored and validated in other independent regional datasets as well as in the extensive database from the European Level II (ICP-Forest) monitoring program covering more than 200 sites.

Dendroclimatic Analysis of Tree-Ring Width, Tracheid Dimension and Wood Density Variations in Conifers Along the Regional Temperature Gradient (the Enisey Meridian

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Keywords: conifers; tree-ring cell structure; wood density; climatic changes

The analysis of climatic factors influence on tree ring width, radial tracheids sizes and wood density variability of different conifers (*Larix gmelinii (Rupr.) Rupr.*, *Larix sibirica Ledeb*, *Picea obovata Ledeb*, *Pinus sylvestrys L.*) from the forest-tundra zone, from the northern and the middle taiga was made. It is shown what kind of information about environmental conditions is contained in variations of different tree ring parameters and how response of tree rings on environmental changes depends on local conditions of tree growth.

Temperature regime of a growing season (especially, of it's beginning) is the main factor that defines tree ring structure. Different characteristics of tree rings are connected with temperature of different intervals of a growing season. For example, cell sizes correlate with temperature of 2-3 pentads of the beginning of a season and maximum latewood density correlates significantly with temperature of almost the whole season. In the northern taiga tree ring width is influenced by June temperature (the beginning of growing season) and May precipitation (negative correlation).

Dendroclimatic analysis of chronologies obtained for the middle taiga show that different species accumulate in variations of tree ring parameters information about different climatic changes (temperature regime of the beginning of a growing season is important for larch and spruce growth and winter precipitation - for pine tree ring growth).

Different tree ring characteristics of one species accumulate information about conditions of different intervals of a year (for example, June temperature is very important for tree ring width of spruce, June-July temperature - for minimum density and May-June temperature and August precipitation - for maximum density).

Trees of one species from different sites (different local conditions) have different response on climatic changes. For example, the cambium of larch trees from the sites on south exposition slope initiates earlier (up to 10 days) than those of trees from the sites on north exposition slope.

The same parameter of tree ring of different species from the same site in the middle taiga records temperature variations of different intervals of a growing season. Temperature from May, 30 till June, 18 is important for larch, from June, 9 till July, 3 - for spruce, and from June, 24 till July, 3 (the latest interval) - for pine tree ring growth.

The results obtained clearly show that along the gradient of temperature the role of temperature regime become less important for tree growth but the influence of precipitation increases. In the middle taiga (the region where the role of the main limiting factor general for the whole region is not so important as for the forest-tundra zone) variations of tree ring characteristics depends on local environmental factors to a great extent.

Desertification Disaster Assessment and Combating Strategies in China

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In light of the definition and criteria of the UN Convention to Combat Desertification, the scope of arid, semi-arid and dry sub-humid areas (i.e. dryland) in China is approximately 3.32 million sq.km, occupying 34.6% of the total land territory of China, which is widely distributed in 471 counties of 18 provinces, municipalities and autonomous regions of whole China. Of which, the total area of the dry sub-humid area is 0.75 million sq. km. occupying 7.8% of the total land territory of China; the total area of semi-arid area is 1.14 million sq. km. covering 11.9% of total China's land territory; and the area of arid area is 1.43 million sq. km. consisting of 14.9% of China's total land territory. At present, desertification affected areas are mainly distributed in arid, semi- arid and dry sub-humid areas in the west part of the Northeast China, the northern part of the North China and the most regions of the Northwest China. The area affected by desertification in China is approximately 2.622 million sq.km, occupying 79.0% of the arid, sub-arid and humid sub-arid area or 27.3% of total territory of China, in which the 1.607 million sq.km of desertification land is caused by wind erosion is, the 0.205 million sq.km by water erosion, the 0.363 million sq.km by frozen and melting processes at cold plateau, the 0.233 million sq.km by salinization alkalization and the 0.214 million sq.km by other factors. The estimated direct lost caused by desertification every year is 54 billion RMB Yuan. The Combating Strategies were summarized into 4 items including 8 measures.

Assessing the environmental changes and forests of Bangladesh

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Bangladesh is a small low-lying deltaic country surrounded mostly by India and the Bay of Bengal. Three major types of forests are hill forests, coastal mangrove forests and inland forests. The forests of Bangladesh is at stake mainly due to excessive population, poverty, natural disasters, scarcity of fuel, urbanization, industrialization and lack of awareness about importance of forests.

The impact of human activity on the forests is clearly felt from the reduction of forest area, which has been cleared for agriculture and human settlements over the past centuries. Besides more direct deforestation of the forest areas, the increasing need for food, fuel and shelter for the growing population in the immediate vicinity of the forests has had dire effects on the remaining forest areas.

Urbanization and industrialization resulted in the destruction of millions of trees for housing construction of roads, towns, and cities. Besides construction of giant projects such as dams, bridges, roads, hydroelectric works, townships etc. involve extensive removal of vegetative green cover.

Oil spills and indiscriminate discharge of bilge and bunker waters from the ships and other vessels occur in Mongla port located immediately upstream to the Sundarbans, the largest single mangrove forests of the world and in the Bay of Bengal. It is found to cause mortality of seedlings, fishes, shrimps and other aquatic animals from the Sundarbans and other coastal forests.

Flood is a common and frequent natural disaster in the country. There is connection between flood disasters after persistent heavy rain and forest density in the precipitation area. In case of treeless forestland or degraded forestland, the forest cannot fulfill its retention function and the soil's absorption capacity diminishes. The denuded areas expand steadily uphill due to continuing erosion, and land slides increases accordingly.

Soil erosion is a severe problem in the country. Due to high rainfall, low organic matter content, poor soil structure, surface soils are being continuously washed away, even there are severe land slides in many places mostly in hill and coastal areas. Part of the sediments carried to the rivers are deposited on the river beds, thus decreasing the carrying capacity of the rivers and increasing the flood hazard. Salinization, waterlogging, sedimentation and many other environmental problems tend either to diminish or destroy the biological potential of land known as desertification process. This process has been detected in the northern part of the country, hill areas, coastal areas and polder areas and in many patches of lands in the country due to unwise landuse practices deteriorating the forests.

Tropical cyclones are most frequent in the country that causes colossal mechanical damage to trees, particularly in the hill and coastal region.

Strong cyclones develop enormous wind forces, which are often accompanied by heavy precipitation and invariably by tidal surges and on occasion thunderstorms of a destructive character. Cyclones cause lasting damage to forests. The surmised global climatic changes resulting from the "green house effect" aggravate temperature extremes and lead to pronounce instability of the weather phenomena, with a tendency to extremes.

Forest fire is not very common in the country. But new pests and diseases are now coming up and are mainly associated with the man-made forest, use of exotics species, monoculture and large plantations of uniform size. This has a considerable role in degrading the quality of the forests.

By the year 2030, global temperature will rise by 1.9-4.5°C that may cause rise in the sea level rise 20cm-165cm. With 1 m sea level rise, the entire 401,600 ha of natural mangrove forests (Sundarbans) as well as 42,000 ha of man-made mangrove forests along the coast will gradually destroyed. As a habitat for wildlife Sundarbans is unique. The forest and the numerous waterways by which it is dissected together support wide range of mammals, including famous Bengal tigers, birds, amphibians, fish reptiles and crustacean. With such sea level rise most of these animals will lose their habitat and will become extinct.

The country would be more vulnerable due to environmental changes in the years to come, if some mitigation measures cannot be adopted right now. This paper attempts to assess the environmental changes and its impacts on forests of Bangladesh. It also suggests some mitigation measures to combat the situation.

Task Force 2
Forest in Sustainable Mountain Development

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People's Participation and Development of Forest Management Strategies in Western Himalayan Region of India.

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The Himalayas constitute a complex ecosystem with a varied climate, ranging from dry cold desertic, moist temperate and wet temperate to subtropical and tropical. The mountains exert profound influence on the climate of the Indian subcontinent and rivers originating in these mountain ranges nourish agriculture and industries in the vast Indo-Gangetic plains. The mountains are considered to be rich store houses of land, forest, water, hydro-electric power, aesthetic and recreational resources. In the Himalayas, forests are intimately involved in the everyday life of the villagers. People need *Timber* and poles for construction, agricultural implements and packing cases, fuel for heating and cooking, fodder & grazing land for cattle and sheep. People's dependence on forests is also associated with protection, conservation and development of these forests.

This article describes the way the management and administration of forests in the Western Himalayan region of India with particular reference to Kumaun and Garhwal hills were influenced by the awareness and active participation of the local people. Prior to 1823 when first settlement of the forests was started, villagers used to protect the forests (mainly from fire) and use the produce according to their needs without any restrictions. The settlement started in 1823 demarcated the village boundaries and the forest area of the villages to meet their requirement. Until 1865 there was no system of forest conservancy, when an Act to regulate forest management and fellings were promulgated. Forest settlement operations were done on an extensive scale and a bulk of the forest area was constituted as protected forests and reserved forests; mainly during the period 1893 to 1917.

The reservation of extensive areas and enforcement of strict control provoked serious resentment from the local people, which compelled the Government to set up a committee in 1921. This committee looked into grievances and made detailed recommendations about the various demands put forward resulting classification of the forest in three main categories for management purpose- Reserved Forests, Civil Forests and Panchayat Forests. Later on three more classes of Forests viz. Soyam Forest, Khat Forest and other Forests also emerged.

The Panchayat Forests, i.e. the Forests managed by a society of the villagers, which came in existence since 1925, is one of the oldest legalized Institution of forest management involving local people for sharing responsibilities and benefits which at present is popularly known as Participatory Forest Management or Joint Forest management. Panchayat Forests are very popular in the mountain area and presently there are about 4802 Panchayat Forests Consisting of about 354270 hectares which is 10.35 % of the total forest area of the concerning civil districts.

In this paper an attempt has been made to describe how awareness and involvement of the local people caused evolution of various classes of forests for management purposes and development of the Institution of Forest Panchayat in the Himalaya. The procedure for constitution of Forest panchayat and Panchayati Forest, their responsibilities and duties and benefit sharing of the produce are also been described which would be helpful to frame rules and regulations for various participatory or Joint Forest Management programmes currently undergoing in the developing countries mainly in tropics.

Sustainable Management of Himalayan Eco-System through Societal Approach

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Himalayan system is fragile and sensitive even to small disturbances caused by human activities. The pressure exerted by the rapidly growing population of human and cattle coupled with unsustainable management policies have resulted in severe ecological degradation which has rendered almost one third of the land area (i.e., 17,000 sq. km) totally unproductive. Expansion of indiscriminate agriculture on unsuitable slopes, uncontrolled grazing, intensive logging for fuel wood, lopping for fodder, inappropriate farming, wrong animal husbandry practices, clear felling and burning for shifting cultivation have degraded these lands to the extent of near non recovery. Disposal of material in the vicinity of the mine to slide into natural drainage channels have caused disturbance to water bodies. The hill topography has changed and the slopes become unstable and prone to erosion. In the deforested areas, the resultant debris, contributed by mining and road construction has spread as finer sediments on the flood plains and resulted in diminished productivity of the agricultural land.

Rapid destruction of the natural base resource has impoverished the poor and powerless and pushed them down the poverty line. The ecological degradation in this earth's most sensitive eco-systems and the fountain head of a multitude of natural resources, upon which depend over half a billion disadvantaged people has reached an alarming dimension.

The well-being of the poor and powerless can only be improved by rehabilitation of eco- system through economically viable and ecologically sound methods and through a "Do it yourself" approach. It has been postulated that application of technologies based on isolated biological, physical and social science researches cannot resolve this issue and that a proper understanding of the socio-economic compulsions of the population is essential. In the model developed under this approach, the village organisation assumes responsibility to meet the needs of the community. In addition to policies of consolidating the land use, tenure and related issues are also addressed so as to ensure sustainability of the technology packages with people's participation. The use of conventional method of policy and management practices which results in alienation of local population from forest and, consequent forest degradation are given up in this approach.

An example of research on sustainable management of mountain forests aimed at protection against erosion: the afforestations of Austrian Black Pine on marly land (southern Alps, France)

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Keywords: mountain forest; sustainable management; protection against erosion; marls; Austrian Black Pine; forest restoration; minimal management; priority forest intervention zones; ARC/INFO; sylviculture

The sustainable management of mountain forests aimed at protection against erosion is a major preoccupation of forest managers in the French southern Alps. Current problems of erosion management with forest vegetation particularly concern old afforestations of Austrian Black Pine (*Pinus nigra ssp. nigra*), undertaken by the services of Mountain ground restoration (Restauration des terrains en montagne : RTM) during the last century on marly lands. These artificial, monospecific and even-aged forests provide protection against erosion and torrential floods; but as they are now overmature, it is critical to consider their renewal. We thus propose here principles to support the sustainable management of these mountain forests, to provide permanent protection against erosion. Present financial restrictions require the establishment of minimal management, i.e., management recommending minimum forest intervention for maximum effectiveness against erosion.

First, we present a method for the identification and cartography of Priority forest intervention zones (Zones d'interventions forestières prioritaires: ZIFP) for permanent protection against erosion, using the ARC/INFO Geographical information system. This method is based on the principles of a "multirisk " method of ZIFP determination developed in the French northern Alps; an adaptation to the context of erosion in the French southern Alps is then realised. It consists of the analysis of two elements: the lithology, which allows the characterisation of erosion and hazards (torrential floods); and the forest stability, which can be obtained by overlaying two datasets: forest physical stability and forest regeneration capacity. Three classes of ZIFP are thus defined: classes with low priority corresponding to no-intervention zones; and one class of zones of eventual rehabilitation (Zones de réhabilitation éventuelle: ZRE), corresponding to forests without natural regeneration. For these last zones, rehabilitation interventions with biological engineering must be considered when the forest cover is not renewed after cutting. An application of the method is proposed for two forests of the Alpes-de-Haute-Provence.

Second, the necessary silvicultural rules are defined, in order to guarantee permanent protection against erosion by minimal management. To do this, we seek on the one hand to maintain a permanent, stable and perennial plant cover; on the other hand to support ecological diversity for a return to the climax forest. Establishment of these rules is largely based on an ecological study of the dynamics of forest restoration, studied on an experimental site of the southern Alps 130 years after the first afforestations, and focusing particularly on potential and limiting factors of regeneration. These rules are the first general principles for minimal management of Austrian Black Pine. The choice of management type is then realised according to land constraints: presence or absence of regeneration, forest density, infestation bym. Concerning regeneration cuts for old forests, two types of cut are recommended: regeneration cut step-by-step if there are few natural seedlings under pines or if they are abundant but little diversified; regeneration cut by gaps if natural seedlings under pines are abundant and diversified.

Forest density and infestation by mistletoe then determine the number of cut passages to apply. Concerning the management of the regeneration and the future forest, the diversification of species and structures must be considered through thinning and precocious clearing, and the adoption of irregular grove silviculture.

A Societal Approach to Sustainable Agroforestry in the Garhwal Himalaya

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Himalayan system is fragile and sensitive even to small disturbances caused by human activities. The pressure exerted by the rapidly growing population of human and cattle coupled with unsustainable management policies have resulted in severe ecological degradation which has rendered almost one third of the land area (i.e., 17,000 sq. km) totally unproductive. Expansion of indiscriminate agriculture on unsuitable slopes, uncontrolled grazing, intensive logging for fuel wood, lopping for fodder, inappropriate farming, wrong animal husbandry practices, clear felling and burning for shifting cultivation have degraded these lands to the extent of near non recovery. Disposal of material in the vicinity of the mine to slide into natural drainage channels have caused disturbance to water bodies. The hill topography has changed and the slopes become unstable and prone to erosion. In the deforested areas, the resultant debris, contributed by mining and road construction has spread as finer sediments on the flood plains and resulted in diminished productivity of the agricultural land. Rapid destruction of the natural base resource has impoverished the poor and powerless and pushed them down the poverty line. The ecological degradation in this earth's most sensitive eco-systems and the fountain head of a multitude of natural resources, upon which depend over half a billion disadvantaged people has reached an alarming dimension.

The well-being of the poor and powerless can only be improved by rehabilitation of ecosystems through economically viable and ecologically sound methods and a "Do it yourself" approach. It has been postulated that application of technologies based on isolated biological, physical and social science research cannot resolve this issue and that a proper understanding of the socio-economic compulsions of the population is essential. In the model developed under this approach, village organizations assume responsibility to meet the needs of the community. In addition to policies of consolidating land use, tenure and related issues are also addressed so as to ensure sustainability of the technology packages with people's participation. Conventional policy and management practices, which result in the alienation of local population from the forests, and consequent forest degradation, are given up in this approach.

On Criteria and Indicators for Sustainable Forest Management of Forest Farm, An Experiment Site in Semi-arid Western China

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Experimental site of Zhangye region is located at 38°N and 100°E with the cold and semi-arid climate in Qilian Mountain of Gansu Province, Northwest China. Water supply for cities and villages in the Xeshi Corridor (including Zhangye region) is coming from 2859 glacier that contains about 81100 million m^3 of ice. Natural *Picea crassifolia* forest in Qilian Mountain stores and regulates the runoff to irrigate the Xeshi Corrido plain in the semi-desert. The Forestry Is Consisted Of 3 Forest Types: Water Resources Conservation Forest (WRCF), Shelter Belt For Farmland (SB) and Economic Plantation (orchard) (EP). Such forestry structure is suitable to whole semi-arid region with the mountain forests in northwest China, so that the C & I for Zhangye could be used for that region at all. The C & I on SFM of Zhangye Region, of Forest Farm for WRCF and that for SB and EP are provided.

Task Force 3
Sustainable Forest Management

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Integrated Planning for Sustainable Forest Management

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Integration of forest operations with regional planning is of increasing importance as landowners, *Timber* producers, states, regions, and nations compete in international markets for forest products. Sustainable forest management and productivity is now a matter not only of individual landowner goals but also of regional and national planning and policy.

Competitiveness in national and international forest products markets will become more and more a function of an assured sustainable wood supply.

This poster describes a system for integrating forest operations planning with policy analysis. A geographic information system (GIS) database, supplemented by a forest growth and yield model, provides input for a strategic/tactical forest operations planning model. Alternative forest policies affect planning choices. Alternative plans that result from policy constrained management choices are linked to a regional economic analysis model that indicates the full impact on jobs, wages, and production values resulting from those policies and management choices.

An application in the state of Maine, U.S.A. is described.

Site classification - a basic requirement for tropical forest management planning An example from Sabah / Malaysia

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Keywords: forest soils; management planning; forest functions; site classification

The objective of this project is to develop a planning concept for integrating site classification into medium-term forest management planning. The three-tiered approach, State - Forest Management Unit (FMU) - Compartment, facilitates a systematic methodology and hierarchic vertical integration.

At state level, Sabah is ecologically stratified into 17 growth regions and 94 -districts. Differentiating parameters are altitude, geology, and climate. At FMU level, Deramakot Forest Reserve (DFR) is chosen for determining the forest formations, soil and site conditions, and management restrictions. Vegetation and site data are collected in a 1 x 1 km systematic inventory. The forest formations and associations are identified by cluster analyses and show to be predominantly correlated with landform and texture of the topsoil. Landform is the major determining factor at association level.

Site-related management restrictions are identified as: soil erosion, soil compaction and soil nutrient status. For soil erosion hazard assessment, the Universal Soil Loss Equation (USLE) is used and facilitates a zonation of the total area by additionally defining preliminary thresholds of tolerable soil loss. For inherent soil compactibility assessment, soil texture is stratified into compaction susceptibility classes. Soil moisture is not incorporated yet and more work is needed on this subject. For soil nutrient status assessment, 437 profile descriptions of DFR (1 x 1 km grid) and 374 profile descriptions including soil samples of a sub-area (0.2 x 0.2 km grid), are used. Soils have a moderately poor to medium content of exchangeable basic cations, are very acid, and aluminium saturation is high. The variation of nutrient contents within a soil type on different landforms in DFR is larger than between different soil types on the same landform. A classification by soil type alone is, therefore, not sufficient. The assumption that repeated *Timber* harvesting will cause soil degradation by loss of nutrients is warranted for fast-growing industrial plantations, but yet unsupported for Selection Systems in tropical rainforest. Nutrient input-output analyses indicate that a *Timber* harvest may cause a reduction up to 25% of the plant-available soil nutrient stocks by erosion and *Timber* removal in one cutting cycle.

Consideration of the management restrictions is incorporated in a 3-D decision matrix. The combinations of nutrient quality, erodibility and soil compactibility lead to one out of four possible management intensity classes (MIC). These MIC options are stratified by their environmental effects ranging from no adverse environmental effect = protection forest (TPA) through Reduced Impact Logging (RIL) techniques to severe environmental effects = industrial tree plantations with quick-growing species. Policy and management decisions can thereby be based on ecologically and environmentally relevant, verifiable and sound information on the area suitable for production forestry and areas, which are only suitable for TPA.

People's Participation in Sustainable Forest Management

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In many developing countries, including India, the Government has managed environmentally significant forests. Protection was through policing. Management was according to prescriptive working plans. Over the years, emphasis of the Government as well as that of the people about the forests have shifted from *Timber* and firewood production to Forest Conservation for eco-balance, environment and livelihood support.

Realizing that Sustainable Forest Management (SFM) is possible only with the willing and active participation of local people, Government of India launched the concept of "Joint Forest Management (JFM)" in alignment with the revised National Forest Policy 1988. In Karnataka, Joint Forest Planning and Management (JFPM) was introduced systematically through a project approach in the Western Ghats Forests Region, the project being supported by the DFID (UK).

The Project has focused on Participation of Stakeholders, Reorientation and Organization development of Karnataka Forest Department, Institutional development at the village level, through formation of Village Forest Committees (VFCs), Self Help Groups, Site-specific Planning System, Micro-planning at the village level, Zonation of forest areas by objectives, Management Information System, Demand-led research, training and development of shared vision. The new process was facilitated by policy support in the form of special Government Order, which provided the framework for participatory role of local people and a provision for sharing of forest produces between People, VFC, and Government.

VFCs provide a forum for participation of all people in planning, negotiating and managing the natural resources at their disposal. Special efforts were made to ensure participation of all stakeholders in planning, especially the poor, and women through series of meetings and participatory Rural Appraisal (PRA) exercises.

People have taken interest in protection of the forests in the neighborhood of their villages from smugglers and fire; afforestation, introducing fuel saving devices and alternate energy resources, choice of species in plantations, management of NTFP on a sustainable basis, skills enhancement for better earning through value addition to raw materials, marketing arrangements, and other community development activities. Although not everything is seen everywhere, different attempts have been pursued across a range of about 400 VFCs spread in three districts.

A number of independent Impact Assessment Studies and case studies in specific villages have been undertaken to assess the impacts and the trend so far. They all indicate to a greater interest and participation of local people, enhanced protection of forests, adoption of fuel saving devices, better relationships between people and the Forest Department officials, greater rapport with the Non-Governmental Organizations, attitudinal change in the front line staff of the forest department.

Some of the areas where the Project is yet to make significant progress so as to achieve the desired objective of Sustainable Forest Management include: greater participation of disadvantaged poor people, women, expansion of project to all villages, extension of sharing of benefits in nondegraded forest areas with special emphasis on NTFP, organization development of Forest Department, higher degree of devolved decision making, networking of VFCs, and information dissemination.

Le Partenariat entre Service Forestier et Exploitants-industriels : une Solution pour l’Aménagement Durable des Forêts Denses Tropicales : Cas de la Sodefor (Côte d’Ivoire)

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Le modèle retenu par les pays tropicaux producteurs de bois, en matière de gestion forestière, n’a pas beaucoup favorisé l’aménagement durable des forêts. En effet trop souvent, l’action forestière vis - à - vis des populations a été vécue en terme d’interdiction, de répression, de limitation de liberté et même d’abus de pouvoir. Ainsi, ces populations se préoccupaient très peu du devenir de la forêt.

Aux exploitants, traditionnellement impliqués dans cette gestion forestière, il n’a été réservé que le droit de récolter le bois. Ils n’avaient pas de droit véritable sur les concessions qui leurs étaient octroyées et l’avenir de ces concessions ne les intéressait guère.

De plus en plus conscients des limites de ce modèle qui a conduit à la raréfaction de la ressource ligneuse voire à la disparition d'importantes surfaces boisées, ces pays ont compris la nécessité d'élaborer des systèmes appropriés pour l'aménagement de leurs massifs forestiers. Il s'agit désormais d'impliquer tous les acteurs vivant directement ou indirectement de la forêt dans sa gestion :

- l'Etat, propriétaire, représenté par son Administration forestière ;
- les populations locales qui dépendent directement de la forêt et de ses produits ;
- les exploitants et les industriels

Dans le cadre de la gestion participative impliquant les exploitants - industriels, différentes formes de partenariat, fonction de la politique forestière de chaque pays, ont été retenues. C'est dans cet objectif que s'inscrivent les conventions provisoires d'aménagement - exploitation initiées par la SODEFOR (Côte d'Ivoire) dans le but d'associer les industriels dans les travaux de prise en main des forêts classées. L'entrepreneur - exploitant met ainsi sa logistique au service des travaux de génie forestier (délimitation de pistes), d'inventaire ou de sylviculture. Pour appliquer l'aménagement il faut réaliser les coupes, et elles sont inconcevables sans les spécialistes que sont les exploitants.

Ce système de partenariat avec les exploitants - industriels pour une gestion rationnelle et durable des massifs forestiers du domaine permanent de l'Etat n'a cependant pas donné les résultats escomptés. Certains industriels ayant souscrit aux conventions, ont souhaité l'arrêt des conventions sous la forme telle qu'elles étaient conçues.

La SODEFOR n'a pourtant pas arrêté d'entretenir les relations commerciales avec ces exploitants industriels. Notamment la SIFCI, la CIB et THANRY qui exploitent respectivement dans les forêts classées du Haut - Sassandra, du SCIO, de GOIN - DEBE. Elle vend aujourd'hui son bois par des contrats de courte durée (2 à 3 ans) par appel d'offres ou de gré à gré.

Les industriels qui veulent garantir leur approvisionnement afin d'entreprendre des investissements souhaitent l'établissement de contrats de longue durée ou conventions pluriannuelles d'approvisionnement..

En ce qui concerne la SIFCI, qui considère la première expérience comme une réussite, des données techniques nécessaires sont réunies pour la mise en place de la convention pluriannuelle d'approvisionnement, il ne reste plus qu'une concertation entre les parties pour affiner les clauses de cette convention.

Mots-clés : forêt tropicale, aménagement durable, gestion forestière, partenariat, Côte d'Ivoire

Traditional skill: a way to sustainable management of tropical forests

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Management of forest can not have any generalised prescription for all sorts of forests. even within a country like India there can not be a common strategy of management as because the ecological parameters vary from forests to forests. Management strategy is very much dependent upon ecosystem of an area. Some studies have been done on management strategies in South West Bengal of India where tropical deciduous sal (*Shorea robusta*) forests with 10 years coppice rotation exists. A major portion of these forests in the region is under Joint Forest Management (JFM). So it has been easy for us to carry out an indepth study. The studies show that the present tactices followed by some of the Forest Protection Committee (FPC) are progressive and so may be included within the process of management. These strategies concern non-*Timber* forest products (NTFPs) in particular. The survey has been conducted for stratifying FPCs according to their management within twenty FPCs of the region.

1. The FPCs having a good management network at least at the institutional level, feel that a canopy cover below 40% is always desirable to have a good NTFP return particularly *Diospyros melanoxylon* from the forests.

2. Perfect protection of a forest ecosystem is not an answer to diversity and better productivity of NTFPs. In turn, exploitation within a particular limit (may be called sustainable limit) also increase productivity of certain NTFPs. This has been proved in some species like *Combretum roxburghi* (basket producing woody shrub species) and *Hollarhaena antidysentrica* (a medicinal shrubs, species)ÿ in South West Bengal. It is found out that exploitation of NTFPs within a limit increases productivity than a perfectly protected forest area.

3. Sweeping of leaves form under the trees, is a general practice in these forests. These leave are generally used a fuel. In this area leaf fall occurs during middle of November till the end of April. December and January being the rice processing months, sweeping of leaves from the forests floors

disturb nutrient cycling of the forest. Thus, it will be pertinent to prescribe that there should be no sweeping of leaves from under the trees after February. Leaves have to leave for decomposition during the next rainy season.

4. Some FPCs have earmarked some species to be used as fuel-wood. These are exotic to the region and have a prolific growth.

The gregariousness of these species decrease the species diversity of the region as these species can compete well eliminating the indigenous herbs and even *shrubs Eupatorium odoratum* and *Lantana camara* are tow such species which has been specified by some FPCs for extraction.

These management decisions taken by FPCs have not been docated by the Forest Department and the traditional in nature. These decisions are useful to keep the health of the forest in good condition.

Implementing sustainability in Ukraine's forestry

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Previous economic development of the country and shortcomings in its past forestry policy and management practices negatively affected the forests, having resulted in their depletion and degradation. Ukraine's forests suffered from overcutting until the 1970s, especially in the western region. Besides, popular during the period of Soviet industrialization practice of spruce plantations has not proved to be wise in the Carpathian mountains causing disastrous windfalls. Wide spread hydroamelioration also failed and led to a considerable loss of biodiversity in the Polissja region. As a result, the Ukraine despite its originally favourable natural conditions, high productivity of forests, MAI of 3.96 m3/ha, and their richness in biological diversity is a scarcely wooded state. Only its western region has a high share of forests. An average share of artificial plantings, consequently, has reached 50%. Forests distribution has become uneven. Age composition of forests is not optimal (52.6% - young stands). These factors influence future *Timber* production and endanger sustainability in Ukraine's forestry.

Besides, the environmental situation in the Ukraine impacted forest ecosystems causing their damage. Radioactive pollution after Chernobyl accident is observed on 2.3 mil ha of forests. The highest level of forests' damage from nuclear contamination is in the central part, from chemical pollution in south-eastern and southern parts of the country. Consequently, the Ukraine satisfies its demands in *Timber* only on 30% by its own production. The conditions of the Ukraine's forests do not allow them to fulfil in a proper way their regulatory, protective and shelter functions. Thus, in-depth changes should be urgently brought into the Ukraine's forestry.

The paper presents key forestry policy and management measures to approach sustainability. From one hand, substantiated on the basis of sustainability concept *Timber* rotation should be put into practice. From another hand, an expansion of wooded area should be achieved at the account of waste, eroded and marginal agricultural lands. The program of afforestation, as a key building block of sustainable forestry policy will shorten *Timber* deficit inside the country, will enhance output possibilities of forest products and services and enables the Ukraine to fulfil its targets regarding the Kyoto Protocol on Climate Change.

Cambios en la diversidad del bosque húmedo tropical después de la intervención

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De las tres áreas geográficas donde se ubica el bosque húmedo tropical en el mundo, el trópico asiático es el que presenta mayor cantidad de especies entre 12.000 y 15.000, le sigue el trópico americano con 5.000 a 7.000 especies y por último el trópico africano con 2.000 á 3.000 especies de plantas con diámetro mayor a 10 cm.

América Central constituye una unión intercontinental, lo que le permite desempeñar desde el punto de vista de dispersión florística un rol de puente biológico entre las regiones Neártica y Neotropical.

Entre los múltiples factores que influyen en la distribución de la flora en América Central, sobresale el carácter de puente y de filtro biológico que constituye el istmo. Este, además de ser un extrecho puente entre dos continentes ricos en especies posee una historia independiente, como archipiélago con un grado variable de aislamiento, lo cual trajo como resultado una expectación, parte de la cual persiste hoy día entre la flora endémica del país.

En Costa Rica la gran variabilidad de factores tales: lluvia abundante, temperatura variada y el vulcanismo reciente han producido suelos ricos en minerales, lo que ha dado un sistema dinámico, con gran heterogeneidad local.

La investigación se desarrolló en la Región Huetar Norte de Costa Rica, específicamente en la localidad de Boca Tapada de Pital. La misma se caracteriza por presentar una estación lluviosa muy marcada de 8 a 10 meses, con una precipitación media anual de 3 163 mm. La temperatura varia entre 25 °C y 27 °C. La zona de vida es de bosque muy húmedo tropical según Holdridge.

Las evaluaciones se realizarón en parcelas permanentes de medición de 1 ha, en las cuales se midieron todos los indiviuduos con un d igual o mayor a 10 cm. Se evaluaron tres áreas de bosques intervenidos (rodales) bajos tres intensidades de aprovechamiento forestal: de bajo impacto (I), media (II) e intensivo (III). Para el bosque no intervenido de la Región, se reporta un promedio de 91 especies arbóreas por hectárea.

Para los rodales evaluados, se obtuvo en total 106 especies en el rodal intervenido bajo el aprovechamiento de bajo impacto, 117 especies en el intermedio y 91 especies en el severo. Para los rodales I y II se contabilizaron más de 82 géneros, en el rodal III se presentaron 68 géneros, el número de familias botánicas varió entre 46 y 36. En promedio el rodal III tuvo 67 especies/ha, los rodales II y III alcanzarón 83,5 especies/ha. Se puede indicar que la composición florística de los boques es compleja.

Las especies comúnes y más frecuentes en los tres rodales fueron*: Ferdinandusa panamensis, Henriettea odorata, Welfia georgii, Pouteria sp*. y *Couma macrocarpa*. En cuanto a las familias más dominantes aparecen *Sapotaceae, Mimosaceae, Rubiaceae, Euphorbiaceae* y *Papilionaceae* son las que dominan con una mayor cantidad de géneros. De acuerdo con la curva especie/área, se determinó que en el rodal I presentó más especies que el bosque no intervenido. Aunque en general la composición florística del bosque intervenido no cambia sustancialmente, lo que se ve modificado es la dominancia de algunas familias y géneros.

A través de los índices de Shannon y Simpson se establecen mejor las diferencias entre el bosque no intervenido y el intervenido. Donde el Rodal I presenta la diversidad mayor, y por su parte para con el índice de Simpson fue el Rodal III, en ambos caso no fue el bosque intervenido.

A study on regional sustainable forestry

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Sustainable development is the common objective and the course of development in all over the world. The practice and study of regional sustainable development is the basis for our country and even the world. It's also the final state of the department and sector's sustainable development. The sustainable forestry plays an important role in the development on the globe, nation, and region.

The idea of sustainable development makes a change for our reconsidering the forestry. In this dissertation, based on understanding the content of the forestry and analysing the circumstance of sustainable forestry. The author demonstrates the status and circumstance of Chinese forestry in the light of Chinese situation and forestry's condition. The two conclusions have been made in this paper: (1) Chinese forestry should be brought into the framework of regional sustainable development, (2) Forestry is the dominant sector for environment reproduction, therefor, it should be protected.

Based on the study of the change regularity of the Haihe River Volley, we proposed the regional mode of sustainable development in the TaiHang Muontain. Meanwhile, Fuping Country is taken as studding object, and the systematic analysis and quantitative assessment method assess the country's ability of sustainable development. By using the methods of AHP (Analytic Hierarchy Process), PCA (Principle Component Analysis) and Fuzzy Clustering, etc., the development advantages and potentiality has been found in Fuping County's sustainable development. Also, a development strategy with the sustainable development principle was put forward. Final, the object systems of Fuping County's sustainable forestry and the sub-regions of forestry type is given according to the forestry's role in the Fuping Country and even the whole Haihe River Volley.

Task Force 4

Management and Conservation of Forest Gene Resources

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Forest Genetic Resources on the Balkans As a Factor for Creation of Sustainable Forest Ecosystems in Europe

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During the Pleistocene in Europe took place the process of formation of the contemporary autochthonous forest tree and shrub vegetation. The Balkan Peninsula as a whole was not affected by permanent glaciatin and became an enormous refugium. Here several hundred trees shrub species have been preserved forming huge forest complexes as in the mountain massifs so in the plains. This phytogeographic area in the crossing point of the European Deciduous Forest Region, the Eurasian Steppe- and Forest-Steppe Region and the Mediterranean Sclerophilic Forest Region. Here are spread termophytes, mesoterms and microterms from the mediterranean south-continental, north-continental, mountain and north-boreal phytogeographic centers.

Now the Balkan Penninsula is a center of forests with total area of 24 millions ha, with an average forest cover of approximately 30% containing significant biological and genetic diversity. Having in mid the new European forest policy laying down, these valuable in genetic potential species may be used as a source for stabilization and enrichment of the biological diversity; for increasing of the productivity and the resistance of the forest ecosystems in Europe. This especially concerns some Central and Northern European countries in which during the Pleistocene occurred strong reduction in the composition of their vegetation. The industrialization during the XIX and XX centuries caused the extermination of a significant part of the autochthonous forest and the improverishment of their biological and genetic diversity.

A great number of deciduous families as *Fagaceae, Betulaceae, Tiliaceae, Acaraceae, Rosaceae, Oleaceae, Salicaceae, Juglandceae, Ulmmaceae, Corylaceae*, etc. determine the basic composition of the contemporary forest on the Balkan Peninsula. The diversity of the conifetous species is deteermines by some main species from the Pinaceae family, the most important role of which have the genus *Pinus, Abies* and *Picea*.

Biotechnology: Key to Sustainability of Biodiversity

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The conservation of both biodiversity and environment is gaining importance lately with the increasing numbers of species becoming extinct. Malaysia has the highest number of critically endangered tree species at 197. It is estimated that 95% of 270,000 species of plants in the world are found in the tropics. Moreover, an equivalent area in the tropics is expected to support four to ten times the number of species found at the temperate latitudes for any given taxonomic group. However, human activity, particularly mining and land conversion is contributing to its destruction. Drought and the clearing of land further exacerbate this, by fire. As it is a well-established fact that biodiversity supports human survival through health (the forest being a medicinal chest), food and industry (*Timber*), its conservation is of prime importance. Therefore, through the capture of germplasm using biotechnology tools such as micropropagation, we can not only make these into products with great commercial potential (for instance the commercialisation of the endemic pitcher plant, *Nepenthes spp*. and wild *orchids*) but also reintroduce and repopulate the natural habitat. *Timber* trees such as *teak*, *meranti* and *jelutong* that have high commercial value are produced via tissue culture techniques and can be used in enrichment planting in logged over forest areas. The problem of slow germination of seeds on the other hand is overcome through somatic embryogenesis techniques, a biotechnology tool in producing artificial seeds. Artificial seeds would then produce consistent and large amounts of viable seeds ensuring the sustainability of our biodiversity. The production of artificial seeds also allows easy broadcasting especially from the air. The use of molecular biology tools offers the possibility to identify and isolate valuable genes from our rich biodiversity as well as to identify where then is a most urgent need for conservation.

Markers developed using techniques such as Amplified Fragment Length Polymorphism (AFLP) are being applied to the improvement of our native plants towards higher productivity levels for viable commercial propagation and to prevent depletion from the wild due to poaching and biopiracy. The use of biotechnology in conserving biodiversity thus would be the next most natural thing to do in this time and era when money is in short supply, especially in developing countries where coincidentally the forest seems to be in abundance too.

Integration of tree breeding and gene conservation: strategies for sustainable use of forest genetic resources

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The objective for sustainable utilization of forest genetic resources is to find an optimal balance between the genetic improvement and the conservation of genetic diversity. Two strategies integrating breeding and conservation are proposed. These strategies can be characterized as 1. Breeding population subdividing, and 2. Selection optimization. The underlying implication of the population subdividing strategy is that the breeding population must be managed in separate or hierarchical sub-populations (groups or sub-lines). While intensive breeding can be applied to the various sub-populations, the genetic diversity is conserved through population subdividing.

Population subdividing also allows exchange of materials among the subdivided or hierarchical sub-populations to maintain genetic diversity within the sub-populations. Each of the strategies has its advantages and disadvantages, The choice of the different approaches depends on several factors such as breeding goals, conservation needs, finance and technologies. Several variants of the population subdividing strategy were demonstrated.

The selection optimization strategy seeks optimal compromise between genetic progress and conservation of genetic diversity in the selection decision regardless of how the breeding population is structured. With the optimization strategy, genetic diversity is first quantified with use of coancestry and then integrated with genetic gain by applying a weighting coefficient to the coancestry.

The weighting coefficient can be generally regarded as the importance of diversity relative to gain. This integration provides a single measurable scale to compare different outcomes from different selection alternatives regarding both genetic gain and diversity. Optimization was conducted by assigning a series of penalties to the coancestry in the selection process. Application of this strategy to a real breeding program demonstrated that in almost all cases the genetic gain and diversity were much better balanced in comparison with the traditional method.

In certain cases, combining the optimization strategy with the subdividing strategy may be a better choice to integrate breeding and conservation. In terms of long-term sustainable utilization of forest genetic resources, there are actually no fundamental differences between tree breeding and gene conservation programs. Integration of tree breeding and gene conservation in a single program substantially reduces the managerial and financial inputs required by running separate programs of tree breeding and gene conservation. This provides a new way towards gene management for sustainable uses of forest genetic resources.

Le santal dans le Pacifique sud insulaire, état de la diversité et stratégies de conservation.

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Le santal, arbre hémi-parasite dont l'huile essentielle extraite par distillation du duramen est très recherchée en parfumerie, appartient à la famille des *Santalaceae* exclusivement composée de plantes parasites. Le genre *Santalum* qui comptait 15 espèces dont une actuellement éteinte, se concentre autour du Pacifique à l'exception de deux espèces de l'Australie occidentale et des localisations indiennes de *S.album*. Les espèces du Pacifique sud insulaire sont *S. austrocaledonicum*, *S. yasi* et *S. insulare*. Ces trois espèces présentent des diversités botaniques variables, que l'on peut aisément rattacher aux caractéristiques géographiques de leurs aires plus ou moins morcelées et isolées. Mais ces dernières sont aussi à l'origine d'un facteur de risque humain qui pèse fortement sur la survie de certaines variétés à moyen terme.

La faculté de cette espèce à rejeter et à drageonner lui a plus ou moins permis de survivre aux campagnes d'exploitations et une partie non négligeable de l'information génétique a été ainsi conservée. Par contre, l'évaluation de sa diversité est difficile par des moyens simples en raison de la forme multicaule et tordue que prend le santal issu de drageons et, dans de nombreux sites, aucune régénération de franc-pied ne peut être trouvée. La composition de l'huile, caractère principal de la valeur économique de l'arbre, nécessite le prélèvement de duramen et son analyse chimique, opérations lourdes et coûteuses et qui demandent un arbre suffisamment vieux. Pour cela, la connaissance plus précise de la variabilité génétique est difficile en de nombreux sites et n'a pu encore être menée à bien.

L'état des peuplements est très variable. *S. insulare* présente une aire très dispersée et morcelée en très petites unités qui portent souvent chacune leur variété. La pression humaine directe, la modification de l'environnement végétal et animal à laquelle le santal est soumis, la faible taille des populations mettent souvent ces variétés en danger d'extinction. *S. yasi*, qui s'étend de Fidji à Tonga présente une unicité botanique et les populations sont plus importantes. Mais, excepté celle d'Eua à Tonga, les effectifs sont relativement réduits. Leur survie peut être mise en cause. Néanmoins, une action rapide de sauvegarde des ressources génétiques permettrait le maintien d'un pool génétique suffisant pour assurer une conservation efficace. *S. austrocaledonicum*, est l'espèce qui recouvre les plus grandes surfaces terrestres. Elle est encore constitué de peuplements relativement importants sur les îles coralliennes de Nouvelle-Calédonie et certaines île de Vanuatu. La diversité génétique y est encore importante bien que l'évolution sur les autres îles nécessite des actions urgentes. Une variabilité importante sur la composition de l'huile a été mise en évidence et la compréhension de ce phénomène est une étape forcée avant de se lancer dans une stratégie de conservation / replantation.

Cet état des peuplements conduit à proposer plusieurs stratégies de conservation selon la situation des peuplements. Si la conservation à but uniquement patrimonial se défend, elle se heurte à des notions de coûts et donc d'efficacité de la protection. Une vision plus économique doit y être associée pour valoriser au mieux et ainsi le justifier, l'effort de conservation. Elle nécessite une bonne connaissance du matériel végétal et du marché aval très limité et exigeant. L'utilisation d'outils génétiques se justifie et permettra des gains importants sur l'amélioration, en particulier sur celle concernant la composition de l'huile essentielle.

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The Global Forest Information Service

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Keywords: GFIS, forests, Global Forest Information Service, Information, Internet, meta-data

Rapid, reliable and universal access to quality information on forests is essential for informed decision-making, and improvement of information systems is generally recognized as a global priority. To address this priority the International Union of Forestry Research Organizations (IUFRO) has convened a consortium of international, regional and national organizations, functioning as a IUFRO Task Force, for the purpose of developing a strategy for, and implementing, an Internet-based meta-data service to provide coordinated world-wide access to forest information. The envisioned Global Forest Information Service (GFIS) will provide substantial benefits: easier access to diverse sets of forest information (e.g., bibliographic, research capacity, forest resources, maps); better comparability of data sets through adherence to common standards; improved user feedback to information providers; identification of information gaps and areas of duplication; generation of value-added products (e.g., reports, newsgroups, workshops); and facilitation of information dissemination and improved technology transfer.

The GFIS is based upon the notion of a distributed network of meta-databases, which catalogue the forest information resources of participating GFIS partners (nodes). It is proposed that GFIS will foster interoperability by providing a standardized core of meta-data (catalogue) fields, a standardized set of search criteria and a standardized interface between web sites and databases. Each GFIS node will host a locator, which serves as a meta-database to catalogue and organize nodal information resources and provides information-seekers with a means of rapidly searching for relevant information on the web. A central GFIS Information Server will coordinate the housekeeping functions of the GFIS network.

The GFIS is an open-ended system to which information providers (e.g., national and international organisations, universities and libraries) who wish to follow GFIS principles may contribute resources. These principles will be expressed in a collection policy, which will define subject coverage, target audience, types of resources to be included, submission procedure, quality assessment, meta-data standards and maintenance arrangements. Anyone with access to the Internet can seek information via the GFIS by: connection to the information locator at any GFIS node, selection of search criteria (e.g., topics), submission of search, examination of meta-data output and accessing or acquiring specific data.

MIRA - an information management system to support research and technology transfer on forest plantations

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During the decade of the 80's the Centro Agronomico de Investigacion Tropical (CATIE) together with the government institutions in charge of forest research in Central America developed a standardized method for the establishment and repetitive measurement of multiple use tree plots. Based on this methodology, more than 15,000 research plots were established in the Central American region. The system 'Management of Information about Forest Resources' (MIRA) was developed to manage and analyze this enormous quantity of information. - By means of MIRA, the network of growth plots and established scientific trials has generated valuable information for silviculture of the species and technology transfer. The system MIRA manages information about study sites, climate, soils, forest ------, seed sources, tree data, and the ----- of various forest products. It has generated data for many scientific publications, including growth and yield models for multiple use species. - Recently by means of an agreement between CATIE and CIFOR, MIRA has been converted into a bilingual system (Spanish and English) in the Windows 9 environment and at the same time the network of MIRA users has grown to include organizations outside of Central America and private companies. Besides being a tool for the management and analysis of information within an organization, the system MIRA has served as a means for the interchange of information and experiences between organizations. One unexpected result is the fact that any private businesses are disposed to combine their data at the level of plot summaries. This has allowed analysis involving a variety of growth conditions and management practices that would have been impossible with smaller data sets.

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Forests and Society : The Role of Research

CONGRESS REPORT

VOLUME IV

XXI IUFRO WORLD CONGRESS 2000
7-12 August 2000
Kuala Lumpur
Malaysia

Forests and Society : The Role of Research

CONGRESS REPORT

VOLUME IV

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Cover photographs - Front: Canopy walkway in FRIM
- Back: *Globba aurantiaca*

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Congress Timetable

	Sunday 6/6	Monday 7/8	Tuesday 8/8	Wednesday 9/8	Thursday 10/8	Friday 11/8	Saturday 12/8
07:30							
09.00		Registration	Plenary Session	Plenary Session	In-Congress Tours	Plenary Session	Plenary Session
09.15							
09.30		Opening Ceremony Plenary Session including Keynote Address					
09.45			Break	Break		Break	Break
10.00	Registration		Sub-Plenary Sessions	Sub-Plenary Sessions		Sub-Plenary Sessions	Sub-Plenary Sessions
10.15							
10.30							
10.45							
11.00							
11.15							
11.30							
11.45							
12.00							
12.15							
12.30							
12.45						Lunch	
13.00		Lunch	Lunch	Lunch			Lunch
13.15						No Official Congress Programme to be scheduled	
13.30							
13.45							
14.00		Sub-Plenary Sessions	Poster and Poster/Panel Sessions	Poster and Poster/Panel Sessions			Group Sessions
14.15							
14.30						Group Sessions	
14.45							
15.00							
15.15							
15.30							
15.45							
16.00							
16.15		Break	Break	Break		Break	Break
16.30		Group Sessions	Group Sessions (16.30-18.15)	Group Sessions		Group Sessions (16.30-18.15) International Council Meeting (16.30-18.15)	
16.45							Closing Ceremony
17.00							
17.15							
17.30							
17.45							
18.00							
18.15							
18.30			(16.30-19.00)				
18.45							
19.00							
19.30		Welcome Dinner	Satelite Meetings/ IUFRO Business Meeting	Satelite Meetings/ IUFRO Business Meeting		Satelite Meetings/ IUFRO Business Meeting	
20.00							Farewell Dinner
20.30							
21.00							
21.30							
22.00							

The XXI IUFRO World Congress in Summary

Preface

The XXI IUFRO World Congress was successfully organized and held at the Putra World Trade Centre (PWTC), Kuala Lumpur, Malaysia, from 7-12 August 2000. A total of 1,906 delegates and 209 accompanying persons from 96 countries participated in the largest forestry meeting ever held in Malaysia. IUFRO's Scientist Assistance Programme supported 169 scientists from 44 developing countries. A full list of delegates and their addresses is included in this Congress Report.

The Minister of Primary Industries, Malaysia, on behalf of the Rt. Honourable Prime Minister, Malaysia, officially opened the Congress. The Prime Minister emphasized the importance of sustainable forest management in order to meet the social, economic, ecological, cultural, human and spiritual needs of present and future generations. In addition, five series of Congress commemorative stamps were launched in the opening ceremony of this remarkable Congress.

During the six-day Congress many interesting scientific programmes were organized ranging from Plenary Sessions, Sub-plenary Sessions, Group Sessions to poster exhibitions and satellite meetings. A three-day Forestry Exhibition was also held at PWTC. Five Keynote Addresses by renowned speakers were delivered during the Congress. These speakers highlighted new visions for forestry and forest research as we enter the new millennium, and stressed the close linkages between forests and society as exemplified by the theme of the Congress: "Forests and Society: the Role of Research". More than 500 papers were presented in 125 Group Sessions and 99 papers in the Sub-plenary Sessions. Approximately 510 approved posters were also displayed during the Congress. Discussions during various sessions were generally of an exceptionally high standard and augured well for the future of IUFRO and the future of forest research.

Full papers of all the Keynote Addresses presented in the Plenary Sessions are included in this Report, in addition to speeches delivered during the Opening and Closing Sessions. Papers presented in Sub-plenary Sessions and abstracts of Group Sessions and posters had been published before the Congress in three volumes of Proceedings, which were also included in a CD-ROM. The Congress Resolutions as approved at the Congress are also included in this Report in all four official languages. These Resolutions are intended to inform governments in countries where IUFRO is represented as well as policy-makers all over the world.

In order to break the monotony of the meeting, an in-Congress tour was organized on the fourth day of the Congress. More than 1,200 delegates participated in the one-day tour and had a choice of nine routes. Twelve post–Congress excursions were also conducted to allow delegates to experience the beauty of Malaysia and the

neighbouring countries Thailand, Indonesia and Brunei. All these tours were specially designed with the focus on forestry, forest industries and attractive sites. The Accompanying Persons' Programme was also well organized. Out of the 10 tour packages, the 'fireflies' tour was the most popular and sensational one.

Special events such as the Tree Planting Ceremony with members of the International Council, as well as the welcome and farewell dinners were organized to enhance the social networking of all delegates over the world. In addition, multi-colour cultural shows of Malaysia were presented; Australia, the next Congress host country, brought in a wonderful didgeridoo player during the closing ceremony.

In letters of thanks written by delegates the Congress was regarded as one of the best Congresses ever held and it had left a memorable impression on the delegates and their accompanying persons. This was very much in line with the slogan adopted by the COC: "committed to ensuring a successful and memorable Congress".

From the very first day of their arrival in Kuala Lumpur, the delegates were impressed by the overall organization of the Congress. The smooth registration process, logistics arrangements in meeting rooms and services rendered at the Computer Centre and Information Counter left good impressions on the delegates. More importantly, assistance and arrangements provided by the Speakers' Service Centre and Congress Information System (CIS) constituted a fine contribution to the Congress. The CIS continues to provide crucial data of the entire Congress, and its generic framework will be beneficial to IUFRO and future Congress organizers in particular. The Congress daily bulletin "Belantara" religiously kept delegates up-to-date with the latest news and activities of the Congress and snapshot photos of events.

The material for this Congress Report was compiled and prepared by the Secretariat of the Congress Organizing Committee with kind contributions from the chairmen of various sub-committees who were responsible for their respective sections. The excellent translation work was done by the IUFRO Secretariat, for which I am grateful. Finally, I must thank everyone who has assisted wholeheartedly in the preparation of the Congress and this Report for their strong commitment and fine contributions.

Abdul Rahim Nik
Chairman of the XXI IUFRO World Congress Organizing Committee
Kuala Lumpur

Opening and Closing Ceremonies

Opening Ceremony
7th August 2000

The Opening Ceremony took place in the Merdeka Hall of Putra World Trade Centre (PWTC) and was attended by an audience of about 3,000. The ceremony was divided into two parts. The first part comprised the official events. During his welcome speech, Dato' Dr. Abdul Razak Mohd. Ali, the Chairman of the Congress Steering Committee, expressed Malaysia's pride in being the first developing country to host this prestigious international Congress.

Professor Jeffery Burley, the IUFRO President, said that the theme 'Forests and Society: the Role of Research' was timely in view of the increasing demands on forests and their products and the need for researchers and policy-makers to enter into closer dialogue.

In his opening speech, Dato' Seri Dr. Lim Keng Yaik of the Ministry of Primary Industries, Malaysia, delivered the Prime Minister's address and offered a warm welcome to all participants. The Prime Minister expressed concern about the glaring vacuum in the global agenda on forestry relating to legal instruments on forests. He urged the developed countries to furnish the financial and technological assistance to the developing countries in order to achieve sustainable management of their forests.

Minister of the Primary Industries, Dato' Seri
Dr. Lim Keng Yaik, declared the IUFRO Congress opened.

Besides speeches, there was the presentation of Honorary Membership to two distinguished members of IUFRO, namely Professor Dr. Franz Schmithüsen from Switzerland and Dato' Dr. Salleh Mohd Nor from Malaysia. There was also a special ceremony for launching the commemorative Congress stamps and the First Day cover.

The second part consisted of the award presentation ceremony for Scientific Achievement Awards and Outstanding Doctoral Research Awards. This was followed by a speech by Dr. Hosny M. El-Lakany, the Assistant Director General of FAO, who emphasized that close cooperation between IUFRO and FAO has enabled the smooth flow of information and knowledge in a multi-channel network. The Keynote Address entitled "Sustainable Management of Natural Resources" was delivered by Tan Sri Razali Ismail of Malaysia. He stressed the great extent and seriousness of the earth's destruction through human activities and outlined the various aspects of sustainable management as the solution to these inter-related problems.

Launching of the Congress Commemorative Stamps

Presentation of IUFRO Honorary Award to Professor Dr. Franz Schmithüsen

Winners of the Outstanding Doctoral Research Awards

Winners of the Scientific Achievement Awards

Closing Ceremony

12th August 2000

The closing ceremony was held on the last day of the Congress in the Merdeka Hall of PWTC. It was attended by almost 2,000 persons comprising the participants, Secretariat members and Congress assistants. In his speech, Professor Jeffery Burley thanked all participants and members of the Organizing Committee for a job well done. Dr. Abdul Rahim Nik in his capacity as Chairman of the Organizing Committee thanked the IUFRO Board for entrusting the job to him and the hundreds of volunteers and Congress assistants for supporting him.

The ceremony proceeded with the presentation of the Best Poster Awards. Dr. John Youngquist read the citations and Dr. Eric Teissier du Cros presented the awards to the ten winners. Mr. Jean Menetrier of Forestry Canada was announced as the winner of the IUFRO logo competition.

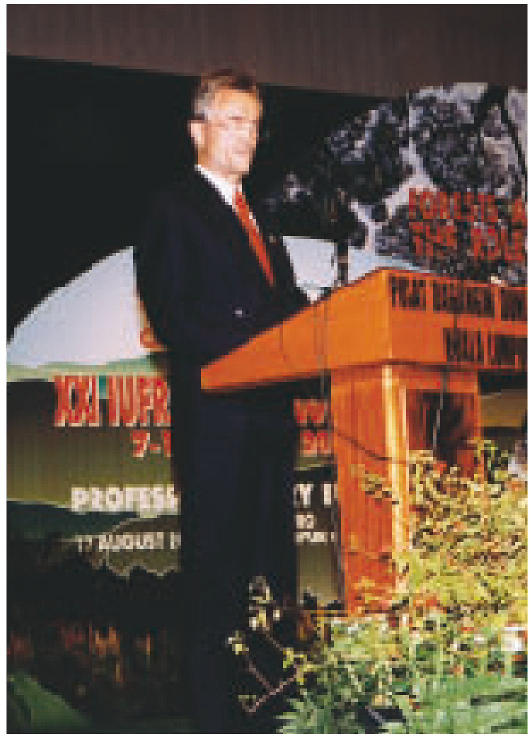
In recognition of their outstanding contribution, two awardees, namely Dr. Abdul Rahim Nik from Malaysia and Dr. Fujio Kobayashi from Japan, received the Distinguished Service Award from the Secretary of IUFRO.

In a short statement, Dr. Mohammed Ellatifi from Morocco thanked the organizers on behalf of the SAP recipients for having made their participation possible through funding.

The Congress Resolutions were presented by IUFRO President Professor Jeffery Burley. The President announced the new line-up of the Executive Board for the period 2001-2005 and introduced them on stage. The President-elect,

IUFRO Presidents and the President-elect R. Seppälä from left to right:
Risto Seppälä (Finland), Jeffery Burley (UK), M.N. Salleh (Malaysia), Robert Buckman (USA), Dusan Mlinsek (Slovenia), Walter Liese (Germany)

Dr. Risto Seppälä, presented his speech and revealed his vision for IUFRO in the next five years.



The President then announced Australia as the next host country for the IUFRO World Congress 2005. A spectacular performance on the Didgeridoo was given by an aborigine of Australia who welcomed all delegates to Australia in 2005 in his aboriginal language, which was translated into English. A video show of Australia and a speech by Professor Russell Haines, Chairman of the COC of the XXII IUFRO Congress 2005, followed.

The IUFRO flag was lowered and folded by four foresters from the Forest Research Institute Malaysia. Dr. Abdul Rahim Nik as Chairman of the Organizing Committee handed the flag to Professor Jeffery Burley who then handed it to Professor Russell Haines of Australia.

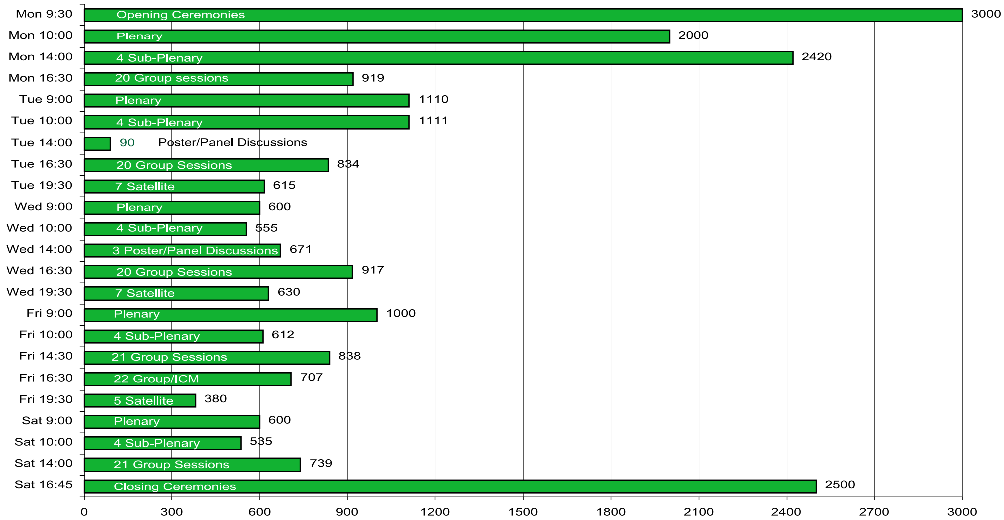
The organizing members from both the IUFRO Secretariat in Vienna and Malaysia were given a round of applause from the participants for successfully organizing the Congress. The Congress was officially closed by Professor Jeffery Burley who expressed thanks to all who had contributed to the IUFRO activities during his tenure and congratulated the new Board members and the new President on their appointment.

The new line-up of the IUFRO Board (2001-2005)

Scientific Programme

The scientific programme comprised five Plenary Sessions, 20 Sub-plenary Sessions and nine Task Force Sessions, which were cross-divisional. A total of 619 papers were presented as oral presentations in 146 sessions over the week, including 21 additional papers and another 527 papers presented during two poster exhibition sessions. This time posters were given strong emphasis in order to provide more opportunity for scientists to present their research findings. The fifth day of the Congress (Friday, 11th August) was the busiest day when 42 concurrent sessions were held. The level of participation in various sessions and the popular sessions are portrayed in Tables 1 and 3.

Table 1. Number of delegates participating in various scientific programmes



Plenary and Sub-Plenary Sessions

During the Plenary and Sub-Plenary sessions, no other sessions took place. On average more than 1,000 delegates attended the Plenary Sessions, and 300-350 participants were present in each of the Sub-plenary sessions. Altogether, five papers were presented in the Plenary Sessions and 99 in the Sub-Plenary Sessions.

All the Keynote Papers, except one, are published in this Congress Report. All the Sub-plenary papers have already been published in Volume I of the Congress Proceedings. In addition, the abstracts of the papers presented during the Group Sessions were published in Volume II of the Congress Proceedings.

Volume III of the Congress Proceedings contains the Abstracts of all Posters scheduled to be presented at the Congress. A CD of the three volumes of the proceedings had been produced and was distributed to participants during the Congress.

Group Sessions

The Congress Group Sessions were jointly organized by the IUFRO Divisions or Research Groups and Working Parties while Task Force Sessions were organized by their respective Coordinators. There were altogether 121 technical sessions with 521 papers presented, including nine Task Force Sessions. The number of Congress Group Sessions and papers by Divisions are given in Table 2, while the five most popular sessions in each Division are indicated in Table 3. The session on "Future of breeding and plantations in a sustainability-oriented world" of Division 2 attracted the largest number of participants in the Congress. Lists of additional papers were presented in various sessions with the details given in the Table 4. In addition, SPDC organized two sessions/workshops in cooperation with the BIO-REFOR project.

Table 2. Number of Congress Group Sessions and papers presented by Division.

Division	Number of Congress Group Sessions			Number of Papers Presented
	Technical	Business	Total	
1	8	5	13	29
2	11	5	16	41
3	12	10	22	44
4	18	4	22	89
5	17	14	31	82
6	18	11	29	87
7	10	1	11	45
8	16	5	21	63
TF1	1	0	1	4
TF2	1	1	2	5
TF3	2	1	3	6
TF4	1	0	1	3
TF5	1	0	1	5
TF6	1	0	1	3
TF7	1	1	2	4
TF8	1	0	1	5
SPDC	2	0	2	6
Total	121	58	179	521

Table 3. The five most popular session themes by Divisions

Division	Theme	Number of participants
Division 1	- Tropical forest restoration (I) (poster/panel sessions)	136
	- International markets for carbon sequestration from tropical forests	90
	- Tropical forest restoration. Poster/panel discussion (II)	75
	- Tropical silviculture	70
	- Short rotation forestry for biomass production (I)	40
Division 2	- Future of breeding and plantations in sustainability-oriented world (II)	150
	- Genetic improvement	75
	- Vegetative propagation	52
	- Seed physiology and technology	47
	- Physiology of tropical and temperate trees	45
Division 3	- Forest operations in the tropics	75
	- Harvesting, wood delivery and utilisation (I)	68
	- Forest operations under mountainous conditions	45
	- Forest operations and environmental protection	38
	- Small-scale forestry	38
Division 4	- Effects of environmental changes on forest growth	95
	- Sustainable forest management under conditions of growing global pressures	77
	- Using models for forest growth and stand dynamics to evaluate sustainability (II)	75
	- Forest resources assessment 2000	65
	- Integration of GIS and remote sensing for assessment of forests and landscapes (II)	63
Division 5	- Production and utilization of bamboo and related species. Challenges for the new millennium	75
	- Non-wood forest products (I)	60
	- Wood quality (I)	60
	- Composite and reconstituted products	53
	- Forest products marketing	52
Division 6	- Sustainable land use as precondition for sustainable forestry	68
	- Bridging the gap between monetary and non-monetary valuation of environmental amenities	61
	- Modelling forest managers environmental decisions	55
	- Tropical forest history	50
	- Research driven by scientists' wish or society's demand?	50
	- Poverty and management of forest resources	50
Division 7	- Biological invasions as agents of global change (II), Management	62
	- Insect pest problems in replanted forests (II)	52
	- Insect pest problems in replanted forests (I)	46
	- Mechanism of tree resistance to phytophagous insects	45
	- Biological invasions as agents of global change (I), Ecology	38
Division 8	- Biodiversity	92
	- Forest fire (III). Temperate and boreal forests. General discussions. (poster/panel sessions)	50
	- Forest environment in general (II)	46
	- Human impacts on tropical rain forests with long term view	35
	- Site (I)	34

Table 4. Listing of Additional Papers Presented in Group Sessions

Session	Author(s) /Papers
4.01.03/4.11.00	a) Valerie LeMay and Christina Kovacs – Relationship of stand structural diversity to common stand measures.
8.08.00	a) Guiseppe Scarascia Mugnozza – Effect of atmospheric carbon dioxide enrichment on cultivated ecosystems - A phase on short rotation intensive Poplar plantations.
5.11.00	a) Karki M. - Biopartnership as a sustainable strategy for management of medicinal plants.
8.00.00	a) Alain Franc – Ecology and Forestry. b) Johann Goldammer – Global Fire. c) Folke Anderson - European Network for research into forest ecosystems. d) Boyle J. – Site definition in relation to forest ecosystems.
T5	a) Fred Watson , Lawrence E. Band and Lars L. Pierce – Hydro-ecological modelling of the impact of environmental change on forest ecosystems at the watershed scale. b) Michele Akeroyd – The use of stable isotope of water and carbon for investigating pant water use strategies.
6.15.00	a) Helene Lundkvist – Quality assurance in forestry education – The Swedish case. b) André Breytenbach - The role of student organisation in improving education.
Sub-plenary E3	a) Carol Colfer – Cultural diversity in forest management (Paper presented by Maffa).
3.07.00	a) Richard Parber – Centre for occupational human factors and ergonomics – New Zealand. b) Seca Gandaseca & Tetsuhiko Yoshimuna – A study on productivity and work loads of natural forest harvesting in central Kalimantan.
4.01.04	a) George Garther & Pablo Parysow – Accounting for interactions in hypothesis testing of simulated forest growth process model.
4.40.00	a) Colin Price – Exact values of vague products? Contingent valuation of passive use value.
5.11.00	a) Wanida Subansenee – Promotion of tropical NWFP in Thailand. b) Marion Karmann – Miombo woodland utilization by smallholders – Tanzania.

Business Meetings and Satellite Meetings

The Congress Business Meetings were organized jointly or individually by the IUFRO Divisions, Research Groups, Project Groups, Task Forces and Working Parties. There were altogether 58 Business meetings. Three evenings during the Congress week were allotted for 19 Satellite meetings organized by various forestry-related agencies, including IUFRO's Task Forces (Table 5).

Table 5. Satellite Meetings and Organizers

Title of meeting	Organization	Participants
- African Forestry Research Network: A joint partnership to promote scientific excellence & to bridge the research gap in sustainable forestry management in Africa	African Forestry Research Network (AFORNET)	50
- General Assembly	Asia-Pacific Association of Forestry Research Institutes (APAFRI)	60
- Forestry Compendium: Launch of Global Module	CABI/FRIM	100
- Challenges and Opportunities for International Forestry Research	Centre for International Forestry Research (CIFOR)	150
- Queens Award for Forestry 2000	Commonwealth Forestry Association (CFA)	120
- CO2FIX User-platform / EU - CASFOR project meeting	EU-CASFOR Project	30
- Oil Palm Utilisation Committee Malaysia	FRIM / UPM / FORIM	50
- Social & Association meeting	International Association of Wood Anatomists (IAWA)	60
- International Foundation for Science - Building Scientific Capacity in Developing Countries	International Foundation for Science (IFS)	100
- Consultation on International Rattan Research and Development Needs	International Network of Bamboo and Rattan (INBAR)	50
- Shaping an Information Service on the Forest Genetic Resources	International Plant Genetic Resources Institute (IPGRI)	30
- ITTO and the Promotion of Sustainable Forests	International Tropical Timber Organization (ITTO)	125
- How can gender research contribute to a more sustainable forest management?	Pilot Group: Gender Research in Forestry (Women & Forestry)	100
- Side meeting on Secondary Forests in Tropical Asia	Secondary Forests Management Group - CIFOR	50
- Consolidation of IUFRO Chapter for Indian Scientists	The Indian Society of Tree Scientists	100
- CITES and Agarwood Use and Trade	Trade Records Analysis of Flora and Fauna In Commerce (Traffic)	60
- Logistics	Wood Logistics Club	40
- How can global research by WFSE sustain forest development	World Forests, Society and Environments (WFSE)	120

Poster Presentations

Scientific posters were given emphasis in this Congress as they play an important role in facilitating scientific exchange besides oral presentations. To highlight this effort, the "IUFRO Best Poster Award" was offered to one poster per IUFRO Division and one for the pooled posters from Task Forces. Abstracts of accepted posters were published in the third volume of the proceedings that were distributed to participants during registration.

About 55% of the originally anticipated participation of 953 posters were eventually displayed (527 posters in total). The breakdown of acceptance and withdrawal per Division, Task Force, Poster/Panel is shown in Table 6. There were also 14 new posters presented as listed in Table 7 (walk-in registration). The IUFRO delegates showed considerable interest in the Poster Exhibition and filled the hall on both days to catch a view of the multitude of topics presented as posters.

In addition, this Congress saw the introduction of two interactive poster/panel sessions held in meeting rooms, one for a Group Session and the other one for sub-plenary discussion. These were therefore treated as relatively lengthy oral presentations of individual posters (rather than papers), or a version of oral presentations.

Table 6. Posters by Divisions

Poster category	# posters presented	# withdrawn
Div. 1	40	28
Div. 2	44	39
Div. 3	35	9
Div. 4	43	57
Div. 5	136	100
Div. 6	75	38
Div. 7	60	47
Div. 8	46	64
Task Forces	8	17
Interactive poster/sessions	26	27
New (walk-in) posters	14	na
TOTAL	**527**	**426**

na=not applicable

Table 7. A List of additional poster titles

1.	Investigation on poplar short rotation systems in Iran by A. R. Modir-Rahmati, A. Hemmati and R. Ghasemi.
2.	Investigation on influence of overstory on pasture dry matter yield by Hossein Arzani.
3.	The manufacturing of particleboard from poplar wood produced under short-rotation forestry in Iran by Hosseinzadeh A., Nourbakhsh A., Golbabaei F. and Hosseinkhani H.
4.	Integrated pest management of wild pistachio in Iran by H. Askary, E. Sadeghi and R. Omid.
5.	Large-scale rainforest rehabilitation for CO_2 sequestration in Sabah, Malaysia: a case study on INFAPRO since 1992 by Yap Sau Wai, Pedro H.Moura-Costa and Igino M. Emmer.
6.	Growth Performance of Schizostachyum lumampao (Blanco) Merr. Planted by seeds after 24 years, by Aida Baja-Lapis.
7.	Efficient modelling of stem curves by Jouko Laasasenaho, Heikki Karttunen and Mark-Leo Waite.
8.	Survey of fungal biodiversity on wood packaging imported into New Zealand by Robin Janson, Arvina Ram, Shona Duncan, and Roberta Farrell.
9.	Succession and biodiversity of macrofungi and vegetation on Scots pine stand after forest fire in eastern Finland by Kauko Salo.
10.	The conceptual frames of the close-to-nature forestry in Slovenian forest wilderness by Milan Hocevar, David Hladnik and Marko Kovac.
11.	Hyrcanian forests (North of Iran), the unique ecosystem in the Near East Region by Khosro Sagheb-Talebi.
12.	Dormancy-breaking and storage strategies of Prunus campanulata maxm. seeds by Ching-Te Chien.
13.	Response of Casuarina seedlings to Frankia inoculation and nitrogen fertilization in sandy and calcareous soils by Kamel Dawh, A.E., Abd. El-Dayem, A., Awad, A.E. and Kamal, H.M.
14.	Determining an integrated information base on forest stands as a basis for the strategy of sustainable forest management by Karoslav Simon and Karel Drapela.

Speakers' Service Centre (SSC)

The Speakers' Service Centre (SSC) was the focal point for the speakers at the Congress. Its main functions were to assist the speakers to finalize and to preview their presentations. Several LCD projectors and slide projectors were available for the speakers for this purpose. For those presenting with slide projectors, slide trays were made available. Digital presentations were copied on CDs according to sessions.

The speakers were requested to report a day before their presentation in order to avoid last-minute haste.

Generally speaking, the SSC was well accepted by the participants and the system developed was effective and beneficial as there were no delays due to technical or logistics problems associated with the use of the AV equipment.

Summaries of the Keynote Addresses

The theme of the Congress, 'Forests and Society: The Role of Research', was eloquently elaborated in five selected topics of keynote addresses: Sustainable Management of Natural Resources; Forests and Society Needs; Changes in Environment and Society; People Issues in Forest Management; and the Global Vision of Forests and Society. The five renowned speakers highlighted new visions for forestry and forestry research as we enter the new millennium. They further stressed the close linkages between forests and society as exemplified by the above theme of the Congress.

Mr. Razali Ismail, currently a special adviser to the Prime Minister of Malaysia, offered his thoughts on the sustainable management of natural resources, while Dr. Christine Dean, currently forest geneticist at the Weyerhaeuser Company in the USA, traced on how best to match research to present and future society needs. Prof. Antonio Andaluz-Westreicher, currently teaching and researching on environmental law in Bolivia, discussed changes in the environment and the role of society in the sustainable management of the environment. Dr. Robert Lewis, who is the Deputy Chief for Research of the USDA Forest Service focused his presentation on cultural diversity in forest management. Finally, Prof. M. S. Swaminathan, who has been described by the UNDP as 'the father of economic ecology' forcefully presented a global vision of forests and society.

Mr. Razali Ismail

Sustainable Management of Natural Resources

Mr. Razali opened his speech by addressing the depth and seriousness of the earth's destruction through wanton human activity. He highlighted the close relationship and domino consequence of forest depletion, plant and animal extinction, water and air pollution and the direct impact all these impose on human survival.

He emphatically stressed that forests do not only support life systems, but actually generate and support life. The discoveries that originate from forest plants and animals have a direct implication and beneficial consequence on a variety of applications that continue to grow. World-wide forest loss is rapid and alarming and natural resources can no longer sustain this rate of destruction and degradation. This is a world-wide problem and forests everywhere are under grave threat. He mentioned that the opening of forest for agricultural expansion, and commercial logging are factors that contributed towards deforestation, although these are not the leading causes; it is rather the method of logging, the mismanagement and deforestation that are the primary causes of the problem.

Mr. Razali then outlined in his speech the various aspects of sustainable management as the solution. These are the allocation of land, establishment of a comprehensive system and maintenance of an adequate permanent forest estate as well as involving the communities that live in or near forests in decisions affecting forest conservation and development. He also addressed the perspective of economic pursuits being given precedence over sustainability of the land as an area of acute concern. It is the common people at large that suffer from the consequences, while a select few are made rich. He touched on the constant tussle between the opportunity cost of industrialization and the preservation of natural forests.

It is this, he said, which requires attention. People should be educated in order to learn about the value of forests and what they represent and then find ways to pay for their conservation and preservation. Mr. Razali said that as part of life on this earth, everybody has a role to play in sustaining the natural resources on the earth and not take more than nature can replenish. This may mean adopting life styles that are sustainable and developing an ethic of care for nature at the global, national and individual levels.

Finally, he pointed out the fact that no nation is self-sufficient and all nations stand to gain from world-wide sustainability. Unless we learn to protect the globally shared resources, all will be threatened. Mr. Razali left the audience with the poignant remark of a famous philosopher "To pluck a flower is to kill a star" and urged them to change it into "To plant a tree is to rekindle the universe".

Christine A. Dean, Peter Farnum & Mark Plummer

Science in Service to Society Matching Research to Society's Needs

This was a lively session addressing the role of science in forestry and the responsibility of the scientist to develop better ways for society to achieve its goals. The interesting and insightful views were presented in line with the argument of the " cognizant and transparent scientist" and how employing these two characteristics allow the scientist to discharge his/her social responsibilities while remaining true to the tenets of science. Also discussed were the perils of science in the real world and how scientific research has to function to contribute to social progress on a dual prong basis of offering better methods or products and helping us identify and quantify the consequences of our actions.

An eye opening slide presentation displayed very pertinent figures about demand on the forests. In 1996, the world consumed 1.5 billion cubic meters of industrial wood products, a figure that is expected to grow to 1.9 billion over the next century. Meeting the demand through harvests of natural forests would require up to 1.5 billion hectares of forestland, equivalent to 40% of the world's forests! However, growing and harvesting wood from managed forests could decrease the amount tenfold, switching to high-yield plantations would decrease it even further and reduce the forestland devoted to industrial production to two percent. The net result is "getting more from less". To this end, scientific research has allowed us to meet a growing demand from a smaller land base, creating the potential for more land remaining in its "natural" state.

An explanation was then presented on the role of forest genetics in the quest of managing to get more from less. Research associated with genetics ensures that the genetics populations are well managed and genetic potential is fully expressed and captured in the plantation. However, in today's complex society, this is rarely a simple task.

The next area that was addressed was the effect of forestry on fish habitat as there is a direct connection between these two. Diagrams were offered to portray the sets of stream characteristics measured on the ground to predict the presence or absence of fish.
"Precautionary Science" is when a precautionary principle is incorporated into a scientific practice, and encapsulating this principle is the rule: "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically".

In merging social values with science, acknowledging the importance of values, interests and passions, as well as the wisdom of proceeding cautiously, does not overthrow the existing tenets of science. Indeed, it points to a stronger role for science, as it is for the society, not the scientist that must determine what "ought" to be.

Professor Antonio Andaluz –Westreicher

Changes in Environment and Society

Professor Antonio Andaluz-Westreicher enlightened the audience about the potential for conservation of our resources with passionate references to his personal experiences in his homeland Bolivia. In an introspective and invoking address, the Professor offered an interesting walk-through of the changes in forests and how they influenced society and what deforestation implied for society. Human tragedy, said the

Professor is that when speaking of the need of keeping and using the forest in a sustainable way, many who decide every day about the future of these forests are the ones who have probably never even been in a forest.

To have “the forest experience “ alone, is one factor that opens eyes and ears to cries of need that no amount of words and explanations alone could ever aptly portray. Forests are worth by their spiritual meaning for the human soul, they “calm you, lead you to serenity and repose; they make you sit down and take possession of yourself”. This is something that does not have a price in the market, and is not merchandise for trade, therefore making it a priceless creation, deserving of protection.

Professor Andaluz outlined the existential categories of man as a distinguished being, if not from the universe, certainly from the planet, in that he is a living being, an intelligent being, a historic being, a cultural being, a being with needs, a social being and finally, an ecosystemical being. Therefore there is nothing worse than for a human being to deny himself and not recognize himself in the existential categories to which he belongs. However, this is the first unfortunate change in human society when forests change into deserts. Divorced from nature, the human soul is isolated and the divorce of man is now with man, but even more tragically, with himself.

Having lost our sense of belonging to the ecosystem, it is not strange that we give only what we have as a sense of sociability – comparing with the goods and services that are exchanged among trees in order to build the forest that makes each of them into a complete individual reality. The destiny of the forest is decided in cities, where the divorce with nature is so apparent. Towns people have forgotten how their lives depend on natural resources and have no conscious idea about the way food is produced, or how the fibres of their clothes are made, or how they enjoy electricity at the flick of a switch and water from the turn of a faucet. They, therefore, have no idea that resources will be exhausted, let alone why they should be preserved.

Attention was also called to the issue of forest burning. As the cheapest tool farmers can use, the worst environmental damage is not produced as a result of lands farmers want to burn but the areas burned that were not supposed to be burned.

In ending his concepts, an explanation was offered elaborating on trees being cut to satisfy hunger, and instead, give rise to hunger because too much has been cut. We all know that the supply of water and its different goods and services depends on harvesting, storage and regular provision of the forest. There are already too many countries all over the world which suffer from the consequences of the destruction of protective basins and water catchment areas. It is even thought that many future wars will be caused by the scarcity of water.

In closing, a brief insight was provided about the new forestry legislation in Bolivia which created the Farm Land Plan as a mandatory tool which defines the ecological easements monitored by the Forest Service. This is one of the tools that are part of the National Forestry Regime, which works to ultimately build the culture of the tree in the human soul.

Robert Lewis, Jr.

People Issues in Forest Management

Robert Louis, Jr. aimed straight at the core issues, which are shrinking forest resources, increasing world population (much of whom is poor) and the loss of forest cover due to a host of reasons. Shrinking resources have seen increasing public attention being given to a variety of global issues including climate change, ozone depletion and loss of biological diversity. “Too many people, too little land” is a common lament and in the coming decades, distribution and population growth rates will only increase pressure on global forests for both industrial products and environmental services. A major contributing factor is poverty as more than half of the world’s population and two thirds of the population in developing countries still live in rural conditions. More than 80% of the world’s population is relatively poor and relies on forest for basic sustenance – primarily fuel and land for growing crops. These factors explain the rapid loss of tropical forests (170 million hectares of tropical forest between 1980 and 1990). He also highlighted use change as another element that contributes to this issue.

The research community, he said, plays an important role in the sustainability of the world's forests. In the United States, several issues are rather unique and deserving of attention from all government, academic and private sector research perspectives, namely: tribal relations, underserved communities, environmental justice, and subsistence/dependence on natural resources. Developing world issues that require addressing include upland development, loss of indigenous knowledge, involvement of local people to solve environmental problems, fair and equitable distribution of resources, agro-forestry and managing eco-tourism.

The speaker informed the audience that the Forest Service International Programs staff have a strategy of several focus countries where several programs are managed. Amongst these programs are fire management, forest monitoring/remote sensing, forest health/invasive species, migratory species/habitat management, watershed management, protected areas/eco-tourism, sustainable forest practices, policy analysis and development and disaster assistance. Forest Service programs are conducted in countries such as Brazil, Mexico, Venezuela, Indonesia, India, China, Vietnam, Russia and others.

Forest Service (FS) scientists have been involved in international work and several FS representatives at this IUFRO Congress are leaders in their fields of expertise. The role that FS R&D plays is to provide technical assistance with many areas of expertise such as fire management, insects and disease, silviculture, wildlife management, forest products technology, inventory, monitoring and more. A certain lack of capacity prevents more areas of engagement", Robert Lewis explained.

As part of his presentation, Robert Lewis then provided a list of suggestions on a few research areas for the science community. These were Preservation and Restoration of Indigenous Knowledge in a bid to capture the knowledge base of the environment and how to sustain it, and Community Forestry to engage the people's participation through research and an understanding of what people want and their ideas for co-management of the land.

From an economic development point of view, more research is needed in the areas of forestry and special forest products that provide options to local people, regardless of country or region of the world. In closing, he said that there is no doubt that research and development will play a larger role in sustaining the world's forests and the contributions go beyond technological and ecological fields.

Prof. M.S. Swaminathan

A Global Vision of Forestry and Society

Dr. Swaminathan began his address by highlighting the significance of 'trees" and in a collective term the 'forest' as a whole and its importance to mankind. The importance of tree has long been ingrained in the ancient civilizations of the world where inscription of trees are seen in ancient places of worship and also in literatures. As a point in case he focussed on the mangrove forests and how important such forests are in not only mitigating floods but also conferring multiple benefits to coastal communities. He pointed that in the past there has been indiscriminate cutting of such forests and now the awareness of its importance has led to the rehabilitation of such forest types.

He next went on to touch on issues relating to the new frontiers of science, with specific reference to climate, forest and crops. The ability to accurately predict cyclone movement with satellite imageries was highlighted in his talk using the images of the movement of the super-cyclone over Orissa coast in October 1999. He further touched on the great strides that have been taken in the field of biotechnology and the opportunities this new emerging field has to offer for the betterment of mankind. He spoke of the potential of the movement of genes across species and genera levels. Of interest, he highlighted the movement of salinity tolerance genes from mangrove trees to the mustard plants. He elaborated on the present strides in molecular breeding with special reference to marker technologies, genetic linkage maps and genetic fingerprinting technologies that are currently making available very vital information of specific gene traits that can be used to manipulate plants in favor of mankind. In this regard, he proposed an urgent need for the establishment of Gene Resource Centers where candidate genes and genotypes of useful value can be identified from different species, which can be isolated, enhanced and utilized in novel genetic combinations in specific problem solving breeding programs.

His next sequence of thoughts touched on the recent global initiatives such as the Agenda 21, Framework Convention on Climate Change and the Convention on Biological Diversity. Along these initiatives, he emphasized on the significance of carbon sequestration, human population in bio-diversity hotspots and biosphere reserves. He proposed that there is a need to integrate in situ, ex-situ and community gene conservation and management activities, to provide a holistic approach towards conservation of gene resources.

His next pertinent thought touched on bio-ethics and the need to give recognition to the contributions made by the indigenous people towards conservation. He eluded to the fact that there should be a shift from bio-piracy to bio-partnerships when useful gene resources were taken into commercialized products. On the issue of patents and the need for a fair mechanism to the sharing of profits, he strongly concurred on the needs to establish it urgently.

His thoughts next moved into the present much talked about phrase – ‘sustainable forest management’. He brought out the concept of ‘Forest Capital Index’ which he elaborated is a tool to provide a uniform numerical indicator of each nation’s current forest capital. The components of which could include items like surface area, stand biomass, net primary productivity, species richness and diversity, age class of trees, leaf area index, soil fertility including soil organic matter and health of forest stands. Following this he eluded to the concept of Agro-forestry, which he believed would be the harmonizing element of today and tomorrow agriculture and forestry. Participatory forest management, sharing of non-wood forest produce and gender considerations would be critical issues in the years to come.

In concluding he touched on the green revolution as a saviour to hunger and feeding of the mass which was an economic challenge form 1980 to the year 2000. Today the views are that of an ecological approach. There is a need for a paradigm shift where the Green Revolution of the eighties which was commodity centered will have to give way to an ever-green revolution that is integrated natural resource management centered. The evergreen revolutionary approach incorporating participatory gender sensitive management aspects, he envisions will be the global trend of forestry and agriculture of the future.

Scientist Assistance Programme

As in previous IUFRO Congresses, the organizers of the XXI Congress attached great importance to a strong representation of scientists and researchers from all parts of the world. Many promising scientists from developing and disadvantaged countries however, find it difficult to participate in such major meetings due to funding limitations. The Scientist Assistance Programme (SAP) was set up with the purpose of assisting potential participants from these countries with evident need. The programme provided funding assistance towards meeting the costs of travel, registration, board and lodging. In addition, some grantees were also sponsored to participate in one of the four Pre-Congress Workshops/Training Courses.

Funding

The SAP received funds totalling RM 935,854.00 (approximately US$ 0.25 million) from the following donor agencies :-

- Department for International Development, United Kingdom (DFID)
- Department of International Development Cooperation of the Ministry for Foreign Affairs, Finland (DIDC)
- IUFRO Special Programme for Developing Countries (SPDC)
- Malaysian government
- United States Department of Agriculture, Forest Service
- Swedish International Development Cooperation Agency and Swedish Agency for Research Cooperation with Developing Countries (Sida SAREC)

The largest contribution, 42% of the total, was received from the Malaysian government. Another major sponsor was the Special Programme for Developing Countries (SPDC).

The International Foundation for Science (IFS) separately supported the participation of 16 IFS grantees to the Congress and one of the Pre-Congress Workshops.

Pre-Congress Workshops/Training Courses

Four Pre-Congress workshops/training courses were organized with a view to attracting additional funds for SAP. A number of SAP grantees participated in three of these Pre-Congress Workshops/Training Courses:

1. Training Course on Forestry Research Strategy Formulation, Planning and Management, 1-5 August 2000.
   Organizer : Faculty of Forestry, Universiti Putra Malaysia.
2. Sustainable Forest Management and Criteria & Indicators, 1-4 August 2000.
   Organizer : Forest Research Institute Malaysia.

3. INFAPRO Workshop - Rehabilitation of Logged-over Rainforest in Sabah, Malaysia, 31 July - 4 August 2000.
   Organizer : Innoprise-Face Foundation Rainforest Rehabilitation Project.
4. Short Course on The Application of Biotechnology in Forestry, 1-5 August 2000.
   Organizer : Asia Pacific Association on Forestry Research Institutions (APAFRI).

Selection Process

All applications received by the extended deadline of 15 November 1999 were subjected to a review and ranking process, in which preference was given to candidates participating actively in the Congress through presentation of papers or posters or in some other specific capacity. In contrast to the previous Congress, scientists who did not play a role in the Congress programme were automatically excluded.

The selection criteria were drafted by the SC in consultation with IUFRO/SPDC and established by the COC for the approval of the IUFRO Executive Board. A modified scoring system modelled after the one developed for the previous IUFRO Congress in Tampere was used for guidance.

Results

The SAP supported a total of 169 grantees from 44 countries. About 92% of the grantees received full sponsorship, i.e. return air ticket, return airport-hotel transfer, costs of hotel accommodation, meal allowances, Congress registration fee, and costs for the In-Congress tour. In addition 36 grantees participated in three Pre-Congress Workshops/Training Courses.

Sixty-one of the grantees presented oral papers, 55 presented posters and another 11 had both oral and poster presentations. At least 4 of the grantees who made presentations were also coordinators of sessions.

The importance of SAP support to forestry researchers in developing countries and countries with emerging economies can be seen in the following statistics:

- representation of 6 countries depended entirely on SAP support
- participation of at least 50% of scientists from another 12 countries would not have been possible without SAP support.

Tours and Excursions

In-Congress Tours

The In-Congress Tours and Post-Congress Excursions were planned in early April 1997 after a meeting of the Sub-Committee then known as the Tours Sub-Committee. The Sub-Committee comprised five members representing the Forestry Department Peninsular Malaysia (FDPM), Faculty of Forestry, University Putra Malaysia (UPM) and the Forest Research Institute Malaysia (FRIM).

During the initial stage of the planning, Peninsular Malaysia was divided into three sectors and for each sector a coordinator was appointed. The responsibility of the coordinator was to gather and consolidate information regarding the sites of the visit. By the end of April 1997, the Sub-Committee decided that the duration of the excursions should be from three to four days, involving 14 different routes. The various routes selected were three routes for Peninsular Malaysia, two routes for Sabah, three routes for Sarawak, two routes for Southern Thailand, three routes for Indonesia and one route for Brunei.

In July 1997, representatives from the Sarawak Forestry Department and Sabah Forestry Department were invited to sit in the Tours Sub-Committee. It was also decided that the sub-committee be split into two, In-Congress Tours and the Post-Congress Excursions, respectively.

The Tours

The In-Congress Tours were held on Thursday, 10 August 2000. There were no concurrent events organized during the one day IUFRO In-Congress technical tours. There were a total of nine routes selected for the tours, which provided delegates and accompanying persons with an overview of Malaysia's forestry, forest industry and places of tourist attractions. The technical tours started at 0730 hrs and all buses departed from PWTC. Altogether 1,067 delegates and their accompanying persons from 96 countries participated in this one-day event. The number of registered participants was 1,123 (Table 8). Due to the large number of participants expected to register for this one-day tour, a professional Tour Organizer had been appointed to assist in transportation, training tour guides and officers, and making other arrangements related to the In-Congress Tours. The only problem encountered on the actual day was the delay of coach departures for some destinations at PWTC.

Short Description of the Tours

Route 1: Rubberwood Industry in Historical Malacca

This tour took the participants to two rubberwood-processing mills in Malacca. Participants were shown the processes involved and the types of products. Everything went well and a lunch at the Harbour Club followed. Participants were satisfied with the overall program and some expressed their desire to return on their own.

Route 2: Landscape, Recreation and Forestry

The tour brought the participants to two sites where major landscaping work has been done over the past few years: Paya Indah Wetland Sanctuary and Putrajaya (the new administration centre of the Malaysian Government). Participants were briefed on the Paya Indah Wetland Sanctuary as a "living experimental site" where modern research methods in environmental science and natural resource management can be applied and developed. At Paya Indah the participants were taken on a short tour of the sanctuary with stops at the biological sewage treatment plant, the boardwalk where several species of migratory birds stop during several periods of the year, the palm arboretum and also areas of natural vegetation of the peat swamp forests.

Table 8. Registration and Participation for In-Congress Tours. The breakdown during the actual event is shown below:-

Route	Theme	Registered Participants	Attended
1	- Rubberwood industry in historical Malacca.	238	233
2	- Landscape, recreation and urban forestry.	79	79
3	- The tropical lowland rainforest - research and recreation in the state of Negeri Sembilan .	99	95
4	- Sustainable forest management and wildlife conservation	156	144
5	- Plantation of Dryobalanops aromatica.	77	69
6	- Integrating forest landscape management in land development.	120	106
7	- Visit to the premier research institutions - FRIM and MRB	154	154
8	- Mangrove forest and the community	120	120
9	- Cultural heritage of the aborigines and lowland tropical forest	80	67
	Total	**1123**	**1067**

Route 3: The Tropical Lowland Forest – Research and Recreation in the State of Negeri Sembilan

This tour took the participants through forested hills and valleys, oil palm and rubber plantations, rural villages and fruit orchards, to two tropical lowland rainforest reserves designated for research and recreation. Participants also had the opportunity to experience a unique cultural dimension of Negri Sembilan with the visit to the Sri Menanti Palace and Royal Museum. In general, most participants were satisfied with the programme. One participant came forward to the microphone to thank and congratulate the organizer for the excellent arrangements and preparation at the Pasoh Field Centre.

Route 4: Forest Management and Wildlife Conservation

The tour presented an introduction to the sustainable management of forest resources and the importance of conserving wildlife species and their habitats. Officers from the Forestry Department of Selangor gave the overview briefing about the forest management system in Malaysia while officers from the Department of Wildlife and National Parks Peninsular Malaysia briefed the participants on the vision, mission, objectives and research of the department. In general the programme was good except for the late departure.

Route 5: Plantation of Dryobalanops aromatica

The tour provided participants with a general view of the design concept of the Commonwealth Forest Park. Other facilities within the park were also introduced by the resource person from the Forestry Department of Selangor. Participants then visited the crystalware centre to see the production of unique crystalware in vibrant colours. Before heading back to PWTC the tour stopped at a batik factory to observe the production of batik for various uses such as attire, curtains, handbags and attractive souvenirs.

Route 6: Integrating Forest Landscape Management with Land Development

The main theme of the tour was to show the participants that land development in highland areas needs a proper planning in order to harmonize such a development with natural landscape. The tour ended with a visit to a mushroom farm. All in all, the programme was useful.

Route 7: Visit to Premier Research Institutions: FRIM and MRB

On this tour the historical background, philosophy, mandate, mission statement, objectives, clients' charter, quality, governing board, and organizational structure of the two

Table 9. Number of Participants in the Post-Congress Excursions by Routes

Excursion	Number	Excursion	Number
Route 1	6	Route 9	39
Route 2	15	Route 10	8
Route 3	67	Route 11 (Cancelled)	-
Route 4	40	Route 12 (Cancelled)	-
Route 5	20	Route 13	15
Route 6	35	Route 14 (Cancelled)	-
Route 7	37	Route 15	9
Route 8	26	TOTAL	317

research institutions were explained by the respective institute's resource person. Other than visiting the museum in FRIM, the participants were taken through two nature trails within FRIM. In MRB, the participants were exposed to the unrivalled collection of rubber products. Through the graphic-wall display at the Exhibition Centre in MRB, participants were reminded of the significant events of the rubber manufacturing industry and the major technological breakthroughs over the past centuries.

Route 8: Mangrove Forest and its Community

The participants visited the Kuala Selangor Nature Park and were briefed about the park by the appointed resource person. They were then taken on a tour visiting some interesting features of the park (Fig tree stand, watchtower, and bird watch bunker). The tour ended with a visit to Bukit Malawati which overlooks the green belt of mangroves along the Selangor coast, thus providing a unique panoramic view of the Kuala Selangor Nature Park.

Route 9: Cultural Heritage of the Aborigines and Lowland Tropical Forests

The main theme of the tour was to show the cultural heritage of the aborigines and a portion of the lowland tropical forests near Kuala Lumpur. This route gave an opportunity to participants to learn about the aborigines and have an insight into the their lifestyle and social cultures. Participants were also briefed by the resource person about the functions of Alang Sedayu Jungle Lodge and also the remains of the five underground tunnels built during World War II. All in all, the participants enjoyed the programme.

Post Congress Excursions

A total of 15 Post-Congress Excursions were planned involving nine destinations to the various states of Malaysia (Peninsular Malaysia, Sabah and Sarawak) and six destinations to the neighbouring ASEAN countries: Brunei, Indonesia, Thailand and Singapore. However, three routes had to be cancelled due to the insufficient subscription of participants. These were Route 11 (Agroforestry and Community Forest, Thailand); Route 12 (Teak Plantation in Central Java, Indonesia); and Route 14 (Pulp-Paper Industry in North Sumatra, Indonesia).

The duration of the excursions varied from three to five days and the excursion fees varied from USD 225 to USD 855 based on twin-sharing basis. The fees covered full board, admission to the respective places of interest, transportation and accommodation. The total number of participants in the Post-Congress Excursions was 317 representing 46 nationalities. The excursions were specially organized to include visits to tourist and cultural sites apart from visiting places of technical and professional interest.

Short Description of the Excursions

Route 1: Best Managed Mangrove in Malaysia

The main theme of this excursion was sustainable management of mangrove forest. The participants visited the Matang Mangrove Forest, the famous and largest single mangrove forest in Peninsular Malaysia estimated at 40,151 hectares. The forest has been acknowledged to be the best managed mangrove forest in this country and it plays an important role in fishery production, coastal habitats for specialized trees as well as for many common, threatened and endangered species. The participants were introduced to the replanting, thinning and harvesting activities in mangrove forests and witnessed the production of charcoal from neighbouring charcoal kilns.

In Kuala Kangsar, Perak, the participants visited buildings of architectural interest – the Royal Palace, the Royal Museum and the Ubudiah Mosque. Kuala Kangsar is known as the home of the rubber industry where the first rubber seedling was planted and has survived until today. The programmes were extended further in Penang where the participants visited the Pulau Pinang Forestry Museum and the popular Butterfly Farm, the first of it's kind in the tropical region. The Forestry Museum, which is located in the Telok Bahang Recreational Forest, is a specialized museum exhibiting various activities and items of forestry interest.

Route 2: Growing Trees for the Future

In this excursion, the participants were exposed to a Multi-storied Forest Management System at Chikus Forest Reserve, Bidor, Perak. The area comprises 2,000 hectares of tropical lowland forest, of which about 750 hectares were planted with Acacia mangium. Continuing with the technical visits, the participants visited a medium density fibreboard (MDF) plant located in Merbok, Kedah. This is the largest MDF factory in northern Peninsular Malaysia with sophisticated wood processing technology, established in 1993. The factory utilized timber from plantation as raw material.

The participants also visited FRIM's Teak Research Centre at Mata Ayer, Perlis. The Centre was established in 1953, covering an area of 455 hectares. In Langkawi, Kedah the participants visited the Eagle's Square (which houses the replica of all the legends and myths of Langkawi's historical events), the Langkawi Crocodile Farm (with more than 2,500 live crocodiles of different sizes and species from all over the world) and the Craft Cultural Complex (a collection of traditional crafts from all over Malaysia), as part of their tourist visit.

Route 3: Sustainable Forest Management of Natural Forest

The main emphasis of this excursion was sustainable forest management of natural forest in forest concessions at Pasir Raja, Terengganu. The concessionaire, the Kumpulan Pengurusan Kayu-Kayan Terengganu (KPKKT) Sdn Bhd specializes in log extraction and other forest development projects managed under a sustainable forest management system. Participants were briefed on the logging/extraction methods used and research work carried out by ITTO-FRIM-KPKKT, JIRCAS (Japan International Research Centre for Agricultural Sciences) and Oikawa Motor Company Limited, Japan. Later they visited a recreation park jointly managed by the State Forestry Department, Terengganu and the KPKKT. Several topics related to the economics, importance of forest management planning and bio-diversity in practical forestry operations were also discussed. In addition, the participants were also introduced to a forest checking station's operation, a downstream wood carving industry, a well known batik handicraft industry, a cultural market and a true holiday experience at the largest man-made lake in Malaysia, Tasik Kenyir Resort, surrounded by lush green tropical rain forest.

Route 4: National Park Management and Forestry Activities

The richness of the tropical rainforest's fauna and flora in their natural habitat was the theme of this excursion. The main emphasis of the excursion was the management of National Parks and the protection of wildlife. The participants took an active part in the prearranged programme in order to have a first-hand experience in nature-related activities in the National Park. A visit to the Orang Asli or the aborigines' settlement gave an added dimension to the excursion. The importance of commercial forest plantations for sustainable timber supply was also emphasized during a visit to the Kemasul Forest Plantation, Pahang. The participants also visited a woodcraft industry where manufacturing techniques of various items were demonstrated.

Route 5: Wood Processing Industry

The first stop of the excursion at the Taman Mini Malaysia and Mini ASEAN, Melaka allowed the participants to have a glimpse of the Traditional Malaysian and ASEAN Wooden Buildings Architecture. The participants visited rubberwood processing industries in Pagoh Industrial Area, Johor, where the timber was processed and manufactured into high quality and export-oriented products including settees, dining sets and other useful items. The participants also had the opportunity to witness solid rubberwood being processed into bent wood, an item commonly used in high-end furniture.

A visit to the Nasuha Enterprise Sdn Bhd, exposed the participants to the richness of Malaysian and exotic spices and herbal plants and products. At the Gunung Ledang (Mount Ophir) Resort, they experienced the splendour and exotic of the lush and green tropical rain forest. The last place of interest visited by the participants was the Singapore Botanical Garden, where they witnessed one of the world's biggest tropical orchid collections in terms of number of species and hybrids.

Route 6: Model of Certified Forest and Orang Utan Rehabilitation (Sabah)

The participants visted the Sepilok Orang Utan Rehabilitation Centre (SORC), Sandakan. After a short briefing, the participants went to the SORC Information Centre and later observed the feeding of the orang utan at Platform A. They were also briefed on the orang utan scientific rehabilitation techniques.

At the Deramakot Forest Reserve (DFR), the participants observed the various aspects and techniques of sustainable management of tropical rainforests in Sabah, and were given a demonstration on directional felling methods to minimize logging damage. The SGS-Forestry Malaysia has certified the DFR, which cover an area of 55,000 hectares, under the Qualifor Forestry Programme in 1977. In 1989, a sustainable forest management (SFM) project, supported by the German Agency for Technical Cooperation (GTZ) was launched with the objective to develop a model forest management plan within this forest reserve.

Route 7: Biodiversity in Sustainably Managed Forest (Sabah)

Danum Valley Field Centre (DVFC), Lahad Datu, covering an area of 438 square kilometres is a private protected area representing not only a natural treasure but also serving as an opportunity for land managers and conservationists to work together to sustain the biological resources unique to tropical habitat. DVFC provided the participants with an unparalleled ecological experience of the wild and wonders of ancient tropical forests. The participants also visited the Innoprise-FACE Foundation Rainforest Rehabilitation Project (INFAPRO), which is involved in the planting of indigenous tree species in logged-over forest areas. After a short briefing, the participants took part in the tree planting ceremony to commemorate their visit to INFAPRO.

A visit to the Tilawas Forestry and Recreational Centre (TFRC) gave the participants an insight into the sustainability of establishing a forest area with fast growing tree species. The participants continued their journey to the Kinabalu Park, where they enjoyed the majestic tip of South-East Asia's highest point - Mount Kinabalu, and the richness of endemic species of flora and fauna within the park’s vicinity.

Route 8: Peat Swamp Forest Management (Sarawak)

In this route, the participants were given one whole day to visit a logging site in the peat swamp forest at Loba Kabang, Sibu. The participants had the opportunity to experience a locomotive ride (used to transport both workers and logs in and out of the forest), and observed the "kuda-kuda" system of pulling logs from the stump to the log-landing site. They also visited a particleboard mill in Sibu, which uses offcuts from other sawmills as its main source of raw material.

Other technical visits included in the excursion were the Semenggoh Wildlife Rehabilitation Centre and the Semenggoh Botanical Research Centre. A visit to the Bako National Park allowed the sighting of a proboscis monkey at the Visitors’ Day Centre and observation of the various species of Nephanthes along the trail.

Interspersed with the technical visits, the participants were taken for a walk over the typical Night Market in Sibu. The participants also visited the Sarawak Cultural Village and the Sarawak Pottery Centre in Kuching.

Route 9: Role of Local People (Sarawak)

The excursion started with a visit to the Lambir Hill National Park, 7,000 hectares of forest covered with virgin rich stands of mixed dipterocarp forests, and continued with a visit to the Latak Waterfall. The participants also visited the Canopy Biology Plot and experienced an exhilarating climb of a 40-meter tree tower from which they viewed the typical canopy structure of the forests and the scenic beauty of the surrounding hills.

The participants visited the Niah Museum at the Niah National Park, which showcased the historical, archaeological and cultural heritage of the Niah Caves. In the Great Caves, they witnessed the local communities collecting guano and harvesting edible birds’ nests. They also visited the local Penan settlements along the Melinau River and had the opportunity to meet the local people living near the Mulu National Park. Visits to the Lang Cave and the Deer Cave gave the participants an opportunity to observe the beautiful limestone formations and the awesome underground passages.

Route 10: Forest Genetic Resources in Thailand

The participants observed nursery operations, vegetative propagation of forest trees, species diversity collection and herbs and medicinal plant collections at the Songkla Nursery Centre, and silvicultural research activities at the Silvicultural Research Centre, Royal Forestry Department of Thailand. They also observed birds’ conservation and species diversity of wetland area under the Wetland RAMSAR Programme at the Wildlife Nursing and Raising Centre, Pattalung.

The participants visited a rattan seed orchard where they witnessed seed production and species conservation activities. At Ranong Biosphere and Mangrove Forest Research Centre they were briefed on mangrove research programmes with Rhizophora apiculata and Rhizophora mucronata as the main research subjects, and learned about conservation efforts for shrimps, crabs, fishes and other marine fauna. In addition, they also witnessed a traditional southern custom at the Southern Study Centre and experienced a short stay in a fishing village at Pan Yee Island.

Route 11: Agroforestry and Community Forest in Thailand (cancelled)

Route 12: Teak Plantation in Central Java, Indonesia (cancelled)

Route 13: Botanical Garden and National Park in West Java

The first excursion destination was the Bogor Botanical Garden, a living museum with the most complete collection of tropical plants in the world. Covering a land area of 87 hectares, the Garden maintains about 3,600 species of plants belonging to over 1,290 genera and 200 families. The Centre for International Forestry Research (CIFOR), located also in Bogor was the next stop of the excursion. CIFOR is an independent scientific research institution established in 1993.

The participants visited the Gade Pangrango National Park, which was established in 1980. The Park covers an area of 15,196 hectares encompassing the Cibodas Nature Reserve, the oldest forest reserve in Indonesia. The participants also visited the Mount Halimun National Park covering an area of about 40,000 hectares of tropical forests. The Park provides protection for the hydrological system, conservation of flora and fauna, conservation of ecosystem diversity, and support and opportunity for research, education and eco-tourism.

Route 14: Pulp and Paper Industry in Riau, Indonesia (cancelled)

Route 15: National Park Management in Brunei Darussalam

The excursion started with a boat ride to the Selirong Island Mangrove Park, which is famous for its mangrove forest and the Kampung Air (Estuarine Village), which offers fascinating natural scenery. The excursion continued with another boat ride to Bangar Town in a meandering water channel that is lined with mangrove forests reputed to be the largest in the region.

A boat ride from Batang Duri to the Ulu Tembulong Natioanl Park gave the participants an opportunity to witness vegetation succession and transformation, birds and other wildlife. At the National Park, the participants climbed a 65-meter high canopy walkway in order to be above the crown of the trees. At the Kuala Belalong Field Study Centre the participants experienced jungle walking in the lush and green tropical rainforest. They also visited a waterfall area along the Apan River and later enjoyed shooting the rapids with inflatable rafts.

Accmpanying Persons' Programme

Organizational Preparation

The Accompanying Persons' Programme was a "tailor-made" tour package offered only to accompanying persons of IUFRO Delegates throughout the Congress week. Thus, each package was very special and unique in order to attract the interest of participants. In addition, these tours avoided competition with and duplication of those offered by normal tour operators.

In general, the sites selected for this programme largely complied with the Congress Theme "Forests & Society: The Role of Research." Even in the City tour, the participants were able to appreciate the forest environment during their visit to an urban Forestry Park in Kuala Lumpur City Centre. A total of ten tour packages were offered to accompanying persons and delegates.

Short Description of the Tours

Package 1: CITY TOUR …full day tour
Days: Tuesday, Wednesday & Friday

Malaysia presents an exotic blend of the old and the new. Despite the rapid change towards the modern lifestyle and advanced technology, Kuala Lumpur still retains its old world charm as depicted in the majestic buildings from the colonial era, quaint pre-war shop-houses and the way business is conducted. In order to get a first impression of KL, the participants took the opportunity of touring the city one day long and saw: Merdeka Square, National Monument, KL Lake Gardens, Orchid & Hibiscus Gardens, Kuala Lumpur Bird Park, National Mosque, King's Palace, National Museum, Commercial Centres, Kuala Lumpur City Centre (KLCC), Kuala Lumpur Tower and Central Market.

Package 2: FRIM & Batu Caves … Nature Tour I
Days: Tuesday, Wednesday, Friday & Saturday

About seventy years ago the Forest Research Institute Malaysia grounds were little more than abandoned tin mine pits, vegetable gardens and shrubby forest. Since 1926, foresters and scientists have nurtured the forest back to life into a serene forest with inspiring trees. Apart from the scientific value of the forest, shady park-like arboreta as well as nature trails are available for educational walks. Visitors were able to experience the Ethnobotanical Garden, an introductory of forestry in Malaysia, Keruing Nature Trail, FRIM Museum, Dipterocarp Arboretum/ Traditional Timber Houses and Sungai Kroh picnic area.

Besides, delegates also visited the limestone formation of the Batu Caves situated about 13km north of Kuala Lumpur. The best known of these caves is the Temple Cave, a large cavern with a vaulted ceiling about 100m above the floor. To reach it, one has to climb 272 steps, a feat performed by many Hindus to offer prayers to their revered deities.

Package 3 : Bukit Cahaya Seri Alam … Nature Tour II
Days: Tuesday, Wednesday & Saturday

The participants visited Bukit Cahaya Seri Alam Agricultural Park, the world's only agro-forestry park located at the Selangor State Capital, Shah Alam. It is a vast complex of landscaped floral gardens, agricultural plots, orchards, lakes and dense jungle. All these are set within a luscious tropical rainforest in a scenic 1,290-hectare site. On the theme of agriculture, the park also includes a rice-field where from time to time a demonstration of rice planting takes place. Here is a place to learn all about trees and their names! A rock garden, a formal garden and a kitchen garden are among the attractions that can be found in the park. As one of Malaysia's most popular parks, it has various facilities for accommodation, camping and picnic areas, public amenities and scenic natural trails throughout the area.

The tour then cruised around Shah Alam, the state capital of Selangor Darul Ehsan and the " Blue Mosque" - Masjid Sultan Salahuddin Abdul Aziz Shah (State Mosque).

Package 4 : Twinkle-twinkle Fireflies
Days: Tuesday, Wednesday & Friday

This tour started in the afternoon and included visits to the historical hill of Bukit Malawati and a boat ride along the Kuala Selangor riverbank to watch the fireflies displays in the late evening. The tour continued to Kampung Kuantan where the fireflies are found. As the sun sets, these fireflies begin to flash simultaneously at a rate of three flashes per second. In so doing a fascinating spectacle similar to a flashing Christmas tree is created. The participants enjoyed this wonderful sight.

Package 5: Alang Sedayu Jungle Lodge… a perfect getaway from the city.
Days: Tuesday, Wednesday & Friday

This is an attractive destination and also an ideal escape from the city where nature and tranquillity wait in a most unique setting. It was a perfect getaway for raw adventures and an intimate rendezvous with nature.

The Jungle Lodge, situated in a natural setting with primary forest on one side and the crystal clear stream on the other side, makes it an attractive blend of elegant kampong or village style surroundings and city convenience. The clean, cool, fresh air is matched by the quiet serenity of its natural surroundings and radiates a totally relaxed mood. The Jungle Lodge provides the sheer beauty of nature, the tropical forest with its varied flora and fauna, featuring waterfall amidst lush greenery and an insight into the cultural activities of the local people. Other features include a taste of Malay traditional games and pastimes, a lively performance of the aboriginal tribe, a blowpipe demonstration, fishing, the freedom fighter tunnel, collecting local tropical fruits, bird watching, refreshing swims in the river and a buffet lunch. After a gruelling adventure in the wild it is time to savour the delightful culinary creations of Malaysia served at the Jungle Lodge.

Package 6 : Malacca … a legacy of history and charm
Days: Tuesday, Wednesday & Friday

This was one of the popular tours. Malacca blends a rich historical past and a vibrant present. Many of its century-old buildings, some of them still in use, can be traced back to its early inhabitants. The tour gave the participants a unique opportunity to discover: Mini Malaysia, Ayer Keroh, the Peranakan Restaurant, the Baba & Nyonya Heritage Museum, Harmony Street, Antique Street/Jonker Street, Stadthuys – Dutch Town Hall, St. Paul's Cathedral/St. Paul's Hill, Porta De Santiago/A Famosa, Malacca's Sultanate Palace (a replica) and Padang Pahlawan/Proclamation of Independence Memorial.

Package 7 : Malaysian Handicrafts
Days: Wednesday & Friday

The legacy of Malaysia's arts and crafts springs from the mighty fountainhead of an age-old heritage of aesthetics and creative temperament. Arts and crafts are a mirror to the soul of the nation, giving shape and solidity. During this tour the participants visited Royal Selangor Pewter famous in the world for its manufacture of Malaysian Pewter, Embroidery Centre, Batik Factory, Handicraft Crystal and Glass Centre and Kompleks Budaya Kraf Kuala Lumpur.

Package 8 : Shopping Spree
Days: Friday & Saturday

Kuala Lumpur is a shopper's paradise, offering a wide variety of goods at reasonable prices. Modern shopping complexes provide numerous facilities for the comfort and convenience of shoppers. The stores display a wide range of goods rivalling that of major cities elsewhere, catering to every taste and budget. Delegates were able to experience shopping from the high-class shopping malls to bargaining stores. Among the places to go there are Suria KLCC, Lot 10, BB Plaza, Sungei Wang Plaza, Central Market, and China Town.

Package 9 : City Tour…a half-day tour
Days: Monday & Saturday

On this perfect half-day tour that only took three hours the participants passed through the busy centre of the town and visited some famous points of interest in Kuala Lumpur such as: Kompleks Budaya Kraf Kuala Lumpur , China Town, Central Market, Merdeka Square, National Monument, National Mosque, Railway Station and King's Palace.

Package 10: Banghuris … experience the country life
Days: Tuesday & Wednesday

The participants experienced the life of a typical villager, the hospitality, culture and tradition of the Malays at Banghuris. This place is made up of three neighbouring kampung (villages), namely Kampung Bukit Bangkong, Ulu Chuchuh and Ulu Teris. The participants were able to get to know the typical friendly villagers and their traditional way of life and were warmly greeted by the village folks. They were shown a performance of Malay martial art – silat, the cottage industry of making traditional Malay delicacies, press flower craft, an orchid farm, a medicinal landscape garden, "Jambu Air" (water apple) farm, an oil palm plantation, traditional 'tempe' making, and a local Malay house. Then they enjoyed the Bagan Lalang seaview.

Exhibitions and Events

Exhibitions

The World Forestry Exhibition was held from 7-9 August at Legar Putra, Level 2, the Putra World Trade Centre. This exhibition was jointly organized with a private event organiser, in conjunction with XXI IUFRO World Congress. A total of 42 organizations from the private sector, government institutions and non-government organizations participated in the exhibition (Table 10) representing 14 different countries. The exhibition was officially opened by the Minister of Primary Industries of Malaysia.

The response from delegates and the public was encouraging. This three-day event displayed on about 572 square meters exhibited many aspects of forestry and forest industries in terms of new products, technical publications, research findings and conservation activities. Besides the Congress delegates, this Exhibition was open to the general public. The IUFRO Secretariat and the Congress Organizing Committee were given six-exhibition booths to share their information and products.

Special Events

In conjunction with the Congress, several events were organized to mark the Congress. These special events included the launching of commemorative stamps, a tree planting ceremony, the Presidential Reception and the EB working luncheon.

Launching of commemorative stamps

A set of commemorative stamps was produced in cooperation with Pos Malaysia. The stamps were launched during the opening ceremony on 7 August 2000. The stamps are unique in the sense that they represent the major trees of the tropical forests. Both scientific and local names of the species were printed on the stamps. Stamps showing different shapes of trees (*Samanea saman, Fagraea fragrans, Dryrobalanops aromatica, Terminalia catappa* and *Dracontomelon dao)*, shapes of leaves (*Heritiera javanica, Endospermum diadenum, Macaranga gigantea, Licuala grandis* and *Johannesteijsmannia altifrons*), types of tree barks (*Shorea leprosula, Ochanostachys amentacea, Dryrobalanops aromatica, Pterocymbium javanicum* and *Dipterocarpus costulatus*) and types of seeds (*Hopea odorata, Adenanthera pavonina, Shorea macrophylla, Dyera costullata* and *Alstonia angustiloba*) were sold to the delegates and to the public. Brief information on the above stamps was contained in a special bi-lingual (English and Malay) Congress brochure, published by Pos Malaysia. The stamps printed were sold out within a week in Malaysia.

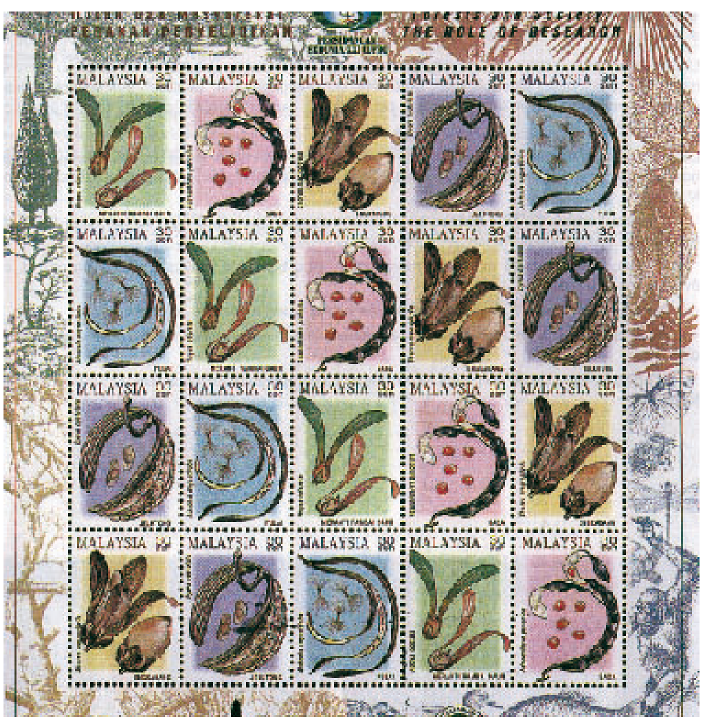


Table 10. Participating Agencies and Countries of Origin

No.	Exhibitor	Country
1.	APAFRI	Malaysia
2.	Asian Timber/First Asia Publishing Pte Ltd.	Singapore
3.	CABI Publishing	United Kingdom
4.	Canadian High Commission	Malaysia
5.	CIFOR	Indonesia
6.	CIRAD-FORET	France
7.	Delta-T Devices Ltd	United Kingdom
8.	Elsevier Science	Netherlands
9.	European Forest Institute	Finland
10.	FORAD	Australia
11.	Forestry Department of Peninsular Malaysia	Malaysia
12.	Forest Department Sarawak	Malaysia
13.	Forest Research Institute Malaysia	Malaysia
14.	Future Harvest/CGIAR	Malaysia
15.	GTZ GmbH	Malaysia
16.	Haglof Sweden AB	Sweden
17.	Innoprise Corporation Sdn Bhd	Malaysia
18.	International Foundation for Science	Sweden
19.	International Network for Bamboo and Rattan	China
20.	International Tropical Timber Organisation	Japan
21.	IUFRO	Austria
22.	Malaysian MDF Manufactures Association	Malaysia
23.	Malaysian Nature Society	Malaysia
24.	Malaysian Timber Council	Malaysia
25.	Malaysian Timber Industry Board	Malaysia
26.	METLA – Finnish Forest Research Institute	Finland
27.	National Board of Forestry, Sweden	Sweden
28.	National Timber Certification Council, Malaysia	Malaysia
29.	Palm Oil Research Institute of Malaysia	Malaysia
30.	Queensland Forestry Research Institute	Australia
31.	Regent Instruments Inc	Canada
32.	Regional Centre for Forest Management	Malaysia
33.	Relaskop – Technik	Austria
34.	Sabah Forestry Department	Malaysia
35.	Scandinavian Journal of Forest Research	Norway
36.	Stora Enso Forest Consulting	Finland
37.	Trelleborg SEA Pte Ltd	Singapore
38.	TropBio Group of Companies	Malaysia
39.	University Putra Malaysia	Malaysia
40.	Wageningen University	Netherlands
41.	WWF Malaysia	Malaysia
42.	YPJ Publications and Distributions Sdn Bhd	Malaysia

Tree Planting Ceremony

The Tree Planting ceremony has a long Congress tradition and was an auspicious way to mark the XXI IUFRO World Congress Kuala Lumpur. There were representatives from about 90 countries, and each of the International Council Members representing his/her country planted a tree. Invited honourable guests were Professor Jeffery Burley (The President of IUFRO), Tan Sri Rama Iyer (Chairman of the Malaysian Forestry Research and Development Board), and Mr Ishak Mohd Yusof (Senior Vice President, Bumiputra-Commerce Bank Berhad).

The Tree Planting was held at Taman Tasik Permaisuri, Kuala Lumpur, on 12 August 2000. Three buses were hired to ferry the members of IUFRO's International Council, EB members and members of the FRIM Directorate to the destination. This memorable event was jointly organized by the City Hall of Kuala Lumpur, FRIM, and the Congress Organizing Committee.

Five types of Malaysian native tree species were selected for this occasion: *Dyera costulata* (Jelutong), *Dryobalanops aromatica* (kapur), *Mesua ferrea* (Penaga Lilin), *Aqualaria malaccensis* (Karas/Aloes wood) and *Neolitsea zeylanica*
(Medang pasir).

Presidential Reception

This reception was held on 11 August 2000, one day before the closing ceremony. A total of 220 guests (EEB members, COC, Congress Secretariat, IUFRO Secretariat and other invited guests) attended this special function, hosted by the IUFRO President.

EB Working Luncheon

This special lunch took place on 12 August 2000, the last day of the Congress. It was a working lunch attended by the out-going and in-coming EB members. Pertinent matters and decisions were made during the meeting, including the appointment of Division Co-ordinators and their Deputies and the formation of new working parties. The President also handed the certificate of appreciation to COC and CS members for their contribution to the Congress organization.

Press and Publicity

Publicity in International Meetings

Congress promotion activities were carried out as early as in 1995, during the XX IUFRO World Congress in Tampere, Finland. A video presentation of Malaysia was shown to the delegates and information as well as souvenir items were given out. This was followed by the distribution of the first Congress announcement (1997), the Congress Information Package (1998), and the Congress Registration Package (1999). All the information was also distributed at major international/local meetings such the Commonwealth Forestry Congress (1997), World Forestry Congress (1997), and IUFRO Seed Symposium (1998).

IUFRO Tower in FRIM

A number of activities were organized to promote the Congress during the FRIM Open Day. Tree planting by corporate companies and individuals was carried out. There was the sale of balloons and used paper. In particular, the IUFRO Tower Aerial Runway was built of mangrove poles and ropes by the Petaling B Rover Crew. The construction of this tower was made possible with monetary contribution from the private sector. The charge was RM2 per ride and RM5 for 3 rides. In addition, the IUFRO Tower mangrove poles and leaves contest was held. Prizes included two "4 days and 3 nights" travel vouchers to Taman Negara, souvenir items and hampers. The money collected at all these activities was used to sponsor SAP candidates to attend the Congress.

Posters and car stickers

Two sizes of the IUFRO Congress posters were printed for distribution. A total of 1,000 big posters (50cm x 77cm) and 4,000 copies of A-4 size posters were disseminated to IUFRO Member Organizations and potential delegates.

A total of 3,000 car stickers (9cm x 35cm) and 20 bus stickers were also distributed to motorists, taxi drivers and bus drivers to promote the Congress.

IUFRO News and FRIM in Focus

Then newsletter IUFRO News played an important role in publicity as it carried news containing activities of the Congress. This is an important means of publicity as the News was circulated to about 15,000 persons in about 150 countries. Other than IUFRO News, FRIM in Focus provided an avenue to publicize the Congress. As FRIM in Focus, a quarterly brochure, is distributed free-of-charge, both the locals and foreigners were kept informed of the Congress updates.

Congress Information / Registration Packages

All information published in the first brochure (12,500 copies), Congress Information Package (12,000 copies) and Congress Registration Package (12,000 copies) were also placed on FRIM's and IUFRO's homepages. FRIM's homepage was also hyperlinked to Malaysia Airlines' homepage. In this manner, more people could access the Congress information through the Internet.

Press Releases

Six press releases were distributed at the following occasions: launching of the Congress Logo in conjunction with the IUFRO Seed Symposium (12 October 1998); signing of agreements with PCO, tour and exhibition organizers (31 March 1999); FRIM's Open Day (20 June 1999); cheque presentation for SAP at the British High Commission (12 May 2000); handing-over of stickers to bus and taxi drivers in a ceremony (18 July 2000); and a special media conference held by the Steering Committee Chairman (26 July 2000). Press releases were also distributed to the press at the media centre during the Congress week.

"Live" TV and Radio Talks

In 1999 and 2000, three TV 'live' talks on Radio Television Malaysia were arranged for the IUFRO President, the Steering Committee Chairman and the COC Chairman to elaborate on the Congress theme and the significance of the Congress. The Steering Committee Chairman and COC Chairman also gave 'live' talks on IUFRO over radio in March and July 2000.

Scientific Articles in Newspapers

A series of scientific articles written by FRIM's scientists were published in the New Straits Times, a leading local daily, one month before the Congress. At the end of each article, information on the Congress (such as theme, telephone, fax and e-mail) was also printed. Consequently, the Congress Secretariat received a number of enquiries on the Congress.

All news and scientific articles on the IUFRO Congress published in local dailies have been collected.

Souvenir Items

Sales of souvenir items were initiated as early as in March 1999 with a view to promote and publicize the Congress. T-shirts were available in six different designs, colours and sizes for both adults and children. Other items made available were mugs, neck-pens, lapel pins, umbrellas, table clocks and caps. Prior to the Congress, souvenir merchandise worth RM 45,000 was sold from the sale of 2,806 items. The souvenir items were also distributed to several forestry-related agencies in Malaysia including Malaysian Timber Industry Board, Forestry Departments of Sabah and Sarawak, FRIM's Club, and Malaysian Nature Society outlet at the Kuala Selangor Nature Park. Sale of souvenir items during the Congress started on Sunday morning, a day earlier than the expected date. Various items were on sale throughout the duration of the Congress from 0700 hrs daily until the eve of 13 August.

Banners

Banners were placed within FRIM a year before the Congress. Congress banners were also placed along the main road leading to the Congress venue one month before the Congress. A hot-air balloon was placed at the Congress venue a week before the Congress, informing the public of the Congress.

The Press Centre

The Press Centre was located on the second level of the Putra World Trade Centre at the second entrance to the building. The press centre was provided with facilities such as phones, computers and printers. Tea/coffee and snacks were served free-of-charge throughout the Congress. A total of 80 media journalists from eight local newspapers, eight foreign agencies, 15 journalists and 4 TV stations registered during the Congress. Invitations and reminders to cover the Congress were made two months and two weeks prior to the event, respectively. Letters of invitation were sent to each and every press agency identified in Malaysia and world-wide. The main Malaysian newspapers, news agencies, television and radio programmes were represented. Wide coverage on the Congress was reported in many Malaysian mass media, during and after the actual event.

Daily Bulletin - Belantara

In conjunction with the Congress, a daily bulletin entitled Belantara was published on five consecutive days and the maiden issue appeared in the morning of 13 August. 2000 copies of Belantara were distributed to inform and update participants on the Congress activities. Circulation of Belantara was done at 0830 hrs every day before the delivery of keynote addresses. The first issue was in full colour, whilst the second and consecutive issues were in two colours.

Three interviews (with Professor Jeffery Burley - the IUFRO President, DI. Heinrich Schmutzenhofer - the IUFRO Secretary, and Professor Risto Seppälä – the President elect) were conducted and published in the Belantara.

Press Conference

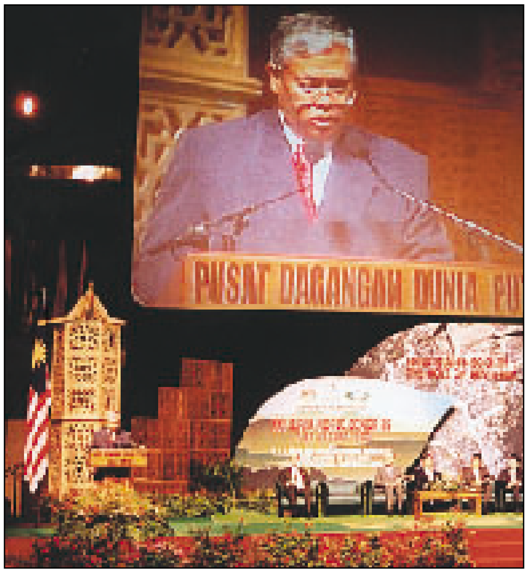
One special media conference was held in FRIM in July 2000 where the Chairman of the Steering Committee briefed the media representatives on the updates of the Congress.

Two press conferences were arranged for the IUFRO President on 7 and 9 August 2000. Another press conference was held on 9 August 2000 by the International Timber Trade Organisation (ITTO) because a new book was launched during its satellite meeting.

Addresses in the Opening and Closing Ceremonies

Addresses in the Opening Ceremonies

Address by



Dato' Dr. Abdul Razak Mohd Ali
Chairman of the Congress Steering Committee

YB Dato' Seri Dr Lim Keng Yaik,
Minister of Primary Industries,
Professor Jeffery Burley, President of IUFRO;
Distinguished guests, ladies and gentlemen;

It is truly an honour for me to welcome all of you to the XXI IUFRO World Congress on behalf of the Congress Steering Committee. Our special thanks goes to the Honourable Minister of Primary Industries of Malaysia for having agreed to attend and officiate the opening of this Congress on behalf of the Right Honourable Prime Minister who cannot be here this morning. To all delegates, and especially for those from abroad, 'Selamat Datang ke Malaysia' or 'Welcome to Malaysia'.

During the IUFRO Executive Board meeting in Madrid in April 1995, Malaysia bid to host this XXI IUFRO World Congress in Kuala Lumpur. The triumphant occasion that happened more than five years ago, remains fresh in my mind as I was then given the task to lead the delegation that presented Malaysia's proposal along with similar bids from South Africa, China and Indonesia.

Malaysia takes great pride in being the first developing country to host the IUFRO World Congress. The Congress is undoubtedly the largest ever forestry meeting organized in the country. In terms of the number of participants and accompanying persons registered, and papers and posters for presentation, it surpasses that of the 14th Commonwealth Forestry Conference held in Kuala Lumpur in September 1993.

We are indebted to the Government of Malaysia and the IUFRO International Council for having the confidence in entrusting this mammoth responsibility of organizing the IUFRO Congress to the Forest Research Institute Malaysia (FRIM). We wish to thank the IUFRO Secretariat in Vienna and the Malaysian Forestry Research and Development Board (MFRDB) for their invaluable guidance and support. The Congress Organizing Committee (COC) and its sub-committees have worked very hard to ensure that the progress of all aspects of the organization is closely monitored.

Ladies and gentlemen,

We are glad to announce that we have a total of 1906 registered participants and over 200 accompanying persons from 96 countries. Over the next few days, 5 keynote papers, 99 sub-plenary papers, 500 oral papers and 833 posters will be presented during the Plenary, sub-Plenary, Group and Poster Sessions, and Panel Discussions on posters. It is our intention that the poster presentations will provide opportunities for scientists to interact with their peers on subjects of interest.

Through the Scientist Assistance Programme (SAP), we are able to provide financial support for 138 scientists from 38 developing countries to attend the Congress. In addition, the Malaysian government has kindly provided funds to support another 31 scientists from Asia and the Pacific region to attend.

We are grateful to the Honourable Minister of Primary Industries of Malaysia who will be addressing us and declare the Congress open on behalf of the Prime Minister. Other highlights of the opening ceremony will include the launching of the XXI IUFRO World Congress commemorative stamps, a cultural show and the presentation of IUFRO awards. We also wish to thank the keynote speakers who will be delivering their speeches during the plenary sessions.

Ladies and gentlemen,

It is my sincere hope that the Congress will serve as a useful forum for scientists throughout the world to discuss the role of research in relation to forests and society. Traditionally, forests have been considered a source of timber. Research has indeed played a significant role in changing this perception and attitude that forests also provide a wide range of other goods and services pertinent to the well being of society.

Please take every opportunity during the course of this Congress to discuss research issues and needs and to forge beneficial R&D collaborations. The scheduled pre-congress, satellite and business meetings are intended to serve such purposes.

All said and done, I wish to apologize for any shortcomings in the organization of the Congress, on behalf of the Congress Steering Committee and the Congress Organizing Committee. Finally, do find the time during the in-Congress tours and post-Congress excursions to visit fascinating Malaysia, a country rich in biological and cultural diversity.

Thank you.

Address by

Professor Jeffery Burley

President of IUFRO

The Honourable Minister for Primary Industries,
Dato' Seri Dr. Lim Keng Yaik;
The Honourable Deputy Minister;
Mr. Secretary-General;
Dato' Dr Abdul Razak Mohd Ali,
Chairman of the Congress Steering Committee;
Dr Hosny El-Lakany,
Assistant Director General for Forestry in FAO;
Distinguished guests;
Ladies and gentlemen;

It is my great privilege and pleasure to welcome you to this 21st World Congress of the International Union of Forestry Research Organizations (IUFRO as it is widely known). Your Excellency, we are extremely sorry not to have the honour of the Prime Minister's presence but we recognize that reasons of State business have prevented his participation. However, we thank you for doing us the great honour of delivering the opening speech, which I am sure will be an address of welcome and exhortation to us. The theme of our Congress is "Forests and society: the role of research"; this is timely as we enter a new millennium of growing human populations, increasing demands on forests for their products, and increasing awareness of the many other environmental and social benefits that forests provide. It is particularly relevant here in Malaysia, a country of vast and variable forest resources and their associated services, and a country with a world-famous research tradition. Minister, you and I have known each other for many years and I know that you have always been an active and leading thinker and speaker on forestry and forest industries, particularly as they relate to Malaysia and South East Asia. We look forward with great interest to your presentation.

In the past five years it has been my continuing privilege to be the President of IUFRO and I would like to take a few minutes to tell you and our other guests something of the history and activities of the Union; in addition I will attempt to show why this should be of interest to a senior politician and why researchers and policy-makers should have increasingly closer dialogue.

IUFRO was founded in 1892 by a small number of European countries and for its first 80 years expanded to include most temperate countries. It was as late as 1971 that we created the first Working Party to deal specifically with a tropical subject (forest genetics and tree breeding). Since then IUFRO has actively sought to bring the benefits of its international collaboration to institutions and scientists in developing countries, including support for APAFRI, FORNESSA and a Latin American Network, and to involve them actively at all levels of its management; the Union now comprises nearly 700 member institutions in 110 countries with approximately 15,000 scientists working collaboratively and voluntarily in 276 Divisions, Research Groups and Working Parties. It is an international, non-governmental, non-profit and multi-disciplinary institution that seeks seriously to obtain the greatest value from government, industrial and private investment in research.

I should point out that the work of IUFRO is essentially voluntary; virtually all the officers of the Union and all collaborating scientists devote considerable efforts towards the success of IUFRO because they believe in the added value of collaboration. Only the Secretariat, generously provided by the Government of Austria, can be considered permanent "Civil Servants"of the Union. In addition the contractual staff of the Special Programme for Developing Countries (SPDC) are equally generously provided by Canada, Denmark and the USA. The European Union and the Governments of Japan, Switzerland and UK have provided great financial support to IUFRO. IUFRO maintains close ties with other organizations, particularly the International Council for Science, the Centre for International Forestry Research, the Food and Agricultural Organization of the United Nations, and the International Centre for Research in Agroforestry; it is an added privilege for us that the representative of the Director General of FAO will be giving a statement in this opening session.

Throughout this century the Union has stimulated and supported excellent research in a wide range of scientific topics. However, research is of no value when conducted independently; it should be seen as an integral part of the continuum from pure and applied research to adaptation and widespread application of new technological and social systems that address the issues of international and national policies. To this end, IUFRO has established Task Forces to encourage the integration of such research and to foster better understanding between researchers and policy-makers. At this Congress in Malaysia during the first year of the new millennium, IUFRO scientists will produce state-of-knowledge reports on many major issues to indicate the currently available information, the management implications of this research, and any need for new research.

In the past decade there has been a rapid expansion of political and public awareness of the importance of forests and trees in human welfare. They provide a vast number of social, environmental and economic products and services to a huge range of stakeholders. In addition to professional forestry books and journals, in most countries nowadays there are frequent publications in newspapers and magazines and programmes on television and radio relating to forests. There is a close interdependency and often competition between the various products and services demanded from forests; research embraces many disciplines that are not naturally cohesive. IUFRO is making strenuous efforts to encourage inter-disciplinary collaboration between biophysical and social scientists. The number 2000 is a nice round number, at least it is if you count by the mathematical base ten. It is also highly significant in certain religious calendars. However, it is totally significant to everyone alive and to unborn billions as the year in which international agencies, national governments, civil societal organizations, educators, researchers, businesses and resource managers must realize the urgent need to manage the world's resources in a wise, equitable, ethical and sustainable manner. Forests and trees will play a major role in such sustainable development and IUFRO will continue to do its utmost to encourage research and researchers to address relevant issues and to present their findings in ways that policy-makers and all stakeholders can understand and apply. The Executive Board of IUFRO feel sure that this Congress will do much to promote this.

Your Excellency, everyone attending IUFRO's 21st Congress is extremely grateful to the Government of Malaysia and the City of Kuala Lumpur for hosting it, for providing such friendly and generous hospitality, and for organizing such interesting and enjoyable study tours for both the scientists and their accompanying persons in your beautiful country. In relation to the organization I can only point out to you that staff of the Forest Research Institute, the Federal and State Forest Departments, and several Universities and other institutions have worked strenuously to support IUFRO in this quinquennial endeavour. While I am afraid that research in Malaysia may have been disrupted somewhat in recent years as a result, I am more concerned that it will disappear altogether in future as all these staff become professional conference organizers and tour operators.

Your Excellency, it will be our pleasure to have you open this 21st IUFRO Congress and to give us your views of the role and needs for forest research. I shall also ask you later to do us the honour of presenting IUFRO's highest award, Honorary Membership, to two outstanding leaders in our Union.

Address by

Dato' Seri Dr. Mahathir Bin Mohamad

The Prime Minister

Read by

Dato' Seri Dr. Lim Keng Yaik,

Minister of Primary Industries Malaysia;

Professor Jeffery Burley, President of IUFRO;
Datuk Haron Siraj, Secretary General of the Ministry of Primary Industries Malaysia;
Dato' Dr. Abd. Razak Mohd Ali, Chairman of the Congress Steering Committee;
Distinguished Guests;
Ladies and Gentlemen;

Let me, first of all, thank the organizers for inviting me to address and officiate the opening of this important forestry congress, the 21st International Union of Forestry Research Organizations, or IUFRO, World Congress. I would also like to extend a very warm welcome to all our guests and participants and wish you all a very fruitful meeting and pleasant stay in Malaysia.

I understand that IUFRO is a non-governmental and non-profit organization, established more than one hundred years ago, in 1892, and that its mission is to promote international cooperation in forestry research and related sciences. I also understand that although IUFRO has about 700 member institutions in 110 countries, this is the first time that the Congress is being held in a developing country. Therefore, it would be incumbent upon me to congratulate the organizers for having successfully bid to host this World Congress in Kuala Lumpur and for having undertaken the necessary preparations that have led us to be gathered here today at the biggest ever forestry meeting held in this country. I hope that this will mark the beginning for the IUFRO World Congress to be held in other developing countries as well.

As we all know, forests play a major role in the livelihood of citizens of many developing countries, contributing significantly towards the economic progress of these nations. I am extremely pleased, therefore, that Malaysia has blazed the trail for developing countries to bid and organize such a Congress, as forestry issues relate very closely to a large number of weak and impoverished citizens of the world. On this score, too, I wish to congratulate IUFRO on the very appropriate theme chosen for the Congress, linking society to forests through research.

I would be preaching to the converted if I were to embark on a discourse on the role and functions of forests. You are the experts on this subject. You are only too familiar with the fact that in the past, forests were considered separate from people who lived in or at their fringes and that forests were considered only for the timber that they supplied. In recent years, however, the trend globally has been towards recognizing that forests and society, both rural and urban, are but two sides of the same coin and that, beyond timber, forests provide a whole range of goods and services important for the well being of society.

But what lessons have we learned from the not-so-distant past, lessons in forestry that have triggered this change in perception and have set the stage for the current international debate on forests? We know that as the industrial revolution began in the early 1800s, vast tracts of temperate forests in Europe, already decimated in the preceding centuries, were further cleared to provide wood that was necessary for the industrialization process. Vast tracts of forests were also lost on the other side of the Atlantic Ocean, in America, in the 1800s. In just decades, millions of hectares of forest were destroyed for pasturage and cultivation, lumber and fuel.

The industrial revolution in the West led to massive negative effects on the environment. Pollution of the atmosphere and waterways as well as degradation of the soil accelerated. The rapid economic growth following the Second World War, in what are now the developed countries, provided the impetus for further environmental degradation. The United Nations Conference on the Human Environment of June 1972 in Stockholm came and went. However, environmental degradation continued unabated. Global warming, ozone layer depletion, marine pollution, acid rain, deforestation and soil degradation–mostly the result of industrial activities–had become a great cause for concern by the early 1980s.

Within this context, the Langkawi Declaration on the Environment of the Commonwealth Heads of Government Meeting (CHOGM) held in Kuala Lumpur in October 1989, planted the seed for a concept which took formal shape in subsequent global meetings. The concept of 'greening of the world' became enshrined as a principle in the Paris Declaration of the 10th World Forestry Congress held in 1991. Subsequently, at the United Nations Conference on the Environment and Development (UNCED) in Rio de Janeiro in June 1992, the Statement of Principles on Forests, accepted by all Governments, embodied this concept in full.

In this connection, just prior to the Earth Summit in Rio, Malaysia had in fact suggested that the world forest cover of 27.6% at the time be increased to 30% by the year 2000 through vigorous afforestation and reforestation programmes throughout the globe. We had envisaged that this increase would cover all types of forests–boreal, temperate and tropical – as there is no discrimination in the way different types of forest sequester carbon, stabilize climate, protect the environment, conserve biological diversity, produce industrial resources and provide sustenance for the livelihood of communities living within and in the vicinity of forests. We had also envisaged that the developed countries with low forest cover, a consequence of wanton forest destruction during the last few centuries, but now with strong economies, vast resources and technical know how, would spearhead efforts at greening the world. We had envisaged further, perhaps in our naivety, that these economically powerful countries would pool their vast resources to actively help implement afforestation and reforestation programmes in the poorer countries of the world.

However, eight years down the road from Rio, it is 'business as usual.' All the hype generated during the run-up to, and at Rio, has virtually dissipated almost overnight. There was no concerted movement to green the world, not even in the embryonic form. Each nation has been virtually left on its own to implement its forestry programmes. I am told that the average total annual cost required to implement the forestry programmes under Agenda 21 of UNCED was estimated at US$32 billion, a major portion of which was committed to come from developed countries. Despite the fact that Agenda 21 as well as the Forest Principles provided the framework for strengthening cooperation among countries, it is now clear that most of the funds required for forestry programmes would have to be generated by developing countries themselves.

Malaysia has always been and is proactive in global issues concerning forests and the environment. We participated actively in the negotiations leading to UNCED, encompassing Agenda 21, the Statement of Principles on Forests, the Convention on Biological Diversity and the Framework Convention on Climate Change, and have continued active participation in the developments since Rio. We adhere very much to the concept of greening of the world, although forests were cleared during the time of our colonial occupation for the purpose of establishing plantations. Nevertheless, natural forests still cover about 58% of our land area. With the inclusion of plantations of rubber and oil palm, the tree cover is about 72% of the land area. We have pledged and will continue to uphold this pledge, that forest cover will remain at a minimum level of 50% of the land area in perpetuity and this will be our contribution to the citizens of the world.

In this regard, we have also acted to strengthen our forestry practices, in line with the concept of sustainable forest management; for example, we have expanded the size of our permanent forest estate from 12.7 million hectares to 14.1 million hectares, revised the National Forestry Policy in 1992 and amended the National Forestry Act in 1993, strengthening its provisions and introducing stiffer penalties for forest offences. We are increasing our efforts in research and development in all relevant fields of forestry, including efforts to develop downstream forest-based industries that would operate sustainably. At the macro level, the National Policy on Biological Diversity, endorsed in 1998, will provide guidance for the conservation of biological diversity and sustainable utilization of its components.

Internationally, we have continued to provide input into the process of the Intergovernmental Panel on Forests (IPF) and the Intergovernmental Forum on Forests (IFF). We are also active participants in the present implementation phase of the Convention on Biological Diversity and the Framework Convention on Climate Change, both of which have direct relevance to forestry issues.

We acknowledge that forestry is important to a nation's economy and its society, as well as to the national and global environment. Consequently, it has become a dominant issue in both the domestic and international agenda on forestry relating to a legal instrument on forests. We are only too aware of the arguments that did not allow for such an instrument to be the subject of extensive debates; the issue of a legal instrument on forests has yet to be resolved. We are still no closer to a legal instrument than before.

Malaysia's position is that a legally binding instrument on all types of forests is a necessity for addressing a whole range of issues on forestry and timber, in a holistic, integrated and comprehensive manner. We believe that such a legal instrument would facilitate the achievement of sustainable forest for all forests, compared to the present 'ad hoc' non-legally binding international environment, which can be a hindrance to the best forestry practices. We also believe that such an instrument would enable international level action to be taken to address underlying factors for forest shrinkage and degradation in transboundary areas, such as international debt and unsustainable consumption patterns. The instrument would also encourage and accelerate cooperation in the transfer of technology.

Presently, the lack of consensus regarding the necessity of a legally binding instrument is due to the impasse concerning critical issues such as finance, transfer of technology and trade. In this regard, I would like to urge the developed countries to re-affirm and put into action their commitments to provide concrete financial assistance and technologies to developing countries to achieve sustainable management of their forests. In addition, sustainable forest management should be promoted through mutually supportive trade and environmental standards to market access. Such actions will only render forest valueless and will result in forests being cleared for other purposes. Trade and environmental restrictions will not reduce deforestation. In fact, greater market access will help promote sustainable forest management by providing the much-needed revenues for this purpose.

The dependence of society on forestry goes back to times immemorial, when society was primitive and societal needs simple. In many corners of the earth, mostly in developing countries, societal needs still remain simple. Elsewhere, needs have increased with development of societies and unsustainable lifestyles have contributed much to the increased and often insatiable needs of expanding societies. But needs are more than just material and hence the maxim that ‘forest resources and forest lands should be sustainably managed to meet the social, economic, ecological, cultural and spiritual human needs of present and future generations.’

I am gratified to have the chance to meet all of you today and to address this Congress of scientists who have committed their lives to forestry research, so that, directly or indirectly, you are contributing to societal needs of the present as well as of the future. Recent history has shown that investment in research and development in any field can lead to high returns. It is my sincere wish that your efforts will lead to returns that would improve the lot of society as a whole, and of the weak and poorer segments of society in particular. You represent both the developed and developing world and it is by way of this kind of North-South partnership that you are linked through IUFRO.

In this regard, I hope that your efforts will help towards building a more equitable forestry agenda in the international arena, whereby the technologies that you develop in your endeavours will be shared equitably and more magnanimously with the developing countries to improve forestry practices globally. If the world is to achieve sustainable forest management, the transfer of technology from the North to the South on preferential terms as agreed to in Rio, must be forthcoming. Unfortunately, this has not been so and developing countries, without access to these technologies, will be unable to meet their commitments on sustainable forest management, which works to nobody’s benefit. IUFRO can, therefore, play an important role to facilitate this transfer of technology. I hope that this Congress will help foster not just an exchange of research experiences but also develop more concrete networks which will serve as effective conduits for North-South transfer of technology. I therefore wish you all the best in your endeavors and hope that you will have a productive Congress.

In conclusion, let me once again extend our warm wishes to all delegates at this Congress. I hope that you will find time in the post-congress tours to savour not just the bio-diversity of our tropical forests but also the multi-racial, multi-cultural and multi-religious society of our country. In Malaysia you will see Asia.

With these remarks, I have great pleasure in declaring open the 21st IUFRO World Congress.

Address by

Prof. M. Hosny El-Lakany

Assistant Director-General,
Forestry Department, FAO

Honoured guests;
President and Members of the IUFRO Executive Board;
Ladies and Gentlemen;

On behalf of the Director-General and the rest of the staff of the Food and Agriculture Organization of the United Nations, and particularly my colleagues in the Forestry Department, I would like to extend warm greetings to all the participants in this twenty-first IUFRO World Congress. It is a great personal pleasure and an honour to be here with you in Kuala Lumpur today!

First of all, I would like to congratulate the Congress organizers and particularly our Malaysian hosts for the magnificent arrangements. Certainly Malaysia, with its long and strong tradition of forestry science contributing to development, is a most appropriate setting for this impressive gathering.

As I look around the hall this morning and see such an eminent and diverse group of participants, the fundamental value of IUFRO as an organization comes through strongly to me. IUFRO offers forestry scientists and researchers the means through which to share experience and knowledge both to advance the cause of sustainable forestry and to develop individually. The opportunity for young scientists at the beginning of their career to exchange ideas with and benefit from the most erudite members of the international forest research community is without parallel, and the possibility to tap the results of research from around the world is of immeasurable value. For how many of us here today, has this opportunity represented an auspicious occasion?

Certainly in my own case, this is so. I remember vividly my own first participation in a IUFRO Congress – in 1976 in Oslo and my direct encounter with many forest scientists; fortunately some of them are with us today. And part of my Ph.D. work was based on a seed collection made under the auspices of IUFRO – the Douglas Fir Provenance Collection of 1966.

Thus, I am particularly honoured to represent FAO at this important meeting – the first IUFRO World Congress of the new millennium. IUFRO has a special relationship with its members, and its relationship with FAO is also unique. At the institutional level, FAO and IUFRO have had a cooperative and symbiotic relationship since FAO was created – IUFRO being, of course, the “older sister” by nearly half a century. IUFRO links scientists and researchers, and FAO helps link IUFRO to the field, thus ensuring that the valuable results of forestry science and research are put into practice – and the “pulse” of the field is transmitted to researchers.

At FAO, all of our forestry officers have direct, ongoing contact with IUFRO and its Research Groups and Working Parties. In addition, through its Partnership Programme, FAO facilitates visits from academics, researchers and especially young professionals who might not otherwise have the opportunity to share experience and expertise on a face-to-face basis. Moreover, FAO, through its function as a neutral forum, helps countries to jointly identify areas where additional research is required, and thus to focus the efforts of forestry scientists world wide. In this regard, I am always pleased when national delegations to the biennial sessions of the FAO Committee on Forestry include forestry scientists and researchers. Thus, information and knowledge flows in a multi-channel network between FAO and IUFRO, to the benefit of all of our constituents.

From FAO’s perspective, the theme of this Congress, “Forests and Society: the Role of Research”, is particularly appropriate. In its work in forestry, FAO is fully committed to an approach based on maximizing the social as well as environmental and economic benefits of sustainable forest management. In fact this commitment is explicit in the FAO Strategic Vision for Forestry. Developed in collaboration with FAO member countries, partner institutions and organizations, including IUFRO, over a period of more than two years, and approved by the FAO Committee on Forestry in March 1999. The FAO Strategic Plan for Forestry describes the Organization's mission, goals, medium-term objectives, current priority activities and vision in forestry. That mission is “To enhance human well-being through support to member countries in the sustainable management of the world’s trees and forests.” It is people and society that come first.

Our priority activities are also focused on forests and society. For example, our effort in community and participatory forestry focuses on bringing a broader range of society more directly into the forest management and decision-making process. I should add that this concerns not only those who actually live in and around forest areas, but also others who depend on forest resources and products.

Another priority area for FAO that has direct relevance to the topic of forests and society is our work in helping countries pursue national forest programmes. These programmes – recognized by the intergovernmental processes that have emerged from UNCED – are aimed at establishing a workable social and political framework for the conservation, management and sustainable development of all types of forests.

A third priority area for FAO Forestry is strengthening world wide access to reliable and timely forestry information. The very first article of the FAO Constitution gives us a mandate to “collect, analyse, interpret and disseminate information.” In forestry, this involves the development of common terms and definitions, and the harmonization of definitions, the collection of statistics on production, consumption and trade, and our assessment of forest resources worldwide. In all of these aspects, we are collaborating closely with IUFRO. It is therefore particularly appropriate that we chose to launch the first results of the FAO Forest Resources Assessment 2000 here at this Congress. I would also mention our important forestry Web site and the collaboration between FAO and IUFRO in the development of the Global Forest Information Service.

Another important, and enduring area of FAO-IUFRO collaboration regards the Special Programme for Developing Countries – the SPDC. A month ago, on 7 July, the Forestry Research Network for sub-Saharan Africa (FORNESSA) was officially established and its first Chairman, Dr. Konuche from Kenya, was selected. In this context, I am happy to note that the SPDC Deputy Coordinator is hosted by the FAO Regional Office for Africa – thus close, ongoing relations with FAO are ensured.

At this Congress, several papers will be presented by FAO staff and many sessions have been co-organized with FAO participation.

By the examples I have provided, I hope it is evident that FAO has a long-term commitment to maximizing the positive relationship between forests and society. The theme of this Congress suggests strongly that IUFRO and its members are also oriented in this direction.

What then is the role of research in moving forward on this track as perceived by FAO. Certainly, we need a greater focus on social aspects of sustainable forestry development. We need to know more about how people can and do approach forest management, and especially about the tools and scientific developments that they need to take on this responsibility more effectively.

We need more research on how best to provide people with the information they need to better participate in forest decision making and specialized research into conflict management.

We especially need research into the potential and modalities of international cooperation in forestry. The past decade has seen a plethora of international agreements that are directly relevant to the future of world forestry, but those who are responsible for framing and implementing them are truly in a new territory. We must study, analyse and learn from the experiences of other sectors that have taken this path before us so that the agreements we forge for forestry are practical in scope as well as noble in intent.

These are challenging tasks indeed, and they will be made even more challenging by the fact that they must complement and not substitute research into other more traditional aspects of forestry. But, to my mind, they are essential if we are to achieve our common goal of sustainable use of forest ecosystems, and I can think of no organization more adroitly poised to take up this challenge than IUFRO.

In closing, Ladies and Gentlemen, I would like personally to congratulate the outgoing Executive Board and particularly the President – a close colleague and good friend, Professor Jeffery Burley, for their strong and competent direction. And permit me, as well, to express our full confidence in the incoming Board and the new President, Professor Risto Seppälä, and to extend warm greetings to Past Presidents, especially Dr. Salleh Mohd Nor.

Mr Chairman, on behalf of FAO Director-General, Jacques Diouf, on my own account, and particularly on behalf of the FAO Forestry Programme, I would like to express our sincere hopes that this will be a successful Congress, and a fitting start to a new millennium for world forestry.

Thank you.

Addresses in the Closing Ceremonies

Five-Year Review Speech
At the Closing Session

Professor Jeffery Burley
President of IUFRO

Distinguished guests, colleagues, ladies and gentlemen, as we come to the closing of this impressive and productive Congress, you will be addressed briefly by me as the current President and by Professor Risto Seppälä as the President-elect. I will summarize for you the activities and progress of IUFRO during the five years of my presidency while Professor Seppälä will outline to you his vision of future developments in forest research and in IUFRO.

The 1995 Resolutions and Challenges

At our 20th Congress in 1995 the following resolutions were accepted:- a) to maintain and enhance well targeted forestry and forest products research; b) to expand research capacity, especially in developing countries; c) to enhance partnerships that strengthen research and improve communications between scientific and general communities; and d) to increase policy and problem-oriented research in economic and social sciences. When I was elected President I offered to the Executive Board a personal view of IUFRO's role, development and activities and I would like to summarize that for you and indicate how IUFRO has responded to the challenges I posed and to the Congress resolutions.

I pointed out that, in the last decade of the last millennium, significant changes were occurring in forest policies, forest practices, and the forestry profession. Forestry issues had become globalized and internationalized with a wider policy-forming base of individuals and institutions that were not traditional foresters. Socio-economic sciences were making greater inputs to decision-making processes. There was global pressure to evaluate the role of forests for all benefits and to monitor their status. Policy-makers constantly sought (a) information on the roles, values and status of forests and trees in relation to conservation and development, (b) views on the linkages between forests, biodiversity, climate and other environmental issues, and (c) advice on sustainable management of forests including institutional issues.

I felt then (and feel now) that IUFRO should seek to respond to those changes while maintaining its primary role of networking among its member voluntary scientists. It should continue to be the principal source of knowledge and experience on forest research in specialized topics while increasing the intensity and frequency of inter-disciplinary cooperation within the Union itself and with organizations and disciplines outside its traditional membership.

Those links also publicized the work of IUFRO, ensured its relevance to modern needs, identified sources of funds for research, and sought productive collaboration while minimizing unnecessary duplication. Early recognition of emerging issues by the Executive Board proved vital and was facilitated by establishing strong links with a range of other institutions. IUFRO has attempted to support the Directors of Member Organizations themselves by undertaking and publishing policy-relevant science and by assisting the Directors in making the case for forests and forestry research to governments and agencies.

IUFRO's New International Role

The Executive Board of IUFRO has made strenuous efforts to advertise the existence, activities and relevance of the Union. The widely acclaimed IUFRO brochure was launched at the World Forestry Congress in Turkey during 1997 and the equally reputed IUFRO Web site has home pages for all research units that are mirrored on servers in several countries and linked to those of many other institutions. Many of these Web pages maintain space for statements of the state-of-knowledge in the particular discipline of the research unit; as you will have realized throughout this Congress, great attention has been given to the dissemination of research results and state-of-knowledge reports.

We have also sought to ensure a role for the Union in international debates and developments. I or other IUFRO officers have attended meetings of:- the Intergovernmental Panel on Forests (IPF); the Intergovernmental Forum on Forests (IFF); the World Forest Forum; the World Forestry Congress; the Committee on Forestry of the Food and Agriculture Organization of the United Nations (COFO/FAO); the IUCN General Assembly; various meetings of several international initiatives developing criteria and indicators for sustainable forest management; the

Board of Trustees of the Centre for International Forestry Research (CIFOR) and the International Centre for Research in Agroforestry (ICRAF); Centres Week of the Consultative Group for International Agricultural Research (CGIAR); the National Exposition at Kunming, China; and various meetings and exhibitions of other organizations. In particular we were delighted to see recommendations of the IFF 4th session calling for improved linkage between forest science and forest policy processes, funding for forest research (particularly in developing countries), enhance access to forest-related information and collaboration with IUFRO in the GFIS. IUFRO's own Special Project on Terminology (SilvaVoc), coordinated by Renate Prueller, and supported by Japan, contracted with FAO to provide definitions of major terms used in the international debates on sustainable forest management. I was delighted that my own Institute was able to represent IUFRO in preparing a document on researchable forest policy issues, financed by the UK Government's Overseas Development Administration (now the Department for International Development) for the World Commission on Forests and Sustainable Development.

The Union has also encouraged research units to pursue specific topics related to the new international concerns. An outstanding contribution of IUFRO to international processes was its role in organizing and publicizing the International Consultation on Research and Information Systems in Forestry (ICRIS) that was sponsored by the Governments of Austria and Indonesia in cooperation with CIFOR and the Forestry Department of FAO. This conference was an inter-sessional activity in support of the Intergovernmental Forum on Forests (IFF) of the United Nations Commission on Sustainable Development (UNCSD) and took place in Austria during September 1998; its major impacts on IUFRO itself were the establishment of Task Forces on the Global Forest Information Service (GFIS) and the Forest Science-Policy Interface.

IUFRO's Enhanced Structure and Activities

The primary role of IUFRO has continued to be the enhancement of the value of research through networking of nearly 700 Member Organizations and 15,000 scientists in their chosen fields; the 268 research units and 8 Task Forces have held 335 meetings in 65 countries, 41 of which were developing countries or emerging economies. Two new Divisions were created at the beginning of the Board period to recognize the great breadth of research activities and to reduce the workload on individual Division Coordinators and Deputy Coordinators (who, like all IUFRO officers, are volunteers). The Executive Board established a number of Special Programmes, Projects, Task Forces and Ad Hoc Committees to address particular topics or issues and it encouraged them to set significant specific goals including emphasis on capacity building. In a short speech it is clearly not possible to provide details or even adequate summaries of all of these but I will pick out some highlights.

As I indicated above, one of the major changes in the last decade has been the greater need for inter-disciplinary, problem-solving approaches to researchable issues and topics. IUFRO has always had wide coverage of sciences in individual biophysical and socio-economic research units. In the past five years we have encouraged interaction between these through inter-divisional meetings, through collaboration with other organizations, and through the work of the Task Forces. We all have to recognize the implicit difficulties of gaining mutual understanding of another person's discipline and of obtaining academic or professional recognition for such multi-disciplinary work, but this is clearly an outstanding need.

The Divisions

A major interdivisional meeting on forest ecosystem and land use in mountain areas took place in Seoul, Korea, in 1998 organized by Divisions 1, 4, 6 and 8; this attracted 350 participants from 24 countries. Within Division 1, Research Group 1.17.00 (Restoration of degraded sites) was closely involved in the international research programme jointly sponsored by the USDA Forest Service, the World Bank, CIFOR and the British Overseas Development Administration that examined the role and implications of plantations in accelerating natural forest recovery on degraded tropical lands.

Division 2 organized a major meeting on forest genetics in Beijing in 1998 and its Working Party 2.04.06 held a meeting on genetic modification in Oxford in 1999, demonstrating IUFRO's continual concern for and advice on current issues of public and political importance. Participants at these meetings recognized that classical genetic improvement still deserves major efforts in funding but should also use new technologies to increase efficiency; at present genetically modified organisms should be considered as laboratory tools, not for release until ethically accepted by the public.

Division 3 held a number of Divisional meetings and inter-Divisional meetings with Division 1 in Bolivia 1997; Division 6 in Japan 1997, Canada 1998 and Australia 2000; Division 8 in Japan 1998 and the Task Force on Sustainable Forest Management in Australia 1998. It also held a number of meetings with external organizations including CIFOR and FAO. Individual Research Groups produced state-of-knowledge reports.

Division 5 devoted considerable efforts to understanding the changing resource of materials in forests, extending the resource and implementing technologies that are environmentally and socially "friendly". The all-Division conference in 1997 focussed on forest products for sustainable forestry and was attended by 222 delegates from 42 countries.

Division 7 was created to address a specific resolution of the 1995 Congress that encouraged research on "… the extent, productivity and health of forests …". In the last five years the Division has convened major research meetings in Europe, North America and Asia dealing with entomology, pathology, air pollution and host-pest interactions.

Task Forces

A key issue throughout the world has been the development of criteria and indicators for sustainable forest management. The Task Force on Sustainable Forestry, coordinated by Alain Franc, collaborated with CATIE, CIFOR and FAO in organizing three major international meetings in Australia, 1998, Costa Rica, 1999, and France, 1999 (in association with Ecofor and EFI); each attracted 100-200 participants and bridged the gap between scientists and forest stakeholders while clarifying relationships between criteria, indicators, certification systems and biodiversity. Particular attention was given to the role of the social sciences.

Based on the contributions of many scientists, the Task Force on Environmental Change, coordinated by John Innes, developed outstanding state-of-the-art reports, two of which have already appeared in the IUFRO Research Series and the remainder will be completed during this year. Task Force officers also represented IUFRO interests at a number of meetings promoting the links between science and policy. The Task Force was specifically responsible for a resolution of the Ministerial Conference on the Protection of Forests in Europe known as "Helsinki 4" which deals with coordinating efforts to mitigate the effects of climate change on European forests.

The Task Force on Forests in Sustainable Mountain Development, coordinated by Martin Price, prepared the first state-of-knowledge report on this topic, bringing together 124 authors from around the world. A critical issue was the definition of the extent of the world's mountain forests; major elements were a map of the world's mountains (according to objective rules) and a map of the mountain forests which account for 28% of the world's forest area.

The Task Force on Water and Forests, coordinated by Rob Vertessy, was established to review the current scientific knowledge and existing hypotheses on fresh water ecosystems in forests and the implications of silviculture and forest management on water quantity and quality; it has produced a major publication on this topic.

The Task Force on Internet Resources, coordinated by Lauri Valsta, has developed a unique and invaluable resource for communication between scientists and for the dissemination of information about IUFRO worldwide.

The Task Force on Global Forest Information Service, coordinated by Risto Paivinen, is a consortium of international, regional and national organizations developing a strategy and implementing an Internet-based meta-data service to provide coordinated worldwide access to forest-related information. It has developed the basic concepts of collection policy and technical solutions including a working prototype, and an EU-funded project for Africa, Caribbean and the Pacific.

The Task Force on Management and Conservation of Forest Gene Resources, is coordinated by Veikko Koski and its committee includes representatives of most IUFRO Divisions, CIFOR, FAO and IPGRI; it gathers scientific information on interactions between all factors affecting the distribution, integrity and conservation of forest gene resources and it has prepared a state-of-knowledge report.

The Task Force on Forest Science-Policy Interface, coordinated by Rich Guldin, helped to shape the Division 6 conference on the contributions of science to the development of forest policies in South Africa and organized two Side Events at the third and fourth sessions of the IFF. Three conferences in the next three years will gather 40-50 case studies showing how research has successfully influenced forest policy.

IUFRO Supporting Developing Countries

The work of the Special Programme for Developing Countries (SPDC), coordinated until June this year by Bob Szaro, has consistently sought to assist in the development of human resource capacity in developing countries and emerging economies; additionally IUFRO has made every effort to support such scientists in participating in IUFRO science and management as officers of research units. The SPDC organized workshops on research management and planning, grant writing and proposal development, and strategic planning. It supported more than 200 scientists and 35 meeting organizers in more than 60 countries and initiated and published the first two volumes in a low-cost textbook series.

IUFRO greatly appreciates the contributions of the Government of the United States of America in providing the Coordinator, the Government of Canada in providing the Deputy Coordinator of the SPDC and the Government of Denmark for providing the Deputy Coordinator (Africa). The Japanese Government has been a generous supporter of the BIOREFOR programme, which has stimulated collaboration among many institutions in the Asia-Pacific region to contribute to our knowledge on how biotechnology can be used for reforestation efforts. We also appreciate the generous support of the European Commission of our GFIS-Africa project designed to foster forest related information sharing in Africa. Other agencies that provided generous support in cash or kind to IUFRO included AusAid (Australia), Deutscher Verb. FVA (Germany), the Royal Danish Embassy, the USDA Forest Service (USA), the Government of China Taipei, and the UK Government.

Disseminating Research Results

Research should not be conducted in a vacuum and its results should be widely disseminated. IUFRO has made valiant efforts to publicize the work, results, value and relevance of forestry research in general and of IUFRO specifically. In addition to the Web pages referred to earlier, and to 91 volumes of proceedings of meetings published by research units, we have continued to expand the IUFRO World Series and IUFRO Occasional Paper Series (published by the Secretariat), while adding the IUFRO Research Series (published by CAB International).

Review of IUFRO Structure and Management

Throughout its five years of office, the current Executive Board has constantly reviewed IUFRO's structure and activities, including commissioning an external review of the Secretariat, SPDC and Special Project. We have made strenuous efforts to attract funding, particularly in support of developing country members, but also to establish IUFRO's own projects such as the SilvaVoc Terminology Project. We have revised IUFRO's investment strategy, especially in view of the difficulties that some Member Organizations face in paying their subscriptions. Incidentally, in response to a recent decline in membership numbers, the Executive Board and International Council have approved the slight change of IUFRO's English name from "Forestry" to "Forest"; this recognizes the need to encompass the wider range of disciplines and institutions who would benefit from, and contribute to, IUFRO. It also recognizes a perception held by some members of the public that "forestry" only refers to massive removal of natural forests or to equally widespread development of plantations of exotic species; this is at a time when IUFRO is doing much more to provide research and advice on the social and environmental benefits of forests.

The Executive Board has encouraged Member Organizations and scientists to feel part of the IUFRO policy and planning processes. Many contributed to the development of the Strategic Plan that has guided the work on the Executive Board in the last five years. The International Council has also been closely involved in the development of IUFRO policy, the revision of IUFRO's Statutes and the election of your next Executive Board. The Executive Board has encouraged the regionalization of IUFRO management and scientific cooperation through the recognition of Chapters such as the Asia Pacific Association of Forest Research Institutes (APAFRI) for which the Secretariat is currently located here in Malaysia. In addition, IUFRO has been pro-actively supportive with FAO of other regional activities that seek to encourage cooperation between national institutions, including the Forestry Research Support Programme for Asia and the Pacific (FORSPA) and the Forestry Research Network for Sub-Saharan Africa (FORNESSA), the latter in close collaboration with the African Academy of Sciences (AAS).

Future Challenges

Ladies and gentlemen, I hope you realize from what I have said that IUFRO, led by the Executive Board and ably assisted by the Secretariat (generously supported by the Government of Austria), has flourished in the past five years and successfully responded to the resolutions of the last Congress; the EB itself responded very actively to the challenges I presented to it. As out-going President, it would be easy for me to offer challenges for the next President and Board to consider; among these I would include the following:-

- Continue the development of internationally acceptable standards for research methods.
- Strengthen networking among members.
- Develop GFIS, standardize terminologies and state-of-knowledge reports.
- Forge and enhance linkages between science, policy, management and use of forests, forest products and services.
- Identify and pursue disciplinary and inter-disciplinary research needs.
- Increase membership.
- Reorganize and enhance the Board and Secretariat to ensure financial security, increased support for members and expanded facilities for information dissemination.

Address by

Dr. Abdul Rahim Nik

Chairman of the Congress Organizing Committee

Professor Jeffery Burley, President of IUFRO;
Tan Sri G.K. Rama Iyer, Chairman of the Malaysian Forestry Research and Development Board;
Dato' Dr. Abdul Razak Mohd Ali, Director General of FRIM;
Professor Risto Seppala, President-Elect;
Honoured Guests and Distinguished Delegates;
Ladies and Gentlemen;

I am delighted that we have finally come to the closing of the XXI IUFRO World Congress. For the last 6 days, there has been a hive of activities at this Congress venue, ranging from scientific sessions, satellite and business meetings to exhibitions, receptions and tours. As organizers of this prestigious gathering, we have tried our very best to accommodate all your expectations and respond to your requests in order to ensure that your participation at the meetings and your stay over the last week or so was pleasant and comfortable.

It was five years ago that I was made the Chairman of the COC and given this monumental task of organizing this Congress. I did not have the slightest clue then as to the magnitude of the challenge and responsibility that was being entrusted to me. Three years down the road, we began to actually heat up and to accelerate the organizational pace. Finally, over the last six months before the Congress, we became fully engrossed in the real challenges. I must humbly admit that we have learnt a lot from organizing this Congress. In this regard, the currently available modern technologies have been very valuable and most helpful towards the preparations. I cannot imagine organizing this meeting without the use of the e-mail and facsimile facilities.

While the theme of the Congress "Forests and Society- the Role of Research" had been well elaborated and discussed in many of the technical sessions, we, the organizers also adopted for ourselves a motto in the process of organizing this congress. This motto is, "We are committed to ensuring a memorable and well organized Congress". You may have seen this motto displayed at all our service locations or stations. This simple motto embodies two important messages. Recognizing that this is the first time a Congress of this nature is being hosted by a developing country in more than one hundred years of IUFRO's history, we wanted to ensure that this XXI IUFRO World Congress, held here in Malaysia, will leave a strong, lasting impression and also pleasant memories in the minds of all the delegates who are present here today. Secondly, a large gathering like this Congress needs an efficient and well organized system in order to provide an impact to the participants and to give them their time and money's worth to participate. Charged and entrenched with this motto, we have worked whole-heartedly and with commitment to delivering the goods. It is up to you, distinguished delegates, to judge our performance!

At this closing session, I would like to share with you some important statistics associated with the Congress and some of our observations that may be useful for the next host of the Congress.

The total number of delegates registered for the Congress was 1906, from 96 countries. including the 209 participants who were registered as accompanying persons. We also received encouraging responses for all the tour and excursion programmes. A total of 1127 registered and participated in the nine In-Congress tour programmes on Thursday, and more than 700 persons participated in the Accompanying Persons' Programme. The tour to see the fireflies recorded the highest participation. Immediately after this Congress, a total of 324 delegates will be joining the 12 Post-Congress excursions covering most States in Malaysia and neighbouring countries including Brunei, Indonesia and Thailand over the next few days.

In terms of scientific presentations, most of the planned scientific sessions were conducted as scheduled. In some sessions, where speakers were unable to attend, the moderators were able to invite other participants in the sessions to cover the vacant slots. However, there were a few sessions that had to be cancelled, as none of the proposed speakers were present to expound on their findings. We noted that those who did not turn up were mostly from the developing countries where funding arrangements were a constraint. With regard to Poster presentations, of the 833 posters that were selected for presentation, only 55% of the poster presenters turned up. Most of the poster presenters who did not turn up were observed to be from developing countries that could not secure funds to attend the Congress. In terms of technical support for this Congress, we deployed 120 technical rapporteurs and almost 270 Congress assistants to facilitate its smooth running.

On a lighter note, to meet the needs of the Congress, we had produced about 6.6 million pages of printed matters including the early announcements and publicity materials. I am not sure of the equivalent number of trees that was needed for making these materials available. I sincerely believe that all this was worth the effort.

Allow me now to take a few moments to share my views with all of you on an issue that may be useful and that may be taken into consideration when the next Congress is convened. If a more active participation from developing countries is intended, then more efforts should be placed on securing sufficient funds for the Scientist Assistance Programme. For this meeting, out of the 169 SAP candidates, 91 had been partially and fully sponsored through funds made available by the Government of Malaysia. In my opinion, more efforts have to be focussed on securing sufficient funds from developed countries. This was not very much forth-coming at this Congress with the exception of funds from SPDC and a few countries like the United States of America, United Kingdom, Sweden and Finland. Some serious thought has to be given to this issue by the new Board and the next host.
I have to admit that it had been a great pleasure and a rich experience for us to organize this Congress, I do sincerely hope that this Congress has not only been beneficial to your scientific career but has also been a rewarding and useful experience. In spite of the great efforts we have put in to achieve perfection, there have still been some shortcomings and weaknesses here and there. For these, I seek your forgiveness and pardon. The time has now come for us to hand over the flag to the host of the XXII IUFRO World Congress.

As you may have noted, we have involved many organizations, agencies and sponsors in organizing this Congress. To all of them, I would like to extend by profound thanks and appreciation for all their kind support, cooperation and assistance without which we could not have succeeded in this difficult task. In particular, I wish to thank the Malaysian Forestry Research and Development Board and FRIM and especially their Chairman and DG for their encouragement and support throughout the entire planning and execution of this Congress. To the EB members and the IUFRO Secretariat, Vienna, I extend my sincere thanks for their advice and guidance towards making this Congress a success. Last, but not least, as the Chairman of the COC, I would like to thank all the members of the COC, Sub committees and Congress Assistants. They are the movers who worked strenuously behind the scene to make the Congress a success. Could you all join me in giving them a big hand…

To our overseas friends, I wish you all a pleasant and safe journey home.

BON VOYAGE AND THANK YOU.

Address by

Dr. Risto Seppälä
President-Elect

President Burley;
Your Excellencies, Members of IUFRO's International Council and Executive Board;
Distinguished Guests;
Fellow Scientists;
Ladies and Gentlemen;

It is a great honour for me to accept the election by the International Council to the post of IUFRO President. I promise to use my best efforts to fulfil the high expectations connected with this post.

In his acceptance speech five years ago our current President said that he had always had three ambitions for IUFRO: to have a President from the tropics, to have a World Congress in a developing country and to have a female President. We have now achieved the first two of these goals but if Jeff Burley wanted a female President as his own successor I am not the right person, although I can take the baton from him and bring it forward.

It is customary that an acceptance speech contains some visions of the incoming President's views of the future structure and activities of the organization. Because our current President presented earlier on this occasion an exhaustive list of future challenges, I pick up only two issues that I consider important. They are IUFRO's membership and IUFRO's role as a clearing house for forest research information and expertise.

IUFRO has now some 680 member organizations, which provide our basic funding. In recent years we have received new members, but at the same time too many of our old members are no longer able or willing to pay their fees. When we lose a member organization, we often also lose its scientists because for individuals it is troublesome and expensive to become a IUFRO member.

The time may be ripe to review the whole concept of IUFRO's membership. First we have to ask what we need members for. An obvious reason is money. Although IUFRO is a voluntary organization we would not survive now without membership dues. However, if we have money coming from sources other than from membership dues, do we still need members to fulfil our mission to promote international co-operation in forestry research and related sciences? The answer is yes. We need members also in this case because co-operation is not possible without co-operators, and our member institutions and their people form the best possible international network of co-operators in forest research.

According to a recent study of the European Forest Institute, in Western Europe alone there are more than a thousand institutions dealing with forest-related research. Out of these only 176 are IUFRO members. I guess that in other parts of the world the situation is similar. Thus, the potential for having new organizations join us is perhaps greater than we think. It is up to us how we use this potential to increase our institutional membership. There are many players, who are increasingly assuming important roles in the changing world of today, and with whom IUFRO has not yet established partnerships.

We need better direct links also with individual scientists. The fact that IUFRO is an organization of organizations does not guarantee that all scientists working in our member institutions know about IUFRO or get information about it. For scientists working in non-member institutions, the information flow was earlier practically non-existent. Now the situation has obviously improved considerably as most visitors to our web site and a considerable number of the participants in this Congress do not come from IUFRO's member organizations. To me this is again a sign of an enormous membership potential, because it shows how attractive IUFRO and its Congress are. An important precondition for increasing the number of individual members is that we make it easy for them to join IUFRO, especially for those in non-forestry disciplines. So far, IUFRO has used very modestly the knowledge and expertise of its member network. We have some non-refundable financed special projects and programmes, such as SPDC and SylvaVoc, but what we need to do is to mobilize the whole information and knowledge base of our scientists and experts, a unique but, for the time being, an underexploited resource. Good steps in this direction are the State-of-Knowledge Reports which have been presented here this week, and the Global Forest Information Service of which a prototype has been running during the Congress.

Ladies and Gentlemen,

My own vision for IUFRO is that we should become a clearing house for forest research information and expertise. Our office holders are key persons in this process but they only represent a fraction of our human resources. We must have direct links to all individuals who act in and are related to our research units. After having relevant information on their field of expertise, we will be able to function as a clearing house and respond to the requests of our clients when, for example, they want to know the state-of-knowledge in a specific field of forest research, or, when there is a need to create an international team to find a solution for a timely research problem.

If IUFRO acquires a good reputation as the clearing house of forest research information and expertise, it will greatly increase our visibility. This would appeal to sponsors and clients creating a snowball effect that would also lead to enhancing IUFRO's finances.

Dear Friends,

As the new President I see that one of my most important tasks is to act as IUFRO ambassador, who markets and sells our organization. The international forest sector community needs our expertise, and they are ready to pay for our services. We need marketing also for strengthening our membership. In addition to encouraging our current members to stay with us, we have to find new members, especially those who are outside the traditional forestry sector. An extensive and high-quality membership base is also an important precondition for selling our services to those, who need them and can pay for them.

Although I have now been expressing my views of the way ahead, I wish to spend a minute on the past. In my capacity as the current Vice-President for Programme I want to take this opportunity to thank all IUFRO office holders for your valuable work since the Tampere Congress. My special thanks go to the Congress Scientific Committee and the IUFRO Secretariat for their tremendous input in preparing the scientific programme of this Congress. Finally, I want to extend my gratitude to our Malaysian hosts. Because I was involved in hosting the previous Congress, I know precisely how much you have worked to make this event happen. I congratulate you on a very successful Congress. Saya ucapkan setinggi-tinggi tahniah kepada tuan rumah Malaysia di atas kejayaan kongres ini.

We Finns are known as people of few words - even when we have something to say. We prefer action to speeches, although speeches are also important when pointing the direction to where to go. I shall finish now, but you will hear from me later, perhaps not so much by what I say but rather and hopefully by what I do. Whatever I do for IUFRO, I want to do it together with all of you.

Address by
The representative of the host of the IUFRO Congress in 2005

Prof. Russell Haines

Queensland Forestry Research Institute

With a forty thousand-year history of utilization of forests and their resources in our country, Australians look forward to welcoming forest researchers internationally to the 22nd IUFRO World Congress in Brisbane in 2005.

Australia has a wide variety of forest types, from temperate to tropical to arid zone, and a rapidly expanding plantation estate. In the management of these forests, we face challenges similar to those faced by forest managers internationally and highlighted at this Congress.

Australia's Federal and State Governments have a strong commitment to the wise use of forest resources for the benefit of current and future generations, and recognize that such use must be based upon sound scientific knowledge. We have a strong commitment to participation in international forestry fora. In particular, we have a strong commitment to international scientific cooperation, and are strong supporters of the International Union of Forest Research Organizations. It is with some pride that I mention that it was my good friend and colleague, Dr Garth Nikles, recently retired after a 50 year contribution to forest science, who with Dr Jeff Burley in 1971 initiated IUFRO's first tropical Working Group.

I believe that we live in exciting times for forest researchers. Never before has there been a broader group of stakeholders with such a passionate interest in the management and utilization of forests and their resources. Never before has international cooperation among forest scientists been more important.

We hope that in 2005 we will be able to show delegates some Australian hospitality, and in particular to reciprocate the hospitality shown to us here in Malaysia.

Australian delegates have appreciated greatly the organizational excellence of the 21st IUFRO World Congress in Malaysia. We recognize that our Malaysian colleagues have set a very high standard for us to match, and the organization of Brisbane 2005 will be shaped significantly by the Malaysian experience.

We look forward to linking with the broader international IUFRO community in organizing the 22nd IUFRO World Congress, and to carrying the IUFRO flag forward for the next five years. In particular, we look forward to seeing all of you in Brisbane in 2005.

Closing Remarks by

Professor Jeffery Burley

President of IUFRO

Your Excellencies,
Distinguished Guests,
IUFRO Members, Colleagues and Friends,
Ladies and Gentlemen.

We come now to the formal closure of the 21st IUFRO World Congress in Kuala Lumpur, Malaysia. Although most people are always glad to return to their own homes, I know that many participants here will feel a tinge of sadness at leaving such a lovely country and people and at finishing such a comprehensive programme of exciting and challenging presentations, posters, discussions, exhibits and field visits. They will also regret leaving the old and new friends they have met here but I hope that professional and social contacts will be maintained in the century-old tradition of IUFRO's scientific and personal collaboration.

The organizers of every Congress are always worried at the outset that they cannot compete with the quality or quantity of the previous Congress but I have always believed that Congresses do not have to compete, just be different. After Montreal in 1990, the Finnish organizers of the Tampere Congress in 1995 initially felt that they could not match it but they did. After Tampere the Malaysians felt they could not possibly match it for this Congress in 2000 but I believe they have proved that they could. The quality of the administrative, political and technical arrangements has been superb, and the friendliness of all the supporting staff has been outstanding.

I have walked about the Congress site throughout the week and sought the views of many participants and have encountered none with any major criticisms. We shall see if this is borne out by the responses to the sample questionnaire survey but I am confident that it will be. Nevertheless the Executive Board of IUFRO will be anxious to hear your views after you have returned home and have had time to reflect on all aspects of the Congress.

It is clearly not possible for me to thank all the individuals and organizations that have contributed to the success of this Congress. On your behalf I will therefore thank collectively the Government of Malaysia; the Executive Board of IUFRO; the Congress Steering Committee chaired by Dr Razak; the Congress Organizing Committee chaired by Dr Rahim; the Congress Scientific Committee chaired by Dr Teissier du Cros; the IUFRO Secretariat led by Heinrich Schmutzenhofer; the many staff of FRIM, State and National Forest Departments, and Universities who have helped in so many ways; the photographers, information staff and Professional Congress Organizer's staff; the Press who reported so conscientiously throughout the week; the interpreters without whom the keynote speakers would not have been fully heard; the Master of Ceremonies without whom the opening and closing ceremonies and dinners would have been less efficient and less enjoyable; the sponsors of many participants; and, above all, the participants themselves. As with most activities in life, you get out of an event as much as you put in and I know that the majority of participants entered fully into the spirit and activities of the Congress and consequently gained much personal pleasure and professional benefit.

Personally I thank you all for your continued support over the past five years, particularly my wife Jean and the IUFRO Secretary, Heinrich Schmutzenhofer. Without them I could not have functioned as your President. Luckily I only have to go home with one of them. For the other I have a small present, an Oxford paper clock with the alarm permanently set at 6 p.m. so that he also will know it is time to go home to his equally supportive wife, Edith.

I wish you all safe onward journeys and may your God go with you. I now declare the 21st IUFRO World Congress closed.

Allocutions des cérémonies d'ouverture et de clôture

Allocution de

Dato' Dr. Abdul Razak Mohd. Ali

Président du Comité directeur du Congrès

Monsieur le Ministre, YB. Dato Seri Dr Lim Keng Yaik,
Ministre des Industries primaires
Monsieur le Professeur Jeffery Burley,
Président de l' IUFRO
Chers invités, Mesdames et Messieurs,

C'est vraiment un honneur pour moi d'accueillir vous tous au XXIème Congrès Mondial de l'IUFRO au nom du Comité directeur du Congrès. Nous sommes particulièrement reconnaissants au Ministre honorable des Industries primaires pour avoir accepté l'invitation à inaugurer ce congrès au nom du Premier ministre honorable qui ne peut pas être avec nous ce matin. À tous les délégués et particulièrement à ceux de l'étranger, „Selamat Datang ke Malaysia" ou „Bienvenue en Malaisie".

Au cours de la réunion du Bureau exécutif de l'IUFRO, tenue à Madrid en avril 1995, la Malaisie a offert d'accueillir ce XXIème Congrès Mondial de l'IUFRO à Kuala Lumpur. Ce sentiment de satisfaction éprouvé il y a plus de cinq ans demeure dans mon esprit puisque j'ai été alors confié la tâche de présider la délégation qui a présenté la proposition de Malaisie outre les offres semblables provenant de l'Afrique du Sud, de la Chine et de l'Indonésie.

La Malaisie est très fière d'être le premier pays en voie de développement qui accueille un Congrès Mondial de l'IUFRO. Ce congrès est certainement la plus grande réunion forestière jamais organisée dans le pays. En termes de nombre de participants et de personnes d'accompagnement inscrits, des exposés et des posters pour la présentation, le Congrès surpasse la 14ème Commonwealth Forestry Conference, tenue à Kuala Lumpur en septembre 1993.

Nous remercions le gouvernement de la Malaisie et le Conseil international de l'IUFRO pour avoir confié la responsabilité gigantesque d'organiser ce congrès de l'IUFRO à l'Institut de recherches forestières de la Malaisie (FRIM). Nous désirons remercier le Secrétariat de l'IUFRO à Vienne et le Comité directeur de la recherche forestière de la Malaisie (MFRDB) de leurs conseils et leur appui inestimable. Le Comité d'organisation du congrès (COC) et ses sous-comités ont travaillé de façon très dure pour assurer que les préparatifs du congrès se dérouleront comme prévus.

Mesdames et Messieurs,

C'est avec plaisir que nous vous informons que 1906 participants et plus de 200 personnes d'accompagnement provenant de 96 pays se sont inscrits. Dans les prochains jours 5 exposés principaux, 9 exposés sous-plénieres, 500 exposés de sessions de groupes et 833 posters ainsi qu'une discussion d'experts sur les posters auront lieu. La présentation de posters permettra un échange d'information entre les scientifiques et leurs collègues.

Grâce au Programme d'assistance aux scientifiques (SAP) nous pouvions financer la participation de 138 chercheurs provenant de 38 pays en voie de développement. Le gouvernement de la Malaisie a fourni des fonds financiers pour soutenir encore 31 scientifiques provenant de l'Asie et du Pacifique.

Nous remercions le Ministre honorable des Industries primaires de la Malaisie qui prononcera le discours d'ouverture au nom du Premier ministre. D'autres points culminants de la cérémonie d'ouverture incluront le lancement des timbres commémoratifs du congrès, une présentation culturelle et la présentation des récompenses de l'IUFRO. Nous aimerions également remercier les orateurs principaux pour leurs contributions pendant les sessions plénières.

Mesdames et Messieurs,

J'espère vraiment que le congrès servira de forum où les scientifiques du monde entier puissent discuter le rôle de la recherche et leur relation avec les forêts et la société. Traditionnellement, les forêts ont été considérées comme source de bois d'œuvre. La recherche a en effet joué un rôle significatif en changeant ces perceptions et attitudes en montrant que les forêts fournissent également un éventail d' autres biens et services pour assurer le bien-être de la société.

Veuillez profiter de l'occasion de ce congrès pour discuter des thèmes divers et des besoins de recherche et de forger des collaborations en matière de recherche et de développement. Les réunions avant le congrès, les réunions satellites et les réunions de travail programmées sont destinées à atteindre de tels objectifs.

Tout dit et fait, je vous demande pardon d'avance pour toutes les imperfections dans l'organisation du congrès, au nom du Comité directeur du Congrès et du Comité d'organisation du Congrès. En conclusion, j'espère que vous trouverez le temps pendant les excursions de visiter la Malaisie, pays fascinant et riche en diversité biologique et culturelle.

Merci.

Allocution du

Professeur Jeffery Burley

Président de l'IUFRO

Monsieur le Ministre honorable des Industries primaires,
Dato' Seri Dr. Lim Keng Yaik ;
Monsieur le ministre adjoint honorable ,
Monsieur le Secrétaire Général ,
Monsieur le Président du Comité directeur du Congrès ,
Dato' Dr Abdul Razak,
Monsieur le Directeur Général adjoint de la FAO ,
Dr. Hosny El-Lakany,
Chers invités ,
Mesdames et Messieurs,

C'est mon grand privilège et plaisir de vous accueillir à ce 21ème Congrès Mondial de l'Union Internationale des Organisations de Recherche Forestière (connue largement sous le nom de l'IUFRO). Votre Excellence, nous regrettons beaucoup de ne pas avoir l'honneur de la présence de Monsieur le Premier ministre mais nous comprenons que les affaires d'Etat ont empêché sa participation.

Cependant, nous vous remercions de nous faire le grand honneur de prononcer le discours d'ouverture qui, j'en suis sûr, sera une adresse de bienvenue et d'exhortation. Le thème de notre congrès est « La Forêt et la société : le Rôle de la science » ; cela est particulièrement important car nous écrivons un nouveau millénaire avec des populations humaines croissantes, des besoins croissants sur les produits de la forêt, et une sensibilisation prononcée pour les nombreuses prestations environnementales et sociales que les forêts fournissent. Cela est particulièrement vrai pour la Malaisie, un pays qui possède de vastes et riches ressources de forêt avec leurs services associés, et un pays avec une tradition de recherche réputée dans le monde entier. Nous sommes également très honorés de la présence de son Excellence, M. le Ministre des Industries primaires, Dato'Seri Dr. Lim Keng Yaik . Il a toujours été un penseur et un orateur actif et conscient en matière de recherche forestière et des industries forestières, notamment par rapport à la Malaisie et le Sud-Est Asiatique. C'est avec grand intérêt que nous attendons son discours.

Durant les cinq dernières années il a été toujours un privilège pour moi d'être le président de l'IUFRO et je voudrais profiter de votre attention pour vous raconter un peu de l'histoire et des activités de l'Union. J'aimerais montrer pourquoi ceci devrait être d'intérêt pour une haute personnalité de la vie politique et pourquoi les chercheurs et les décideurs politiques devraient chercher le dialogue.

L'IUFRO fut fondée en 1892 par un nombre restreint de pays européens, et au cours de ses 80 premières années d'existence la plupart des pays tempérés y ont adhéré. C'est seulement en 1971 que le premier groupe de travail traitant un thème spécifiquement tropical a été crée (génétique forestière et amélioration des arbres). Depuis lors l'IUFRO s'est empressée à faire profiter les institutions et les scientifiques dans les pays en voie de développement des avantages d'une collaboration internationale (y compris l'appui à l'APAFRI, au FORNESSA et au Réseau d'Amérique latine) et à les impliquer activement à tous les niveaux de sa gestion. L'Union comporte maintenant presque 700 organisations membres dans 110 pays avec approximativement 15,000 scientifiques travaillant en collaboration et volontairement dans 276 divisions, groupes de recherche et groupes de travail. C'est une organisation internationale, non-gouvernementale, sans but lucratif et multidisciplinaire qui cherche sérieusement à tirer les plus grands avantages de l'investissement que les gouvernements, les industries et les personnes privées font en matière de recherche.

J'aimerais souligner que le travail de l'IUFRO est essentiellement volontaire : pratiquement tous les cadres et coordonnateurs de l'Union et tous les chercheurs déploient des efforts considérables visant le succès de l'IUFRO parce qu'ils croient en la valeur ajoutée de la collaboration. Seulement le personnel du Secrétariat, généreusement financé par le gouvernement de l'Autriche, peut être qualifié de "fonctionnaires permanents" de l'Union. Le personnel contractuel du Programme spécial pour les pays en développement (SPDC) est généreusement financé par le Canada, le Danemark et les Etats-Unis. L'Union européenne et les gouvernements du Japon, de la Suisse et du Royaume-Uni ont aussi accordé une aide financière importante à l'IUFRO. L'IUFRO entretient des relations étroites avec d'autres organisations, en particulier le Conseil International pour la Science, le Centre pour la Recherche Forestière Internationale, l'Organisation des Nations Unies pour l'Alimentation et l'Agriculture et le Centre International pour la Recherche en Agroforesterie . C'est un privilège supplémentaire pour nous que le représentant du Directeur Général de la FAO va prononcer un discours au cours de cette séance d'ouverture.

Tout au long de ce siècle l'Union a encouragé et soutenu des travaux de recherche excellents abordant un éventail de thèmes scientifiques. Pourtant, la recherche est sans valeur une fois conduite indépendamment ; elle devrait être considérée comme partie intégrante du continuum de la recherche pure et appliquée destinée à l'adaptation et à l'application de grande envergure de nouveaux systèmes technologiques et sociaux qui abordent les grandes questions politiques internationales et nationales. A cet effet, l'IUFRO a mis en place des Groupes de réflexion afin d'encourager l'intégration d'une telle recherche et pour améliorer les relations entre les chercheurs et les décideurs politiques. Pour ce congrès de Malaisie qui a lieu dans la première année du nouveau millénaire, les scientifiques de l'IUFRO produiront des bilans scientifiques de connaissance sur beaucoup de questions d'intérêt faisant le point sur l'information actuellement disponible, sur les implications de la gestion de cette recherche, et sur tout besoin en nouveaux travaux de recherche.

Dans la décennie passée on pouvait noter une sensibilisation croissante au niveau de la politique et du grand public quant à l'importance des forêts et des arbres pour le bien-être de l'humanité. Ils fournissent un grand nombre de produits et de services sociaux, environnementaux et économiques au bénéfice de bon nombre de parties prenantes. Outre les livres et les journaux scientifiques, dans la plupart des pays, on note de plus en plus de contributions ayant trait à la forêt dans les journaux et les émissions à la télévision et à la radio. Il y a une interdépendance et souvent une compétition entre les divers produits et services exigés de la forêt. La recherche embrasse beaucoup de disciplines qui ne sont pas naturellement cohésives. L'IUFRO fait des efforts considérables afin d'encourager la collaboration interdisciplinaire entre les sociologues et les biophysiciens.

Le chiffre 2000 est un joli chiffre rond, du moins si vous appliquez le système décimal. Il est également fortement significatif dans certains calendriers religieux. Pourtant, il est totalement significatif pour tout être vivant et pour les milliards d'hommes pas encore nés car c'est l'année dans laquelle les agences internationales, les gouvernements nationaux, les organismes sociaux civils, les éducateurs, les chercheurs, les entreprises et les gestionnaires de ressources ont dû réaliser le besoin urgent de développer la gestion des ressources du monde d'une façon raisonnable, équitable, moralement impeccable et durable. Les forêts et les arbres joueront un rôle important dans un tel développement durable et l'IUFRO continuera à faire de son mieux pour encourager la recherche et les chercheurs à aborder les questions pertinentes et à présenter leurs résultats de sorte que les décideurs politiques et toutes les parties prenantes puissent les comprendre et appliquer. Le Bureau exécutif de l'IUFRO estime que ce congrès contribuera de manière décisive à cette approche.

Votre Excellence, tout participant au XXIème Congrès Mondial de l'IUFRO est extrêmement reconnaissant au gouvernement de la Malaisie et à la ville de Kuala Lumpur pour l'accueil chaleureux, l'hospitalité amicale et généreuse, et pour l'organisation des excursions intéressantes et agréables dans votre beau pays dont peuvent profiter les scientifiques et les personnes qui les accompagnent. Par rapport à l'organisation je tiens à souligner que le personnel de l'Institut de recherche, les Services des forêts et quelques universités et d'autres institutions ont travaillé durement pour appuyer l'IUFRO dans cet effort quinquennal. Ayant peur que cela a eu des conséquences pour la recherche en Malaisie je suis d'autant plus inquiet que les activités de recherche s'arrêtent complètement puisque les collaborateurs administratifs et scientifiques de l'institut sont devenus des organisateurs de congrès et de circuits touristiques.

Votre Excellence, nous vous prions maintenant d'inaugurer ce XXIème Congrès mondial de l'IUFRO et de partager avec nous votre avis du rôle et des besoins en recherche forestière. Je vous invite aussi à nous faire l'honneur de conférer le titre de membre honoraire, la distinction la plus haute de notre Union, à deux hauts cadres de l'IUFRO.

Allocution de

Y.A.B. Dato' Seri Dr. Mahathir bin Mohamad

Premier Ministre

prononcée par

Dato' Seri Dr. Lim Keng Yaik

Ministre des Industries primaires, Malaisie

Monsieur le Professeur Jeffery Burley , Président de l'Union Internationale de Recherches Forestières.
Monsieur le Secrétaire Général du Ministre des Industries primaires, Datuk Haron Siraj, Malaisie
Monsieur le Président du Comité directeur du Congrès, Dato' Dr. Abd. Razak Mohd Ali,

Chers invités, Mesdames et Messieurs,

Permettez-moi tout d'abord, de remercier les organisateurs de cet important congrès forestier qui m'ont invité à prononcer ce discours d'ouverture au 21ème Congrès Mondial de l'Union internationale des organisations de recherche forestière. J'aimerais aussi souhaiter la bienvenue à tous nos invités et participants en vous souhaitant des réunions couronnées de succès et un séjour agréable en Malaisie.

Autant que je sache, l'IUFRO est une organisation non-gouvernementale à but non lucratif, fondée en 1892, il y a plus de cent ans, et sa mission est de promouvoir la coopération internationale en matière de recherche forestière et sciences connexes. L'IUFRO compte environ 700 organisations membres dans 105 pays, et c'est la première fois que le congrès a lieu dans un pays en voie de développement. De ce fait, c'est ma tâche de féliciter les organisateurs pour avoir gagné le concours pour accueillir ce Congrès Mondial à Kuala Lumpur et pour avoir entrepris les préparations nécessaires qui nous ont permis à nous réunir ici à l'occasion de l'événement forestier le plus grand jamais organisé dans ce pays. J'espère que cela sera le début d'une série d'autres congrès qui se tiendront dans des pays en voie de développement.

Nul n'ignore que les forêts jouent un rôle majeur dans l'existence des peuples de beaucoup de pays en voie de développement tout en contribuant de manière significative au progrès économique de ces nations. Je suis extrêmement content que la Malaisie a ouvert la voie pour les pays en voie de développement de faire des offres pour organiser un tel congrès, puisque les thèmes forestiers concernent de plus près un grand nombre d'hommes et femmes dépourvus et pauvres dans le monde entier. Dans ce contexte, j'aimerais féliciter l'IUFRO pour avoir choisi un thème approprié, à savoir: la forêt et la société : le rôle de la science.

Mesdames et Messieurs,

J'enfoncerai des portes ouvertes si je vous parlais maintenant des rôles et des fonctions de la forêt. C'est vous qui sont les experts en cette matière. Vous savez très bien que les forêts ont été considérées toujours séparément des peuples qui habitent dans ou au bord de la forêt et que les forêts ont été considérées seulement pour le bois qu'elles fournissaient. Cependant, depuis des années on note une tendance vers la reconnaissance que les forêts et la société, tant rurale et urbaine, sont deux côtés de la même monnaie et qu'à part du bois, la forêt fournit une série de biens et de services importants pour le bien-être de la société.

Mais quelles sont les leçons que nous avons tirés de ce passé pas si lointain, des leçons qui ont déclenché ce changement de perception et qui ont marqué le début du débat international sur les forêts? Nous savons tous que lors du démarrage de la révolution industrielle au début du 19ème siècle, une grande partie des forêts tempérées de l'Europe, déjà décimées au cours des siècles précédents a été coupée pour fournir le bois nécessaire au processus de l'industrialisation. De grandes surfaces de forêts ont également été déboisées de l'autre côté de l'océan, aux Amériques, au cours du 19e siècle. Dans quelques décades seulement, des millions d'hectares de forêt ont été détruits pour gagner des pâturages et cultures, du bois d'œuvre et du bois de chauffage.

La révolution industrielle dans les pays occidentaux a provoqué des effets néfastes pour l'environnement. La pollution atmosphérique et des eaux ainsi que la dégradation du sol sont devenues plus importantes. La croissance économique initiée à grand pas après la Seconde Guerre Mondiale dans les pays maintenant développés a provoqué une dégradation continue de l'environnement. La Conférence des Nations Unies sur l'Environnement Humain tenue en juin 1972 à Stockholm n'a pas laissé de traces. Cependant, la dégradation de l'environnement continue comme avant. Le réchauffement du globe, la diminution de la couche d'ozone, la pollution des eaux marines, la pluie acide, le déboisement et la dégradation des sols - en grande partie conséquences des activités industrielles - sont devenues des causes importantes de préoccupation au début des années 80.

Dans ce contexte, la Déclaration de Langkawi sur l'Environnement issue de la réunion du Commonwealth des dirigeants de gouvernements (CHOGM) tenue à Kuala Lumpur en octobre 1989, a préparé le terrain pour un concept qui a pris forme au cours des réunions internationales subséquentes. La notion d'une "terre verte" sera désormais inscrite en tant que principe dans la Déclaration de Paris du 10ème Congrès Forestier Mondial tenu en 1991. Par conséquent, lors de la Conférence des Nations Unies sur l'Environnement et le Développement (CNUED) à Rio de Janeiro, en juin 1992, la Déclaration de Principe sur les forêts acceptée par tous les gouvernements traduit complètement cette notion.

Dans ce contexte, juste avant le Sommet de la Terre à Rio, la Malaisie a notamment proposé de porter la surface forestière mondiale qui était de 27.6 % à l'époque, à 30 % d'ici l'an 2000, et cela à l'aide de puissants programmes de reboisement à l'échelle mondiale. Nous avons envisagé que cette augmentation couvrirait tous les types de forêt - boréale, tempérée et tropicale – puisqu'il n'y a pas de différence dans la manière avec laquelle les forêts accumulent le carbone, stabilisent le climat, protègent l'environnement, conservent la diversité biologique, fournissent des ressources industrielles et la base de l'existence des communautés qui vivent dans et au bord de la forêt. Nous avons aussi pensé que les pays développés avec peu de surfaces boisées, ce qui est la conséquence de la mauvaise exploitation au cours des siècles écoulés, mais qui disposent maintenant des économies viables, de vastes ressources et du savoir-faire technologique, partageront nos efforts pour une "terre verte". Nous avions envisagé en plus, peut-être dans notre naïveté, que ces pays possédant de puissantes économies réuniront leurs vastes ressources pour la mise en œuvre des programmes de boisement et de reboisement dans les pays les plus pauvres du monde.

Cependant, huit ans après Rio, on note 'business as usual.' Toute euphorie engendrée par Rio s'est évaporée virtuellement du jour au lendemain. Aucun mouvement concerté pour une terre verte est né, même pas sous forme embryonnaire. Chaque nation a été pratiquement laissée à son propre chef pour mettre en œuvre ses programmes de reboisement. On m'a informé que, selon l'Agenda 21, le coût annuel moyen pour mettre en œuvre les programmes de reboisement a été estimé à US$32 milliards. Une partie importante devrait venir des pays développés. Malgré le fait que l'Agenda 21 et la Déclaration des Principes sur les forêts ont fourni le cadre pour renforcer la coopération des pays il s'est avéré que la plupart des fonds requis pour des programmes de reboisement devraient être trouvés par les pays en voie de développement eux-mêmes.

La Malaisie a toujours été et reste toujours proactive en ce qui concerne les questions globales au sujet des forêts et de l'environnement. Nous avons participé activement aux négociations menant à l'CNUED, y compris l'Agenda 21, le Rapport des Principes sur les forêts, la Convention sur la Diversité Biologique et la Convention-cadre sur les changements climatiques, et nous avons continué à participer activement aux développements depuis Rio. Nous préconisons le concept de la terre verte, bien que les forêts aient été détruites pendant la période de l'occupation coloniale dans le but de planter des cultures de rente.

Néanmoins, les forêts naturelles couvrent toujours environ 58% de notre terre. La couverture forestière est de 72% de la surface du pays, y compris les plantations du gommier et du palmier à huile. Nous avons mis en gage et continuerons à confirmer cet engagement, que cette couverture de forêt se stabilise à un niveau minimum de 50% de la surface à perpétuité. Cela sera notre contribution pour l'humanité.

À cet égard, nous nous sommes également efforcés de renforcer la sylviculture pratique, conformément au concept de la gestion forestière durable, par exemple, nous avons augmenté notre patrimoine forestier de 12,7 millions d'hectares à 14,1 millions d'hectares, nous avons révisé la politique nationale de sylviculture en 1992 et nous avons modifié la Loi nationale forestière en 1993, renforçant ses dispositions et prévoyant des pénalités plus strictes pour des réfractions en forêt. Nous augmentons nos efforts dans la recherche et le développement dans tous les domaines appropriés de la sylviculture, y compris des efforts de développer les industries du bois de manière durable. A l'échelle régionale, la politique nationale sur la diversité biologique, approuvée en 1998, fournira des conseils pour l'économie de la diversité biologique et de l'utilisation durable de ses composants.

Sur le plan international, nous avons continué à contribuer au processus du Groupe d'experts intergouvernemental sur les forêts (IPF) et du Forum intergouvernemental sur les forêts (FIF). Nous participons activement à la mise en place de la Convention sur la Diversité Biologique et de la Convention sur les changements de climat, tous les deux portent directement sur des thèmes forestiers.

Nous reconnaissons que le secteur forestier est important pour l'économie et la société d'une nation, aussi bien que pour l'environnement national et mondial. En conséquence, c'est devenu une question dominante aux ordres du jour forestiers locaux et nationaux notamment en ce qui concerne la mise en place d'un instrument législatif en matière forestière. Nous connaissons très bien les arguments qui n'ont pas permis qu'un tel instrument soit discuté largement; le problème d'un instrument législatif en matière forestière n'est pas encore résolu. Nous ne sommes pas plus près d'un tel instrument qu'avant.

La position de la Malaisie est telle qu'un instrument législatif obligatoire qui porte sur tous les types de forêts est nécessaire pour adresser une vaste gamme de thèmes forestiers d'une façon holistique, intégrée et complète. Nous croyons qu'un instrument légal faciliterait le développement d'une gestion durable pour toutes les forêts, par rapport aux solutions « ad hoc » qui peut être un obstacle à la mise en place de meilleures pratiques en matière de sylviculture. Nous croyons également qu'un tel instrument encouragerait les actions à niveau international destinées à adresser les facteurs responsables de la diminution et la dégradation de forêts telles que la dette internationale et la surconsommation. Un tel instrument encouragerait et accélérait la coopération dans le domaine du transfert de la technologie.

Actuellement, le manque de consensus sur la nécessité d'un instrument législatif obligatoire est dû à l'impasse au sujet des questions critiques telles que le financement, le transfert technologique et le commerce. À cet égard, je voudrais inviter les pays développés à réaffirmer et à réaliser leurs engagements pour fournir l'aide financière et les technologies concrètes aux pays en voie de développement en vue du développement de la gestion durable de leurs forêts. En outre, la gestion forestière durable devrait être encouragée à travers des pratiques commerciales plus souples et des normes environnementales. Les restrictions commerciales et environnementales ne réduiront pas le déboisement. Elles rendront la forêt inutile et auront comme conséquence que la forêt se voit détruite pour d'autres buts. En fait, un plus grand accès aux marchés aidera à favoriser la gestion forestière durable en fournissant les revenus si importants à cette fin.

La dépendance de la société à l'égard de la sylviculture remonte à la nuit des temps, quand la société était primitive avec des besoins simples. Dans beaucoup de parties de la terre, et notamment dans les pays en voie de développement, les besoins sociaux sont demeurés toujours simples. Ailleurs, le développement et les modes de vie gaspilleurs ont rendu souvent insatiables les besoins des sociétés. Mais, ces besoins ne sont pas simplement matériels, par conséquent il faut absolument appliquer la maxime que les ' ressources et les terres forestières devraient être gérées de façon durable pour répondre aux besoins humains sociaux, économiques, écologiques, culturels et spirituels des générations présentes et futures'.

Je suis content d'avoir l'occasion de rencontrer vous tous aujourd'hui et de vous parler lors de ce Congrès qui réunit des scientifiques ayant consacré leur vie directement ou indirectement à la recherche forestière. Ils contribuent aux besoins sociaux du présent aussi bien que du futur. L'histoire récente a prouvé que d'investir dans la recherche et le développement dans n'importe quel domaine peut entraîner des bénéfices importants. C'est mon souhait sincère que vos efforts aboutiront aux bénéfices qui amélioreraient le sort de la société dans l'ensemble, et des faibles de la société en particulier. Vous représentez les pays développés et en voie de développement du monde et c'est l'IUFRO qui assure la liaison Nord-Sud.

À cet égard, j'espère que vos efforts aideront à établir un ordre du jour plus équitable sur le plan forestier sur la scène internationale, par lequel les technologies que vous développez dans vos efforts soient partagées équitablement avec les pays en voie de développement pour améliorer les pratiques en matière de sylviculture globalement. Si le monde doit réaliser la gestion forestière durable, le transfert de la technologie du Nord au Sud à conditions préférentielles comme convenu à Rio doit être réalisé. Malheureusement, cela n'a pas été ainsi et les pays en voie de développement sans avoir accès à ces technologies, ne pourront pas assumer leurs responsabilités concernant la gestion forestière durable, cela n'apporte rien à personne. L' IUFRO joue donc un rôle important pour faciliter ce transfert de technologie. J'espère que ce congrès aidera non simplement à encourager un échange des expériences scientifiques mais qu'il développera également des réseaux plus concrets qui serviront des liens pertinents pour le transfert de la technologie en direction Nord-Sud. Donc, je vous souhaite que vos efforts soient couronnés de succès et que vous aurez un congrès productif.

En conclusion, laissez-moi saluer les délégués de ce congrès. J'espère que vous trouverez le temps au cours des excursions d'admirer non simplement la biodiversité de nos forêts tropicales mais de faire aussi la connaissance de la société multi-ethnique, multi-culturelle et multi-religieuse de notre pays. En Malaisie vous verrez l'Asie.

Ceci dit, j'ai le grand plaisir de déclarer ouvert le XXIème Congrès Mondial de l'IUFRO.

Allocution du

Professeur M. Hosny El-Lakany

Directeur Général Adjoint,
Département des Forêts, FAO

Chers invités,
Monsieur le Président,
Chers membres du Bureau exécutif de l'IUFRO,
Mesdames et Messieurs,

Au nom du Directeur Général et du personnel de l'Organisation pour l'Alimentation et l'Agriculture des Nations Unies, et tout particulièrement au nom de mes collègues du Département des Forêts, j'aimerais saluer cordialement tous les participants à ce 21ème Congrès Mondial de l'IUFRO. Il est pour moi un grand plaisir et un grand honneur d'être avec vous aujourd'hui, ici à Kuala Lumpur!

Tout d'abord, j'aimerais féliciter les organisateurs du Congrès et tout particulièrement nos hôtes Malaysiens pour leur organisation magnifique. Certainement, la Malaisie, avec sa longue tradition dans la recherche forestière, contribuant au développement est le cadre approprié pour un rassemblement tellement impressionnant.

En regardant autour de moi je vois un groupe divers et éminent de participants et je me rends ainsi compte de la valeur de l'IUFRO en tant qu'organisation. L'IUFRO offre aux scientifiques et chercheurs forestiers les moyens pour partager l'expérience et le savoir et ceci aussi bien pour avancer la cause d'une gestion forestière durable que celle de leur développement individuel. L'opportunité pour les jeunes scientifiques au début de leur carrière d échanger des idées et de profiter des membres savants de l'Union est sans égal et la possibilité d'exploiter des résultats des recherches du monde entier est d'une valeur immense. Combien parmi nous, présents aujourd'hui ici, n'ont pas saisi cette occasion unique?

Pour moi je peux le dire, c'était ainsi. Je me souviens très bien de ma première participation à un congrès de l'IUFRO – c'était en 1976 à Oslo, et de ma rencontre avec beaucoup de chercheurs forestiers dont quelques-uns sont heureusement avec nous aujourd'hui. Une partie de ma thèse de doctorat s'est appuyée sur la collection des semences réalisée sous l'égide de l'IUFRO – la collection de provenances de sapin de Douglas de 1966.

Ainsi, c'est un grand honneur pour moi de représenter la FAO lors de cette réunion importante – le premier Congrès Mondial de l'IUFRO du nouveau millénaire. L'IUFRO entretient des relations étroites avec ses membres, et les relations avec la FAO sont également uniques. A l'échelle institutionnelle, la FAO et l'IUFRO avaient entretenu des relations faisant preuve de coopération et de symbiose depuis la création de la FAO – l'IUFRO étant, bien entendu, « la sœur aînée" de près de presque d'un demi siècle. L'IUFRO établit des liens entre scientifiques et chercheurs et la FAO contribue à établir des liens entre l'IUFRO et le terrain, assurant ainsi que les résultats précieux de la recherche forestière soient appliqués – et les impulsions venant du terrain soient transmises aux chercheurs.

A la FAO, tous les fonctionnaires forestiers ont des contacts directs et continus avec l'IUFRO et ses groupes de travail et de recherche. En outre, à travers son programme de partenariat, la FAO facilite les visites et la communication directe entre personnel universitaire, chercheurs et tout particulièrement jeunes professionnels qui n'auraient pas autrement l'opportunité de partager l'expérience et l'expertise avec leurs collègues. De plus, la FAO, à travers son rôle de forum neutre, aide les pays à identifier conjointement les domaines où il faudrait des travaux de recherche supplémentaires, et de concentrer ainsi les efforts des scientifiques forestiers à l'échelle mondiale. Je suis toujours content de voir des scientifiques et chercheurs forestiers parmi les délégués nationaux dans les réunions bisannuelles du Comité des Forêts de la FAO. Ainsi, le flux d'informations et du savoir à travers les réseaux multiplies est assuré entre la FAO et l'IUFRO, au bénéfice de tous les intéressés.

Aux yeux de la FAO, le thème de ce Congrès « La forêt et la société : le rôle de la recherche » est particulièrement approprié. Dans son travail en matière de recherche forestière, la FAO se voit complètement engagée à une approche basée sur la mise en valeur maximale des bienfaits environnementaux et économiques de la gestion forestière durable. En effet, cet engagement est clairement inscrit dans la Stratégie pour les Forêts de la FAO, élaborée pendant plus de deux ans, en collaboration avec les pays membres de la FAO, les instituts et organisations partenaires, y compris l'IUFRO, et approuvée par le Comité des Forêts de la FAO en mars 1999. Le plan stratégique des forêts de la FAO décrit la mission, les buts, les objectifs à moyen terme, les activités actuelles prioritaires et sa vision pour le secteur forestier. Sa mission est "d'accroître le bien-être de l'humanité par l'appui aux pays membres pour développer une gestion durable des arbres et forêts du monde entier »." Ce sont les hommes et la société qui viennent en premier.

Nous aussi, nous concentrons nos activités prioritaires sur les forêts et la société. Nos efforts en matière de foresterie villageoise et participative ont pour but d'associer directement une partie plus grande de la société aux prises de décisions en gestion des forêts. Je devrais ajouter que l'objet de ces préoccupations sont non seulement ceux qui vivent dans et aux environs des forêts mais aussi ceux qui dépendent des ressources et produits forestiers.

Une autre priorité de la FAO ayant trait directement aux forêts et à la société, est notre appui aux pays pour poursuivre leurs programmes forestiers nationaux. Ces programmes – reconnus par les processus intergouvernementaux issus du CNUED – visent à établir un cadre social et politique propice pour la conservation, la gestion et le développement durable de tous les types de forêts.
Un troisième champ d'action du volet "forêts" de la FAO est la promotion de l'accès à l'échelle mondiale aux informations forestières fiables et actuelles. Le premier Article de la Constitution de la FAO nous donne le mandat de « Recueillir, analyser, interpréter and diffuser l'information." En matière forestière, cela implique le développement des termes communs et des définitions, l'harmonisation des définitions, la collection des statistiques sur la production, la consommation et le commerce, et notre évaluation des ressources forestières mondiales. Dans tous ces domaines, nous coopérons étroitement avec l'IUFRO. Pour cette raison, il est particulièrement important de lancer les premiers résultats de l'évaluation des ressources forestières 2000 de la FAO ici et à ce Congrès. J'aimerais aussi mentionner les pages forestières de notre site Web qui est très important et aussi la collaboration entre FAO et l'IUFRO dans le développement du Service mondial de l'information forestière.

Un autre domaine important est la collaboration de la FAO/IUFRO avec le Programme spécial pour les pays en développement – le SPDC. Il y a un mois, le sept juillet, le Réseau forestier de recherche pour l'Afrique subsaharienne (FORNESSA) fut crée officiellement et le premier président, Dr. Konuche du Kenya, fut nommé. Dans ce contexte, je suis heureux de voir que le Coordonnateur adjoint du SPDC s'est installé dans le Bureau régional de la FAO pour l'Afrique – ce qui est la garantie pour la continuation des relations avec la FAO.

Lors de ce Congrès, les collaborateurs de la FAO présenteront de nombreux exposés, et beaucoup de séances ont été co-organisées avec la participation de la FAO.

J'espère que par ces exemples donnés, il en ressort clairement que la FAO s'est engagée à long terme à maximiser les relations positives entre foresterie et société. Le thème de ce Congrès suggère que l'IUFRO et ses membres aillent dans cette direction.

Comment la FAO imagine le rôle de la recherche en poursuivant ce chemin? Certainement, il faut se concentrer encore plus sur les aspects sociaux d'une gestion forestière durable. Nous avons besoin de savoir plus comment on aborde ou peut aborder la gestion forestière et en particulièrement pour ce qui est des instruments et des développements scientifiques dont on a besoin pour assumer cette responsabilité plus efficacement.

Nous avons aussi besoin de plus de recherche sur la diffusion de l'information aux populations pour leur permettre de participer activement aux processus de prise de décision. Il faut aussi des travaux de recherche plus spécialisés concernant les questions de maîtrise des conflits.

Il faut que nous étudions le potentiel et les modalités de la coopération internationale en matière forestière. La décennie passée a vu une pléthore d'accords internationaux qui sont en relation directe avec le futur de la foresterie mondiale mais pour les responsables chargés de la mise en œuvre il s'agit là vraiment du nouveau terrain. Nous devons étudier, analyser et tirer des leçons des expériences des autres secteurs qui se sont lancés sur ce chemin avant nous, de sorte que les accords que nous concluons pour ces ressources soient en même temps raisonnables dans leur ampleur et noble dans l'intention.
Ce sont des véritables défis qui nous attendent, et ils sont d'autant plus intéressants par le fait qu'ils doivent compléter et non pas seulement substituer la recherche forestière traditionnelle. A mon avis, ils sont essentiels si nous voulons atteindre notre objectif commun ce qui est l'utilisation durable des écosystèmes forestiers. Et je pense qu'il y n'a pas une autre organisation plus appropriée que l'IUFRO à faire face à ces défis.

En conclusion, Mesdames et Messieurs, j'aimerais féliciter personnellement le Bureau exécutif et le Président sortant en particulier – qui est un collègue proche et un ami cher, le Professeur Jeff Burley, pour la direction compétente et forte. Et permettez-moi aussi d'exprimer ma confidence dans le Bureau et le Président, le professeur Risto Seppälä désigné, et de saluer tout cordialement les anciens présidents, et notamment le Dr. Salleh Mohd Nor.

Monsieur le Président, au nom du Directeur Général de la FAO, Jacques Diouf, et à mon propre nom, et tout particulièrement au nom du Programme des Forêts de la FAO, j'aimerais exprimer nos espérances sincères pour un Congrès couronné de succès, et pour un démarrage sans problèmes de la foresterie mondiale dans ce nouveau millénaire.

Merci.

Rapport quinquennal Séance de clôture Allocution du

Professeur Jeffery Burley
Président de l'IUFRO

Chers invités,
Chers collègues,
Mesdames et Messieurs,

Arrivant à la fin de ce congrès impressionnant qui a donné bien des résultats je vous parlerai brièvement en tant que président actuel et le professeur Risto Seppälä vous adressera quelques mots en tant que président désigné. J'aimerais faire le point sur les acquis que l'IUFRO a réalisé pendant les cinq années de ma présidence tandis que le professeur Seppälä vous tracera les grandes lignes de sa vision de futurs développements dans la recherche forestière et dans l'IUFRO.

Les Résolutions de 1995 et les défis
Lors du 20ème Congrès en 1995 les résolutions suivantes ont été adoptées : a) maintenir et renforcer la recherche appliquée à la forêt et aux produits forestiers ; b) accroître le potentiel de recherche, surtout dans les pays en développement, c) étendre le partenariat pour améliorer l'efficacité de la recherche en vue d'une meilleure communication entre la communauté scientifique et l'extérieur ; et d) encourager une recherche adaptée à la demande sociale. Lors de mon élection à la présidence de l'IUFRO j'ai proposé au Bureau exécutif une vue personnelle du rôle de l'IUFRO, du développement et des activités et j'aimerais vous en parler brièvement en montrant comment l'IUFRO a répondu à ces défis et aux résolutions du Congrès.

Je faisais alors état des changements importants qui se sont produits en politique forestière, en pratiques forestières et dans le métier du forestier. Les thèmes forestiers ont connu une expansion au niveau mondial et international avec une contribution toujours plus grande d'individus et d'institutions qui ne sont pas des forestiers traditionnels. Les sciences socio-économiques ont contribué encore plus aux processus de prise de décision. On notait une pression internationale pour évaluer le rôle des forêts en vue des services rendus et de surveiller sa condition. Les responsables ont cherché à recueillir (a) des informations sur les rôles, les valeurs et la condition des forêts et des arbres relatifs à leur conservation et leur évolution, (b) des vues sur les relations entre les forêts, la biodiversité, le climat et d'autres thèmes ayant trait à l'environnement, et (c) des conseils sur la gestion forestière durable, y compris des thèmes se rapportant au renforcement structurel.

Déjà en 1995, j'ai pensé (et je le pense toujours) que l'IUFRO devrait répondre à ces changements tout en conservant son rôle primaire de réseau de scientifiques volontaires membres de l'Union. Elle devrait continuer à être la source principale de connaissances et d'expériences en recherche forestière dans des sujets spécialisés tout en augmentant la coopération interdisciplinaire au sein de l'Union et avec des organisations et disciplines n'étant pas des membres traditionnels.

Ces relations ont également donné de la publicité au travail de l'IUFRO, elles ont assuré sa pérennité pour être à la page des besoins modernes, elles ont identifié des ressources pour la recherche, et recherché la collaboration productive tout en réduisant au minimum la duplication inutile. L'identification des besoins émergents par le Bureau exécutif s'est avérée essentiel et a été facilitée par l'établissement des liens forts avec bon nombre d'autres organismes. L'IUFRO a essayé de soutenir les directeurs des organisations membres eux-mêmes en encourageant des travaux de recherches orientés vers la politique et en aidant les directeurs à attirer l'attention des gouvernements et des agences sur les forêts et sur la recherche forestière.

Le nouveau rôle de l'IUFRO sur le plan international
Le Bureau exécutif n'a ménagé aucun effort pour afficher l'existence, les activités et l'importance de l'IUFRO. La brochure largement acclamée a été lancée au Congrès Forestier Mondial pendant 1997 et le site Web également réputé contient les pages d'accueil pour toutes les unités de recherches qui sont reflétées sur des serveurs dans plusieurs pays et jointes à ceux de beaucoup d'autres instituts. Beaucoup de ces sites incluent des pages pour accueillir des bilans scientifiques de connaissances dans les disciplines particulières des unités de recherche ; comme vous avez pu noter pendant ce congrès, l'accent a été mis sur la diffusion des résultats de recherche et des bilans scientifiques de connaissances.

Nous avons également essayé à renforcer le rôle de l'Union dans les discussions et les développements internationaux. Des cadres de l'IUFRO ou moi-même ont assisté aux réunions suivantes: - le Groupe d'experts intergouvernemental des forêts (IPF) ; le Forum intergouvernemental des forêts (IFF) ; le Forum mondial des forêts ; le Congrès forestier mondial ; le Comité sur les forêts de l'Organisation des Nations Unies pour l'Alimentation et l'Agriculture (COFO/FAO) ; l'Assemblée générale de l'UICN ; les réunions variées de plusieurs initiatives destinées à développer des critères et indicateurs pour la gestion forestière durable ; le Comité directeur du Centre international de la Recherche Forestière Internationale (CIFOR) et le Centre international pour la Recherche en agroforesterie (ICRAF) ; le Centres Week du Groupe consultatif pour la recherche agronomique (CGIAR) ; l'Exposition nationale à Kunming, Chine ; et plusieurs réunions et expositions d'autres organisations. En particulier, nous avons été satisfaits de voir les recommandations émanantes de la 4e Séance du Forum Intergouvernemental des Forêts (IFF) demandant le renforcement des liens entre la science de forêt et les politiques forestières, la mise à disposition des ressources financières pour la recherche forestière (aux pays en développement en particulier), l'amélioration de l'accès à l'information forestière et aux disciplines connexes et la collaboration avec l'IUFRO et le Service mondial d'information forestière (GFIS).

Le Projet spécial de l'IUFRO sur la terminologie (SilvaVoc), coordonné par Renate Prueller, et appuyé par le Japon, a signé un contrat avec la FAO pour fournir les définitions des termes principaux de la gestion forestière durable utilisés au cours des discussions internationales. Je suis content que mon propre institut pouvait représenter à l'IUFRO en préparant un document sur les aspects politiques de la recherche forestière, financé par l'Agence de développement d'outremer (ODA) du Royaume-Uni (maintenant le Département pour le développement international) pour la Commission mondiale sur les forêts et le développement durable.

L'Union a également encouragé les unités de recherches à se pencher sur les questions spécifiques en relation avec les préoccupations sur le plan international. Une contribution exceptionnelle de l'IUFRO aux processus internationaux était son rôle dans l'organisation et dans la diffusion des informations sur la Consultation internationale sur les systèmes d'information et la recherche forestière (ICRIS) tenue grâce à l'appui financier des gouvernements de l'Autriche et de l'Indonésie, en coopération avec le CIFOR et le Département forestier de la FAO. Cette conférence était une activité à l'appui du forum intergouvernemental sur les forêts (IFF) de la Commission des Nations Unies sur le développement durable (UNCSD) et a eu lieu en Autriche en septembre 1998. Ses retombées principales sur l'IUFRO étaient la mise en place du Groupe de réflexion sur le Service mondial de l'information forestière (GFIS) et du Groupe de réflexion de l'Interface entre sciences forestières et politiques forestières.

La structure améliorée de l'IUFRO et ses activités

Le rôle primordial de l'IUFRO a continué à être le rehaussement de la valeur de la recherche par son réseau de presque 700 organisations membres et de 15,000 scientifiques qui travaillent dans des domaines spécifiques ; les 268 Unités de recherche et les 8 groupes de réflexion ont tenu 335 réunions dans 65 pays, dont 41 étaient des pays en développement ou des pays défavorisés. Deux nouvelles divisions ont été créées au début du mandat du Bureau pour identifier l'ampleur des activités de recherches et pour réduire la charge de travail sur les coordonnateurs de divisions et leurs adjoints (qui, comme tout fonctionnaire de l'IUFRO, sont des volontaires). Le Bureau exécutif a établi un certain nombre de programmes spéciaux, de projets et de groupes de réflexion pour aborder des sujets ou des questions particulières. Dans un discours court il n'est certainement pas possible de fournir des détails ou même des sommaires adéquats de tout mais je sélectionnerai quelques points importants culminants.

Comme mentionné ci-dessus, l'un des changements principaux de la dernière décennie a été le besoin croissant d'approches interdisciplinaires pour résoudre les problèmes au niveau scientifique et social. L'IUFRO s'efforce sans cesse de couvrir tous les domaines scientifiques au sein des unités de recherche biophysique et socio-économique. Dans les cinq années écoulées nous avons encouragé l'interaction entre les divisions par des réunions interdivisionnaires, la collaboration avec d'autres organismes, et par les activités des Groupes de réflexion. Nous tous devons identifier les difficultés impliquées dans la compréhension mutuelle de la discipline scientifique de l'autre et d'obtenir la reconnaissance professionnelle pour un tel travail multidisciplinaire, mais c'est clairement un besoin exception nel.

Les Divisions

Une réunion importante sur les écosystèmes forestiers et l'utilisation des terres en montagne a eu lieu à Séoul, Corée, en 1998, organisée par les Divisions 1,4, 6 et 8 ; cet événement a réuni 350 participants de 24 pays. Le Groupe de recherche 1.17.00 (Réhabilitation des stations dégradées) a été étroitement impliqué dans le programme de recherche international financé par le Service forestier USDA, la Banque mondiale, le CIFOR et la British Overseas Development Administration qui ont examiné le rôle et les implications des plantations en accélérant la régénérations naturelle de la forêt naturelle sur les terres tropicales dégradées.

La Division 2 a organisé une importante réunion sur la génétique forestière à Beijing en 1998 et son Groupe de travail 2.04.06 a tenu une réunion sur la modification génétique à Oxford en 1999. Cela a montré l'intérêt continu de l'IUFRO pour les questions actuelles d'importance publique et politique. Les participants à ces réunions étaient tous d'accord qu'il faudra trouver des ressources financières pour l'amélioration génétique classique mais qu'il faudra également employer de nouvelles technologies pour augmenter l'efficacité; actuellement des organismes génétiquement modifiés devraient être considérés comme outils de laboratoire tant que les problèmes éthiques ne soient pas résolues.

La Division 3 a tenu bon nombre de réunions divisionnaires et interdivisionnaires avec la Division 1 en Bolivie en 1997 ; la Division 6 au Japon en 1997, le Canada en 1998 et en Australie en 2000 ; la Division 8 au Japon en 1998 et le Groupe de réflexion sur le rôle de la forêt dans le développement durable des montagnes en Australie en 1998. Elle a aussi organisé de nombreuses réunions avec des d'autres organisations, y compris le CIFOR et la FAO. Les différents groupes de recherche ont élaboré des bilans scientifiques de connaissances.

La Division 5 a consacré des efforts considérables à étudier la ressource changeante dans les forêts, à améliorer l'utilisation de cette ressource et à mettre en application des technologies qui ne nuisent ni à l'environnement ni à la société. La conférence de toute la division tenue en 1997 a porté sur les produits de la forêt pour la sylviculture durable et a réuni 222 délégués de 42 pays.

La Division 7 a été créée pour répondre à une résolution spécifique du congrès 1995 qui a encouragé la recherche sur "... l'ampleur, la productivité et la santé des forêts… ». Dans les cinq dernières années la Division a organisé des réunions principales de recherches en Europe, Amérique du Nord et Asie portant sur l'entomologie, la pathologie, la pollution atmosphérique et les interactions entre hôte et parasite.

Les Groupes de réflexion
Une question clé sur le plan international est le développement des critères et des indicateurs de la gestion forestière durable. Le Groupe de réflexion sur la gestion forestière durable, coordonné par Alain Franc, a coopéré alternativement avec le CATIE, le CIFOR et la FAO en organisant trois importantes réunions internationales en Australie, 1998, Costa Rica, 1999, et en France, en 1999 (conjointement avec l'Ecofor et l'EFI) qui réunissaient 100-200 délégués. Le but de ces réunions était de combler les lacunes et d'établir les liens entre les sociologues, les biophysiciens et les parties prenantes du secteur forestier.

Se basant sur les contributions de beaucoup de scientifiques, le Groupe de réflexion sur le changement de l'environnement coordonné par John Innes, a élaboré des bilans scientifiques de connaissance, dont trois ont déjà été publiés dans les « IUFRO Research Series ». Le reste sera publié au cours de cette année. Les fonctionnaires des Groupes de réflexion ont aussi défendu les intérêts de l'IUFRO lors d'une série de réunions en faveur des liens entre la science et la politique. Le Groupe de réflexion était responsable de la mise en œuvre d'une résolution issue de la Conférence ministérielle sur la protection des forêts en Europe connu sous le nom de « Helsinki 4 » qui s'occupe de la coordination des efforts pour atténuer les effets du changement du climat sur les forêts européennes.

Le Groupe de réflexion sur le rôle de la forêt dans le développement durable des montagnes, coordonné par Martin Price, a élaboré le premier bilan scientifique de connaissances sur ce sujet basé sur les contributions de 124 auteurs provenant du monde entier. Beaucoup d'importance a été consacrée à la définition de l'extension des ressources mondiales en forêts de montagne ; les travaux visaient la production d'une carte avec les montagnes du monde (d'après des critères objectifs) et une carte des forêts de montagnes qui représentent 28 % du couvert forestier du monde.

Le Groupe de réflexion sur les eaux et les forêts, coordonné par Rob Vertessy, a été mis en place pour faire le point sur la connaissance scientifique actuelle et les hypothèses existantes sur la valorisation des eaux douces dans la forêt et les effets de la sylviculture et de la gestion forestière sur la quantité et la qualité de l'eau. Ces efforts ont débouché sur une importante publication.

Le Groupe de réflexion sur les ressources Internet, coordonné par Lauri Valsta, a développé une ressource unique et de valeur inestimable pour la transmission et la diffusion de l'information sur l'IUFRO entre les scientifiques du monde entier.

Le Groupe de réflexion sur le Service mondial d'information forestière (GFIS), coordonné par Risto Päivinen, est un consortium d'organismes internationaux, régionaux et nationaux développant une stratégie et mettant en application un service de meta-données basé sur l'Internet pour offrir l'accès mondial coordonné aux informations relatives à la recherche forestière. Les concepts de base sur les méthodes de collecte de données et les solutions techniques ont été élaborés, y compris le prototype de la base de données. Un projet financé par la Commission européenne pour les pays de l'Afrique, les Caraïbes et le Pacifique couvre le volet pays en développement.

Le Groupe de réflexion sur la gestion et la conservation des ressources génétiques forestières est coordonné par Veikko Koski et son comité inclut des représentants de la plupart des Divisions de l'IUFRO, du CIFOR, de la FAO et de l'IPGRI ; il recueille l'information scientifique sur les interactions entre les facteurs effectuant la distribution, l'intégrité et la conservation des ressources génétiques forestières. Un bilan scientifique des connaissances a été élaboré.

Le Groupe de réflexion: Interface entre les sciences forestières et les politiques forestières, coordonné par Richard Guldin, a contribué à mettre l'accent de la conférence de la Division 6 sur la contribution de la science au développement des politiques forestières en Afrique du Sud. Deux réunions satellites ont été organisées à l'occasion de la troisième et quatrième Session du GIF. Trois conférences dans les prochaines trois années recueilleront 40-50 études de cas montrant comment la recherche a influencé avec succès la politique forestière.

L'IUFRO soutenant les pays en développement
Le travail du Programme spécial pour les pays en développement (SPDC), coordonné par Bob Szaro jusqu'en juin de cette année, a fait un effort considérable en vue du renforcement des compétences et des capacités en recherche forestière dans les pays en développement et les pays défavorisés. Le SPDC a organisé des ateliers sur la planification et la gestion de la recherche, il a entrepris la rédaction d'un manuel pour la soumission des propositions de projets de recherche et la planification stratégique. Il a subventionné plus de 200 scientifiques et 35 organisateurs d'ateliers se réunissant dans plus de 60 pays et lancé et publié les premiers deux volumes d'une série peu coûteuse de manuels de formation.

L'IUFRO aimerait remercier le gouvernement des Etats-Unis de l'Amérique pour mettre à disposition le coordonnateur, le gouvernement du Canada pour mettre à disposition le Coordonnateur adjoint du SPDC et le gouvernement du Danemark pour fournir le Coordonnateur adjoint (Afrique). Le gouvernement du Japon a soutenu généreusement le programme BIOREFOR qui a stimulé la collaboration parmi bon nombre d'établissements dans la région Asie-Pacifique et nous a montré comment la biotechnologie peut être utilisée pour le reboisement. Nous remercions aussi la Commission européenne qui a financé le projet GFIS Afrique destiné à améliorer la diffusion de l'information forestière en Afrique. D'autres agences ont aussi contribué des ressources financières ou du personnel au programme, y compris l'AusAid (Australie), l'Union allemande des organisations de recherche forestière (Allemagne), l'Ambassade royale du Danemark, le Service forestier de l'USDA (Etats-Unis), le gouvernement de Chine-Taipei, et le gouvernement du Royaume-Uni.

La diffusion des résultats de recherche
La recherche ne devrait pas se faire dans le vide et ses résultats devraient être diffusés largement. L'IUFRO a fait des efforts considérables de faire connaître le travail, les résultats, la valeur et l'importance de la science forestière en général et de l'IUFRO en particulier. Outre les pages Web mentionnées ci-dessus et les 91 volumes d'actes publiées par les unités de recherches, nous avons continué à publier les IUFRO World Series et les IUFRO Occasional Paper Series (éditées par le Secrétariat), tout en ajoutant les IUFRO Research Series (éditées par CAB international).

L'évaluation de la structure et de la gestion de l'IUFRO
Pendant son mandat de cinq années, le Bureau exécutif actuel s'interroge constamment sur la structure et les activités de l'Union. Ainsi une commission d'experts à été chargé d'une évaluation externe du Secrétariat, du SPDC et du projet spécial. Nous avons fait des efforts énormes pour attirer des fonds financiers pour appuyer des membres de pays en voie de développement mais nous avons aussi essayé d'établir des projets au sein de l'IUFRO tel que le projet de terminologie SilvaVoc. Nous avons examiné la stratégie d'investissement de l'IUFRO, en particulier sous l'angle des difficultés de nombreuses organisations membres de payer leurs cotisations. En réponse à un déclin récent du nombre de membres, le Conseil international a approuvé le changement du nom anglais de l'IUFRO « Forestry » à « Forest » ; ceci met en relief la nécessité d'entourer l'éventail de disciplines et d'institutions qui profiteront des prestations de l'IUFRO et qui y contribueront. Ce changement tient compte de la perception de l'opinion publique qui lie la notion « forestry » seulement avec les déboisements de grande envergure de la forêt naturelle ou des plantations artificielles des essences exotiques, et cela à une époque où l'IUFRO s'efforce sans cesse de mener des recherches et de tirer l'attention sur les services sociaux et environnementaux rendus par la forêt.

Le Bureau exécutif a encouragé les organisations membres et les chercheurs à contribuer aux processus de sensibilisation et de planification de l'IUFRO. Beaucoup de scientifiques ont contribué au développement du Plan stratégique qui a guidé le travail du Bureau exécutif pendant les 5 années écoulées. Le Conseil international était impliqué au développement des politiques de l'IUFRO, à la révision des Statuts de l'IUFRO et à l'élection du nouveau Bureau exé cutif.

Le Bureau exécutif a encouragé la régionalisation de la gestion et de la coopération scientifique de l'IUFRO par l'identification des Chapitres tels que l'Association pacifique de l'Asie des instituts de recherche (APAFRI) dont le Secrétariat se situe ici en Malaisie. En outre, l'IUFRO collabore étroitement avec la FAO en vue de la réalisation d'autres activités régionales destinées à encourager la coopération entre les institutions nationales, y compris le Programme de support de recherche forestière pour l'Asie et le Pacifique (FORSPA) et le Réseau de recherche en matière de recherche forestière pour l'Afrique du sud du Sahara (FORNESSA), le dernier en collaboration étroite avec l'Académie africaine des sciences (AAS).

Mesdames et Messieurs, j'espère que vous réalisez de ce que j'ai dit que l'IUFRO, dirigée par le Bureau exécutif et habilement aidée par le Secrétariat (avec l'appui généreux du gouvernement autrichien), a fait du progrès dans ces cinq années et qu'elle a avec succès répondu aux Résolutions du dernier Congrès. En tant que président sortant, il serait facile pour moi de mettre en évidence les défis à relever par le prochain Président et le Bureau; parmi ces derniers j'inclurai les suivants :

- continuer le développement des normes des méthodes de recherche sur le plan international
- promouvoir la création des réseaux parmi les membres
- développer le GFIS, standardiser les terminologies et les bilans scientifiques de connaissances
- améliorer les liens entre les sciences, les politiques, la gestion et l'utilisation des forêts, des produits et services forestiers.
- identifier et poursuivre les besoins en recherche disciplinaire et inter-disciplinaire
- augmenter les effectifs des membres
- réorganiser et renforcer le Bureau et le Secrétariat de sorte qu'ils soient en mesure d'assurer la sécurité financière, d'aider les membres et de mettre en place des moyens pour la diffusion de l'information.

Allocution du

Dr. Abdul Rahim Nik

Président du Comité d'organisation du Congrès

Monsieur le Professeur Jeffery Burley, Président de l'IUFRO,
Monsieur le Président du Comité directeur pour la recherche et le développement de la Malaisie,
Tan Sri G.K. Rama Iyer
Monsieur le Directeur-Général de FRIM, Dato' Dr. Abdul Razak Mohd Ali
Monsieur le Président désigné, Professeur Risto Seppälä,
Chers invités et délégués,
Mesdames et Messieurs,

Je suis très content que nous sommes arrivés à nous réunir pour la cérémonie de clôture du XXIème Congrès Mondial de l'IUFRO. Pendant les six derniers jours, nous avons assisté à une multitude d'activités allant des séances scientifiques, réunions satellite et de travail jusqu'aux expositions, réceptions et circuits touristiques. En organisant cette réunion prestigieuse nous avons essayé de faire de notre mieux pour satisfaire toutes vos espérances et demandes pour assurer un agréable séjour et le déroulement impeccable des réunions.

Il y a cinq ans, on m'a confié le rôle du président du Comité d'organisation du Congrès avec pour tâche gigantesque l'organisation de ce congrès. Je n'avais pas eu une idée de l'ampleur de ce défi et de la responsabilité qui m'attendaient. Trois ans plus tard les préparatifs ont pris forme. Enfin, six mois avant le congrès nous nous sommes vus impliqués aux défis véritables de l'organisation. Je dois avouer que nous avons beaucoup appris de l'organisation de ce congrès. Les technologies modernes disponibles aujourd'hui nous ont aidé beaucoup lors des préparatifs. Je n'aurais pas pu imaginer l'organisation d'une seule réunion sans l'utilisation du courrier électronique et des télécopies.

Tandis que le thème du congrès „La forêt et la société – le rôle de la recherche" a fait l'objet de nombreuses discussions au cours des sessions techniques, nous les organisateurs, ont choisi la devise suivante, soit „Nous avons pris l'engagement d'assurer un congrès mémorable et bien organisé". Vous avez du voir cette devise affichée aux murs de nos locaux et stations. Cette simple devise contient deux messages. En reconnaissant que c'est la première fois dans l'histoire centenaire de l'IUFRO qu'un congrès mondial ait lieu dans un pays en développement nous voulions assurer que ce XXIème Congrès Mondial, tenu ici en Malaisie fait grand effet dans la mémoire des délégués présents ici. Ensuite, un grand rassemblement comme ce congrès a besoin d'un système efficace et bien organisé pour assurer un impact durable aux participants et leur donner l'impression qu'ils n'ont pas dépensé leur temps et leur argent en vain. Ayant cette devise sous les yeux nous avons travaillé acharnement et dédiés pour achever un bon résultat. C'est à vous maintenant, chers délégués de juger si nous avons réussi.

Mesdames et Messieurs,

Lors de cette séance de clôture j'aimerais mettre en relief quelques données statistiques importantes relatives aux congrès et quelques-unes de nos observations qui devraient être utiles pour l'organisation du prochain congrès.

Au total, 1906 délégués provenant de 96 pays se sont inscrits à ce congrès, y compris les 209 participants inscrits en tant que personnes accompagnantes. Nous avons aussi reçu des réactions encourageantes en ce qui concerne le programme des excursions et des circuits touristiques. Un total de 1127 personnes était inscrit pour les neuf excursions organisées pour jeudi et plus de 700 personnes ont participé au programme des personnes d'accompagnement. Le tour pour voir les lucioles a vu la plus grande participation. Juste après ce congrès, un total de 324 délégués participera aux voyages d'études après le congrès, qui les conduiront dans les prochains jours aux différentes parties de la Malaisie et aux pays voisins tels que le Brunei, l'Indonésie et la Thaïlande.

Pour ce qui est des présentations scientifiques, la plupart des séances scientifiques programmées se sont déroulées comme prévues. Dans quelques-unes où les orateurs ne sont pas venus, les modérateurs ont réussi à inviter d'autres participants pour combler les lacunes. Cependant, quelques séances ont dû être annulées puisque les auteurs des contributions ne sont pas venus. Nous avons remarqué qu'il s'agissait surtout des auteurs des pays en développement qui ne pouvaient pas venir par manque de ressources financières. Pour ce qui est des présentations des posters, seulement 55 % des auteurs de posters d'un total de 833 posters sélectionnés est venu, dont la plupart des auteurs des pays en développement qui n'ont pas réussi à trouver des moyens financiers. Pour ce qui est de l'appui technique au congrès, nous avons mis à disposition 120 rapporteurs techniques et environ 270 assistants de congrès pour faciliter un déroulement sans problème.

Nous avons produit un total de 6,6 millions de pages d'imprimés, y compris les annonces et le matériel de publicité. Je n'ai aucune idée combien d'arbres étaient nécessaires pour produire ces documents. Je pense sincèrement que l'effort valait la peine.

Permettez-moi maintenant de consacrer quelques moments à un problème qui dû à l'importance qu'il revêt devrait être tenu en compte pour le prochain congrès. Si nous souhaitons un nombre plus important de participants de pays en développement nous devrions faire plus d'efforts pour chercher des fonds financiers pour le Programme d'assistance des scientifiques. Pour cette réunion, 169 candidats ont été financés, ou bien complètement ou bien partiellement à travers des ressources mises à la disposition par le gouvernement de la Malaisie. A mon avis, on devrait concentrer les efforts à chercher des ressources financières auprès des pays industrialisés. Cela n'était pas le cas pour ce congrès, exception faite du SPDC et de quelques pays comme les Etats-Unis, le Royaume-Uni, la Suède et la Finlande. Il faut que le Bureau désigné et le prochain pays d'accueil se penchent sur cette question.

Je dois avouer que c'était un plaisir et une expérience intéressante pour nous d'organiser ce congrès. J'espère que vous avez non seulement profité de ce congrès dans votre carrière scientifique mais qu'il était une expérience utile et fructueuse. Malgré les grands efforts il y avait des imperfections pour lesquelles je vous demande pardon. Le temps est venu pour passer le drapeau à l'hôte du prochain XXIIème Congrès mondial.

Enfin, Mesdames et Messieurs,

Comme vous avez pu noter, beaucoup d'organisations, agences et bailleurs de fonds étaient impliqués dans l'organisation de ce congrès. C'est à eux que j'aimerais exprimer mes remerciements pour leur soutien, leur coopération et leur appui sans lesquels nous n'aurions jamais réussi à s'embarquer sur cette tâche difficile. En particulier, j'aimerais remercier le Comité directeur pour la recherche et le développement de la Malaisie et le FRIM, et notamment son président et Directeur-Général pour leur encouragement et appui pendant les phases de planification et d'exécution de ce congrès. Grand merci aussi à tous les membres du Bureau exécutif et du Secrétariat dont le conseil et l'appui étaient très importants pour la réussite de ce congrès. Enfin, en ma qualité de président du Comité d'organisation du congrès, j'aimerais remercier tous les membres du COC, les sous-comités et les auxiliaires de congrès. C'est la force motrice qui en travaillant acharnement derrière la scène, a assuré le succès du congrès. Veuillez les applaudir avec moi…….

A nos amis d'outre-mer je souhaite un voyage de retour agréable, sain et sauf.

Bon voyage et Merci

Allocution du

Docteur Risto Seppälä

Président désigné de l'IUFRO

Monsieur le Président
Excellences,
Chers Membres du Conseil international de l'IUFRO et du Bureau exécutif
Chers invités, chers collègues
Mesdames et Messieurs

C'est un grand honneur pour moi d'accepter l'élection au poste de président de l'IUFRO par le Conseil international. Je promets de faire de mon mieux pour répondre aux hautes espérances liées à ce poste.

Dans son discours de réception il y a cinq ans notre président actuel a déclaré qu'il avait toujours eu trois ambitions pour l'IUFRO: avoir un président des tropiques, avoir un congrès mondial dans un pays en voie de développement et avoir un président féminin. Nous avons maintenant réalisé les deux premiers de ces buts mais si Jeffery Burley voulait un président féminin pour lui succéder, je ne suis pas la personne appropriée, cependant je peux prendre le bâton de lui et l'avancer.

Habituellement, un discours de réception contient des visions du président entrant sur la nouvelle structure et les activités futures de l'organisation. Puisque notre président actuel a présenté à cette occasion déjà une liste approfondie de futurs défis, je voudrai évoquer seulement deux thèmes que je considère importants. Ce sont les membres de l'IUFRO et le rôle de l'IUFRO comme centre de vérification pour l'information et l'expertise en matière de recherche forestière.

L'IUFRO compte maintenant environ 680 organisations membres qui fournissent les ressources financières de base. Ces dernières années bon nombre d'organisations ont adhéré à l'Union mais en même temps un trop grand nombre de nos anciens membres ne sont plus capables ou ne veulent plus payer les cotisations. Quand nous perdons une organisation membre, nous perdons souvent aussi ses scientifiques parce que pour le chercheur individuel il est ennuyeux et coûteux de devenir membre de l'IUFRO.

Il est peut être temps d'examiner de plus près le concept entier de membres de l'IUFRO. D'abord nous devons nous demander pourquoi nous avons besoin de membres. Une raison évidente est l'argent. Bien que l'IUFRO soit une organisation volontaire nous ne pourrions pas survivre maintenant sans cotisations. Cependant, si nous aurons de l'argent provenant des sources autres que les cotisations, aurions nous toujours besoin de membres pour accomplir notre mission qui consiste à encourager la coopération internationale en matière de recherche forestière et sciences connexes? La réponse est oui. Nous avons besoin de membres également dans ce cas-ci parce que la coopération n'est pas possible sans ceux qui coopèrent, et nos organisations membres et leurs collaborateurs forment le meilleur réseau international de coopérants dans la recherche forestière.

Selon une étude récente de l'Institut européen des Forêts, il y a en Europe de l'Ouest plus de mille organisations travaillant dans le domaine de la recherche forestière. Parmi elles, seulement 176 instituts adhèrent à l'IUFRO. J'estime que dans d'autres régions du monde la situation est semblable. Ainsi, le nombre de nouveaux membres potentiels est peut-être plus grand que nous imaginions. Il dépend de nous comment nous utiliserons ce potentiel pour augmenter les effectifs. Il y a beaucoup d'acteurs qui occupent des rôles importants dans le monde changeant d'aujourd'hui, et qui ne sont pas encore partenaires de l'IUFRO.

Nous avons besoin des relations plus étroites avec les chercheurs individuels. Le fait que l'IUFRO est une organisation parmi d'autres organisations ne garantit pas que tous les scientifiques travaillant dans nos organisations membres connaissent l'IUFRO ou obtiennent des informations sur elle. Avant, les scientifiques travaillant dans des établissements qui ne sont pas membres de l'IUFRO étaient exclus du flux d'information. La situation s'est maintenant améliorée considérablement car la plupart des visiteurs de notre site Web et un nombre considérable de participants à ce congrès ne viennent pas des organisations membres de l'IUFRO. Pour moi, cela est un signe pour un énorme potentiel de membres et il montre à quel point l'IUFRO est ses congrès sont attrayants. Faciliter l'adhésion à l'IUFRO, particulièrement pour ceux qui travaillent dans des disciplines non-forestières sera une condition préalable importante pour augmenter le nombre de membres.

Jusqu'ici, l'IUFRO a utilisé très modestement la connaissance et l'expertise de son réseau de membres. Nous avons quelques projets et programmes spéciaux financés à partir des sources extérieures, tels que le SPDC et SilvaVoc, mais ce que nous devons faire c'est de mobiliser l'information toute entière et toute la base de connaissance de nos scientifiques et nos experts, ce qui est une ressource unique mais sous-exploitée pour l'instant. Les bonnes étapes dans cette direction sont les bilans scientifiques de connaissance qui ont été présentés ici cette semaine, et le Service mondial d'information forestière dont le prototype avait été présenté pendant le congrès.

Mesdames et Messieurs,

Ma propre vision pour l'IUFRO est que nous devrions devenir un centre de vérification pour l'information et l'expertise en matière de recherche forestière. Nos fonctionnaires sont les protagonistes dans ce processus mais ils représentent seulement une fraction de nos ressources humaines. Nous devons avoir des liens directs avec tous les individus qui agissent dans et sont liés à nos unités de recherches. Ensuite, ayant l'information appropriée sur leur domaine d'expertise, nous pourrons fonctionner comme centre de vérification et répondre aux demandes de nos clients quand, par exemple, ils veulent savoir l'état-de-connaissance dans tel ou tel domaine spécifique de la recherche forestière, ou, quand il y a le besoin de créer une équipe internationale pour trouver une solution pour un problème scientifique.

Une bonne réputation comme centre de vérification pour l'information et l'expertise en matière de recherche forestière augmentera considérablement la visibilité de l'IUFRO. Cela rendra l'IUFRO plus intéressante pour les bailleurs de fonds et les clients en créant un effet multiplicateur pour engendrer les ressources financières nécessaires.

Chers amis,

En ma qualité de président désigné j'estime que l'une de mes tâches les plus importantes est d'agir en tant qu'ambassadeur de l'IUFRO, qui offre et vend notre organisation sur le marché. La communauté forestière internationale a besoin de notre expertise, et elle est prête à payer nos services. Nous avons besoin du marketing également pour renforcer nos effectifs de membres. Tout en encourageant nos membres actuels à rester avec nous, nous devons trouver de nouveaux membres, particulièrement ceux, qui ne font pas partie du secteur forestier traditionnel. Une base étendue et de haute qualité d'adhésion est également une condition préalable importante pour vendre nos services à ceux, qui en ont besoin et peuvent payer pour eux.

Bien que j'aie maintenant exprimé mes opinions pour le futur, j'aimerais faire le point du passé pour une minute. En ma qualité de vice-président programmes actuel je voudrais saisir cette occasion de remercier tous les fonctionnaires de l'IUFRO de leur travail précieux depuis le congrès de Tampere. Je remercie tout spécialement le Comité scientifique du congrès et le secrétariat de l'IUFRO pour leur contribution énorme lors de la préparation du programme scientifique de ce congrès. En conclusion, j'aimerais remercier nos hôtes en Malaisie. Puisque j'ai été impliqué dans l'organisation du congrès précédent, je sais exactement combien vous avez travaillé pour réaliser cet événement. Je vous félicite pour un congrès très réussi. Saya ucapkan setinggi-tinggi tahniah kepada tuan rumah Malaysia di atas kejayaan kongres ini.

On sait que nous, les Finlandais, nous sommes des personnes de peu de mots - même lorsque nous avons quelque chose à dire. Nous préférons l'action aux discours, bien que les discours soient également importants en montrant la direction où aller. Je terminerai maintenant, mais vous aurez des nouvelles de moi plus tard, peut-être pas tellement par ce que je dis mais plutôt - et si tout va bien - par ce que je fais. Tout ce que je ferai pour l'IUFRO j'aimerais faire avec vous tous.

Discours prononcé par le hôte du Congrès Mondial IUFRO 2005

Prof. Russell Haines
Queensland Forestry Research Institute

Vu les 40 ans d'utilisation des forêts et des ressources forestières dans notre pays, il nous fera un grand plaisir d'accueillir les chercheurs forestiers du monde entier au 22e Congrès Mondial IUFRO à Brisbane, en 2005.

L'Australie est riche en forêts les plus diverses, allant des zones tempérées aux zones arides en passant par les zones tropicales, et en plantations immenses qui ne cessent de croître. Les défis auxquels nous sommes confrontés en ce qui concerne la gestion de ces forêts sont les mêmes que ceux auxquels doit faire face le monde forestier et qui sont à l'ordre du jour de ce congrès.

Les gouvernements fédéraux de l'Australie et de ses Etats se sont engagés dans l'utilisation rationnelle des ressources forestières au profit des générations présentes et futures, reconnaissant qu'une telle utilisation demande des connaissances scientifiques solides. Nous avons pris l'engagement de participer aux fores forestiers internationaux et à la coopération scientifique internationale tout particulièrement. Nous appuyons à l'Union Internationale des Instituts de Recherche Forestière. Je suis fier de pouvoir mentionner que c'était mon cher ami et collègue, le Dr. Garth Nikles, retraité après 50 années de contribution à la science forestière qui, avec le Professeur Jeffrey Burley, a crée le premier Groupe de travail de l'IUFRO en 1971.

A mon avis, l'époque que nous vivons relève bien des défis intéressants pour les chercheurs forestiers. Jamais le groupe des parties prenantes n'a été aussi diversifié faisant preuve d'un intérêt passionné pour la gestion et l'utilisation des forêts et de leurs ressources. Jamais la coopération internationale entre les chercheurs forestiers n'a été plus importante.

Nous espérons qu'en 2005 nous pourrons montrer l'hospitalité australienne aux délégués, pour donner en retour un peu de l'hospitalité offerte par le peuple de Malaisie.

Les délégués australiens ont beaucoup apprécié les excellents arrangements du 21e Congrès Mondial IUFRO en Malaisie. Nous reconnaissons que nos collègues de Malaisie ont établi des standards très élevés et l'organisation du Congrès de Brisbane en 2005 aura recours aux expériences vécues en Malaisie.

Il sera un grand plaisir pour nous d'organiser le 22e Congrès Mondial IUFRO conjointement avec la grande communauté de l'IUFRO et de porter le drapeau de l'IUFRO haute dans les prochaines cinq années. En particulier, nous serons heureux de vous voir tous à Brisbane en 2005.

Séance de Clôture, Samedi 12 août 2000
Allocution du

Professeur Jeffery Burley

Président de l'IUFRO
Excellences,
Chers invités,
Chers Membres de l'IUFRO, Collègues et Amis,
Mesdames et Messieurs,

Nous arrivons maintenant à la séance de clôture du XXIème Congrès Mondial de l'IUFRO à Kuala Lumpur, en Malaisie. Bien que la plupart des participants soient heureux de rentrer dans leurs pays, je sais que beaucoup d'entre eux vont regretter un peu de quitter un pays si charmant, avec des gens extraordinaires et de voir s'achever un programme riche en exposés, posters, discussions, expositions et excursions intéressants. Ils vont aussi regretter d'être obligés de quitter les anciens et les nouveaux amis, mais j'espère que les contacts professionnels et sociaux nouvellement établis seraient maintenus selon l'ancienne tradition de l'IUFRO de collaboration scientifique et personnelle.

Les organisateurs de tout congrès se sont toujours inquiétés qu'ils ne puissent pas concourir avec le congrès antérieur tant par sa quantité ou par sa qualité, mais à mon avis, il n'est pas important qu'un congrès soit supérieur au précédant mais qu'il soit différent. En 1990, après Montréal, les organisateurs finlandais du Congrès de Tampere en 1995 ont pensé qu'ils ne pouvaient pas arriver à leur cheville, et pourtant ils y sont arrivés. Après Tampere, les organisateurs malaysiens ont pensé qu'ils n'arriveront non plus à atteindre le niveau du dernier congrès pour ce Congrès 2000, mais, à mon avis, ils y sont arrivés. La qualité des préparatifs sur le plan administratif, politique et technique a été superbe, et la gentillesse du personnel auxiliaire a été extraordinaire.

Pendant mes promenades aux lieux du congrès pendant toute la semaine j'ai demandé à beaucoup de participants de me faire savoir leur opinion ou leur critique. Nous allons voir si ces opinions sont identiques aux résultats du questionnaire mais j'en suis sur que cela sera le cas. Pourtant, le Bureau exécutif de l'IUFRO sera très intéressé à apprendre vos opinions une fois que vous avez eu le temps de réfléchir sur tous les aspects de ce congrès après votre retour.

Il n'est certainement pas possible de remercier individuellement toutes les personnes et organisations qui ont contribué au succès de ce congrès. Pour cette raison, j'aimerais remercier collectivement à votre nom le Gouvernement de la Malaisie ; le Bureau exécutif de l'IUFRO, le Comité directeur du Congrès présidé par le Dr. Razak, le Comité d'organisation du Congrès présidé par le Dr. Rahim Nik, le Comité scientifique du Congrès présidé par le Dr. Teissier du Cros, le Secrétariat de l'IUFRO géré par Heinrich Schmutzenhofer, le personnel nombreux de FRIM, les départements forestiers gouvernementaux et nationaux, les universités qui nous ont beaucoup aidé, les photographes, le personnel de liaison et les organisateurs professionnels du congrès, les journalistes pour leurs rapports conscients pendant cette semaine, les interprètes sans lesquels les orateurs principaux n'auraient jamais été entendus complètement, le maître des cérémonies sans qui les séances d'ouverture et de clôture n'aient pas été si efficaces et agréables, les bailleurs de fonds qui ont financé beaucoup de participants, et avant tout, les participants eux-mêmes. Comme avec la plupart des activités dans la vie, vous sortez d'un événement autant que vous mettez dedans et je sais que la majorité des participants se sont identifiés avec l'esprit et les activités du congrès profitant ainsi autant sur le plan personnel que professionnel.

Moi, personnellement, je vous remercie tous de votre appui pendant ces cinq dernières années, et tout particulièrement ma femme Jean et le Secrétaire de l'IUFRO, Heinrich Schmutzenhofer. Sans eux, je n'aurais jamais été en mesure d'assumer les responsabilités d'un président. Heureusement, je ne dois rentrer qu'avec l'un des deux. Pour l'autre, j'ai apporté un petit cadeau, un réveil d'Oxford mis sur 6 heures du soir, pour que Heinz sache qu'il est temps de rentrer pour joindre sa femme Edith.

Je vous souhaite tous un bon voyage de retour, et que Dieu vous bénisse. Le XXIème Congrès Mondial de l'IUFRO est clos.

Ansprachen in den Eröffnungs-und Abschlussfeierlichkeiten

Ansprache des Vorsitzenden desKongress Steuerungskomitees

Dato' Dr. Abdul Razak Mohd. Ali

Sehr geehrter Herr YB Dato Seri Dr Lim Keng Yaik, Minister für Primärindustrie,
vereehrter Herr Professor Jeffery Burley, Präsident von IUFRO
Geschätzte Gäste, sehr geehrte Damen und Herren,

Es ist wirklich eine Ehre für mich, Sie alle hier im Auftrag des Kongress-Steuerungskomitees am 21. IUFRO Weltkongress willkommen zu heissen. Unser besonderer Dank geht an den verehrten Herrn Minister für Primärindustrie, dafür, dass er zugesagt hat, an diesem Kongress teilzunehmen und diesen im Namen des ehrenwerten Herrn Premierministers, der leider heute morgen verhindert ist, feierlich zu eröffnen. Allen Delegierten und speziell jenen aus dem Ausland sage ich ein herzliches 'Selamat Datang ke Malaysia' oder 'Willkommen in Malaysia'.

Bei der IUFRO Direktoriumssitzung in Madrid im April 1995 hat sich Malaysia um die Abhaltung des 21. IUFRO Weltkongresses in Kuala Lumpur beworben. Dieser Augenblick des Triumphs vor fünf Jahren ist mir immer noch gegenwärtig und es war mir damals die Aufgabe übertragen worden, die Delegation anzuführen, die das malaysische Angebot zusammen mit ähnlichen Anboten von Seiten Südafrikas, Chinas und Indonesiens vorstellte.

Malaysia ist sehr stolz, das erste Entwicklungsland zu sein, in dem ein IUFRO Weltkongress stattfindet. Ohne Zweifel ist der Kongress die grösste forstliche Veranstaltung, die je in unserem Land stattfand. Die Anzahl der registrierten Teilnehmer und Begleitpersonen, sowie der Beiträge und Poster übersteigt bei weitem jene der 14. Commonwealth Forstkonferenz, die im September 1993 in Kuala Lumpur stattfand.

Wir sind der Regierung von Malaysia und dem Internationalen Rat IUFROs zu grossem Dank verpflichtet, dass sie dem Forstforschungsinstitut Malaysias (FRIM) die immense Verantwortung für die Organisation des IUFRO Kongresses übertragen haben. Wir möchten dem IUFRO Sekretariat in Wien und dem Malaysischen Beirat für Forschung und Entwicklung (MFRDB) für ihre unschätzbare Unterstützung und Führung danken. Das Kongress-Organisationskomitee (COC) und seine Subkomitees haben sehr hart gearbeitet, um den Erfolg dieses Kongresses auf allen Ebenen sicherzustellen.

Sehr geehrte Damen und Herren,

Wir freuen uns, bekanntzugeben, dass insgesamt 1906 Teilnehmer und über 200 Begleitpersonen aus 96 Ländern für diesen Kongress registriert sind. In den nächsten Tagen werden 5 Hauptvorträge, 9 Subplenarvorträge, 500 Vorträge und 833 Poster im Rahmen der jeweiligen Veranstaltungen und Sitzungen präsentiert werden. Unsere Absicht ist es, den Wissenschaftlern die Möglichkeit zu geben, mit Ihren Begutachtern Fachthemen zu diskutieren.

Mit Hilfe des Programms zur Unterstützung von Wissenschaftlern (SAP) konnte die Teilnahme von 138 Wissenschaftlern aus 38 Entwicklungsländern finanziert werden. Zusätzlich hat die Malaysische Regierung Geldmittel für die Unterstützung von weiteren 31 Wissenschaftlern aus Asien und der Pazifikregion zur Verfügung gestellt.

Wir möchten dem ehrwürdigen Herrn Minister für Primärindustrie, Malaysia, herzlich danken, der im Anschluss an seine Rede im Namen des Premierministers den Kongress feierlich eröffnen wird. Weitere Höhepunkte der Eröffnungszeremonie werden die Präsentation der Sonderbriefmarken zum 21. IUFRO Weltkongress, eine Folkloreshow und die Überreichung der IUFRO-Auszeichnungen sein. Wir möchten auch den Autoren der Hauptvorträge danken, die ihre Vorträge während der Plenarsitzungen halten werden.

Sehr geehrte Damen und Herren,

Ich hoffe sehr, dass der Kongress ein sinnvolles Forum für den Gedankenaustausch der Wissenschaftler untereinander zu den Themen Wald und Gesellschaft bieten wird. Schon immer wurden Wälder als Holzlieferanten betrachtet. Die Forschung hat bei der veränderten Wahrnehmung und Haltung dem Wald gegenüber eine massgebliche Rolle eingenommen, indem sie uns vor Augen führt, dass Wälder viele andere Güter liefern und Funktionen zum Wohl der Gesellschaft erfüllen können.

Bitte, nehmen Sie im Rahmen dieses Kongresses im Sinne der gegenseitigen Zusammenarbeit in Forschung und Entwicklung die Gelegenheit wahr, Forschungsbelange und Forschungsbedarf zu diskutieren. Die Nebenveranstaltungen vor und während des Kongresses sowie die Arbeitssitzungen der Forschungsgruppen sollen diesem Zweck dienen.

Nun ist alles gesagt und getan. Ich möchte mich, auch im Namen des Kongress-Steuerungskomitees und des Kongress-Organisationskomitees für eventuelle Pannen im vorhinein entschuldigen, die vielleicht bei diesem Kongress auftreten. Und schliesslich hoffe ich, dass Sie die Exkursionen während und nach dem Kongress nutzen können, um unser faszinierendes Land Malaysia zu entdecken, ein Land, das reich ist an biologischer und kultureller Vielfalt.

Ich danke Ihnen.

Eröffnungsansprache des IUFRO Präsidenten

Professor Jeffery Burley

Verehrter Herr Minister für Primärindustrie,
Dato'Seri Dr. Lim Keng Yaik,
Verehrter Herr Ministerstellvertreter,
Herr Generalsekretär,
Dato' Dr. Abdul Razak,
Vorsitzender des Kongress-Steuerungskomitees,
Dr. Hosny El-Lakany,
Stellvertretender Generaldirektor für Forstwirtschaft in der FAO,
Liebe Gäste,
Meine sehr verehrten Damen und Herren,

Es ist mir eine grosse Ehre und Freude, Sie hier bei diesem 21. Weltkongress des Internationalen Verbandes Forstlicher Forschungsanstalten (wohlbekannt unter dem Namen IUFRO) begrüssen zu dürfen. Eure Exzellenz, es tut uns sehr leid, dass der Herr Premierminister aufgrund seiner Staatsgeschäfte an der Teilnahme verhindert ist.

Ich danke Ihnen jedoch dafür, dass Sie uns die grosse Ehre erweisen, die Eröffnungsrede zu halten, die, dessen bin ich sicher, uns ein herzliches Willkommen vermitteln wird. Das Thema unseres Kongresses ist mit „Forstwirtschaft und Gesellschaft: die Rolle der Forschung" zeitgemäss, da wir ein neues Jahrtausend schreiben, in dem Bevölkerungswachstum, wachsende Ansprüche an den Wald und seine Produkte, wachsendes Bewusstsein um viele andere Leistungen des Waldes für die Umwelt und für die Gesellschaft grossen Raum einnehmen werden. Dies gilt auch besonders für Malaysia, ein Land mit ausgedehnten und vielfältigen Waldressourcen und Leistungen, ein Land mit einer international anerkannten Forschungstradition. Herr Minister, wir kennen uns seit vielen Jahren und ich weiss, dass Sie immer ein aktiver und fortschrittlicher Denker und Sprecher der Forstwirtschaft und Holzindustrie waren, insbesondere in bezug auf Malaysia und Südostasien. Wir erwarten mit grossem Interesse Ihre Rede.

In den letzten fünf Jahren war es ein besonderes Privileg für mich, Präsident von IUFRO zu sein, und ich möchte einige Minuten dazu verwenden, Ihnen und den übrigen Gästen etwas über die Geschichte und Aktivitäten von IUFRO zu erzählen; zusätzlich werde ich versuchen, Ihnen zu zeigen, warum dies für einen hohen Politiker von Interesse sein sollte und warum Wissenschaftler und politische Entscheidungsträger den Dialog suchen sollten.

IUFRO wurde 1892 von einer kleinen Zahl europäischer Staaten gegründet. In den ersten 80 Jahren seiner Existenz wurden die meisten Länder der gemässigten Zone Mitglied von IUFRO. Erst 1971 wurde die erste Arbeitsgruppe gegründet, die sich speziell mit einem Thema der Tropen befasste (Forstgenetik und Baumzüchtung). Seit damals hat IUFRO sich aktiv bemüht, an den Vorteilen der internationalen Zusammenarbeit auch Institutionen und Wissenschaftler aus Entwicklungsländern teilhaben zu lassen (einschliesslich der Unterstützung von APAFRI, FORNESSA und dem Netzwerk Lateinamerika) und sie aktiv auf allen Ebenen seiner Geschäftsführung zu beteiligen; der Verband umfasst nun fast 700 Mitgliedsorganisationen in 110 Ländern mit etwa 15,000 Wissenschaftlern, die auf freiwilliger Basis in 276 Abteilungen, Forschungs- und Arbeitsgruppen zusammenarbeiten. Es ist eine internationale, nicht gewinnorientierte, multidisziplinäre Nicht-Regierungsorganisation, deren ernsthaftes Bestreben es ist, den bestmöglichen Nutzen aus den von Regierung, Industrie und Privaten in die Forschung investierten Mitteln zu lukrieren.

Ich sollte darauf hinweisen, dass die Arbeit IUFROs im wesentlichen auf freiwilliger Basis geschieht; praktisch alle Funktionäre des Verbandes und alle mitarbeitenden Wissenschaftler unternehmen grosse Anstrengungen, um den Erfolg von IUFRO sicherzustellen, da sie an den Mehrwert ihrer Mitarbeit glauben. Nur die Mitarbeiter des Sekretariats, das grosszügigerweise von der österreichischen Regierung unterstützt wird, sind als ständige „Beamte" des Verbandes anzusehen. Das Vertragspersonal des Sonderprogramms für Entwicklungsländer (SPDC) wird aus grosszügigen Zuwendungen der Regierungen Kanadas, Dänemarks und den USA finanziert. Die Europäische Union und die Regierungen von Japan, der Schweiz und Grossbritannien leisteten ebenso grosszügige finanzielle Unterstützung für IUFRO. IUFRO unterhält enge Beziehungen mit anderen Organisationen, insbesondere mit dem Internationalen Rat für Wissenschaft, dem Zentrum für Internationale Forstliche Forschung, der Organisation der Vereinten Nationen für Ernährung und Landwirtschaft und dem Internationalen Zentrum für Agroforstwirtschaftliche Forschung. Es ist für mich ein Privileg mehr, dass der Repräsentant des Generaldirektors der FAO anlässlich dieser Eröffnungssitzung eine Rede halten wird.

In diesem Jahrhundert wurde der Verband nicht müde, ausgezeichnete und qualitativ hochwertige Forschung in vielen wissenschaftlichen Disziplinen zu fördern und zu unterstützen. Jedoch hat Forschung keinen Wert, wenn sie isoliert stattfindet; sie sollte als intergrierter Bestandteil des Kontinuums von theoretischer zu angewandter Forschung zur Anpassung und weit verbreiteten Anwendung neuer technologischer und sozialer Systeme angesehen werden, die Fragestellungen der internationalen und nationalen Politik aufgreifen. Hier wurde IUFRO aktiv und hat Sonderarbeitsgruppen ins Leben gerufen, die die Integration solcher Forschungsbemühungen fördern und zur Verbesserung des Dialogs zwischen Wissenschaftlern und Entscheidungsträgern beitragen sollen. Bei diesem Kongress in Malaysia, der im ersten Jahr des neuen Jahrtausends stattfindet, werden Wissenschaftler von IUFRO Berichte zum Stand der Wissenschaft zu vielen aktuellen Themen vorstellen, und so einen Überblick über verfügbare Informationen, die Problematik von Forschungsmanagement und den Bedarf an neuer Forschung geben.

In der Vergangenheit wurden wir Zeugen fortschreitender Sensibilierung der Politik und der Öffentlichkeit in Hinblick auf die Bedeutung des Waldes und der Bäume für das Wohl der Menschen. Unbestritten sind die Leistungen des Waldes für die Umwelt, die Wirtschaft und die Erholung für eine grosse Zahl von Menschen. Zusätzlich zu forstwissenschaftlichen Publikationen und Zeitschriften bringen heute in den meisten Ländern Zeitungen und Fernsehstationen Beiträge zu forstlichen Themen. Es gibt eine starke gegenseitige Abhängigkeit, ja sogar Konkurrenz zwischen den einzelnen Produkten und Leistungen, die vom Wald verlangt werden. Die Forschung umfasst viele Disziplinen, die nicht notwendigerweise kohäsiv sind. IUFRO macht hier unheimliche Anstrengungen, um die interdisziplinäre Zusammenarbeit zwischen Biophysikern und Soziologen zu fördern.

Die Zahl 2000 ist eine schöne runde Zahl, zumindest wenn man das Dezimalsystem anwendet. Sie ist auch in manchen religiösen Kalendern aussagekräftig. Jedoch ist sie für alle die Lebenden und die Milliarden Ungeborenen als das Jahr von Bedeutung, in dem internationale Organisationen, Unternehmen und Ressourcenmanager realisieren mussten, dass ein dringendes Bedürfnis besteht, die Ressourcen dieser Welt sinnvoll, gerecht, ethisch einwandfrei und in nachhaltiger Weise zu nutzen. Wälder und Bäume werden eine Hauptrolle bei einer nachhaltigen Entwicklung spielen, und IUFRO wird auch weiterhin sein möglichstes tun, um Wissenschaft und Wissenschaftler zu ermutigen, aktuelle Themen zu behandeln und ihre Ergebnisse so zu präsentieren, dass politische Entscheidungsträger und alle Interessensgruppen diese verstehen und anwenden können. Das Direktorium IUFROs ist sicher, dass dieser Kongress dazu beitragen wird.

Exzellenz, alle Teilnehmer am 21. IUFRO-Kongress sind der Regierung von Malaysia und der Stadt Kuala Lumpur sehr verbunden, dass sie sich als Gastgeber für diesen Kongress zur Verfügung gestellt haben, wir danken insbesondere für die grosszügige Gastfreundschaft und die äusserst interessanten und vergnüglichen Exkursionen, die für die Kongressteilnehmer und ihre Begleitpersonen in ihrem schönen Land organisiert wurden. Zur Organisation kann ich nur anmerken, dass das Personal des Forstforschungsinstituts, der Forstabteilung der Regierung und zahlreicher Universitäten keine Mühe gescheut hat, um die Bemühungen IUFROs für die Krönung seiner Fünfjahresperiode zu unterstützen. Ich fürchte nur, dass bei diesen Aktivitäten die Forschung in Malaysia nicht nur beeinträchtigt wurde, sondern dass sie auch bald nicht mehr da sein wird, wenn alle diese Forscher professionelle Kongressorganisatoren und Reiseleiter werden.

Exzellenz, ich bitte Sie nun, diesen 21. IUFRO-Kongress zu eröffnen und uns Ihre Sicht zur Rolle und zum Bedarf forstlicher Forschung darzulegen. In der Folge werde ich Sie bitten, uns die Ehre zu geben, die höchste Auszeichnung IUFROs, nämlich die Verleihung der Ehrenmitgliedschaft an zwei herausragende Wissenschaftler unseres Verbandes vorzunehmen.

Ansprache des

Premierministers
Y.A.B. Dato' Seri Dr. Mahathir bin Mohamad

Vorgetragen von

Dato' Seri Dr. Lim Keng Yaik,
Minister für Primärindustrie, Malaysia;

Professor Jeffery Burley, Präsident des Internationalen Verbandes Forstlicher Forschungsanstalten;
Sehr geehrter Herr Datuk Haron Siraj, Generalsekretär des Ministers für Primärindustrie, Malaysia
Dato' Dr. Abd. Razak Mohd Ali, Vorsitzender des Kongress-Steuerungskomitees

Verehrte Gäste, meine Damen und Herren,

Zuerst möchte ich den Organisatoren für die Einladung zur Eröffnung dieses wichtigen 21. Weltkongresses des Internationalen Verbandes Forstlicher Forschungsanstalten (IUFRO) danken. Ganz herzlich möchte ich auch alle unsere Gäste und Kongressteilnehmer begrüssen und Ihnen allen fruchtbringende Diskussionen und einen angenehmen Aufenthalt in Malaysia wünschen.

Soweit ich weiss, ist IUFRO eine nicht gewinnorientierte Nicht-Regierungsorganisation, die vor mehr als hundert Jahren, nämlich 1892, mit der Aufgabe gegründet wurde, die internationale Zusammenarbeit in der forstlichen Forschung und in verwandten Wissensgebieten zu fördern. Ich weiss auch, dass, obwohl IUFRO 700 Mitgliedsorganisationen in 105 Ländern zählt, es das erste Mal ist, dass ein Weltkongress in einem Entwicklungsland abgehalten wird. Deshalb möchte ich den Organisatoren gratulieren, dass es ihnen gelungen ist, die Ausschreibung für die Abhaltung dieses Weltkongresses in Kuala Lumpur zu gewinnen und dass sie die notwendigen Vorbereitungen getroffen haben, die es uns erlauben, uns hier anlässlich der grössten forstlichen Veranstaltung, die je in unserem Land abgehalten wurde, zu versammeln. Ich hoffe, dies wird der Beginn sein dafür, dass auch in anderen Entwicklungsländern in Zukunft IUFRO Weltkongresse abgehalten werden.

Wie wir wohl alle wissen, spielen Wälder im täglichen Leben vieler Menschen in den Entwicklungsländern eine sehr grosse Rolle und tragen massgeblich zum wirtschaftlichen Fortschritt dieser Nationen bei. Ich bin äusserst erfreut, dass Malaysia diese Ausschreibung gewonnen hat und somit den Weg geebnet hat für die Organisation derartiger Kongresse, da forstliche Themen in der Armutsbekämpfung von grosser Bedeutung sind. Auch möchte ich IUFRO zur gelungenen Wahl des Kongressthemas gratulieren, nämlich die Verknüpfung von Gesellschaft und Wald durch die forstliche Forschung.

Meine Damen und Herren,

Zu Ihnen von der Rolle und den Funktionen des Waldes zu sprechen würde wohl heissen: Eulen nach Athen tragen, denn Sie sind die Experten in diesem Bereich. Sie sind nur allzu vertraut mit der Tatsache, dass in der Vergangenheit die Wälder getrennt von ihren Bewohnern gesehen wurden und in den vergangenen Jahren nur als Holzlieferanten betrachtet wurden. Der globale Trend geht jedoch in Richtung Anerkennung der Tatsache, dass Wälder und Gesellschaft - und zwar sowohl im urbanen als auch im ländlichen Bereich - zwei Seiten derselben Medaille sind und dass die Wälder neben dem Nutzholz eine ganze Reihe von Gütern liefern und Funktionen erfüllen, die für das Wohl der Gesellschaft besonders wichtig sind.

Welche Lehren ziehen wir nun aus der nicht so weit entfernten Vergangenheit, Lehren, die dieses Umdenken mit sich gebracht hat und den Grundstein für die derzeitige internationale Debatte über die Wälder gelegt hat? Wir wissen, dass mit der industriellen Revolution im 19. Jahrhundert weite Teile der Wälder der gemässigten Zone in Europa, die bereits in den vergangenen Jahrhunderten dezimiert worden waren, einem nochmaligen Raubbau unterlagen, um das für die aufkeimende Industrie notwendige Holz zu liefern. Riesige Waldflächen fielen auch auf der anderen Seite des Ozeans, in Amerika, im 19. Jhdt dem Kahlschlag zum Opfer. Innerhalb von Jahrzehnten wurden Millionen Hektar Wald zerstört, um Weiden und Ackerland, Nutzholz und Brennstoff zu gewinnen.

Die industrielle Revolution im Westen hatte verheerende Konsequenzen für die Umwelt. Umwelt- und Wasserverschmutzung sowie Bodendegradierung nahmen weiter zu. Das rasche Wirtschaftswachstum am Ende des Zweiten Weltkrieges in den heutigen Industrieländern gaben Anlass zu neuerlicher Umweltzerstörung. Die Konferenz der Vereinten Nationen für die Menschliche Umwelt vom Juni 1972 in Stockholm kam und ging. Die Umweltzerstörung ging jedoch unvermindert weiter. Globale Erwärmung, Zerstörung der Ozonschicht, Verschmutzung der Weltmeere, saurer Regen, Entwaldung und Bodendegradierung - zumeist Auswirkungen der industriellen Aktivitäten - nahmen in den frühen 80er Jahren ein besorgniserregendes Ausmass an.

Vor diesem Hintergrund lieferte die Langkawi Erklärung für die Umwelt der Regierungsbeauftragten der Commonwealth

Konferenz (CHOGM), die im Oktober 1989 in Kuala Lumpur abgehalten wurde, den Anstoss für eine Konzept, dass in weiteren Treffen formell Gestalt annahm. Das Konzept der "Grünen Erde" wurde in der Pariser Deklaration des 10.. Welt-Forstkongresses 1991 zum Prinzip erhoben. In der Folge wurde mit dem bei der Konferenz der Vereinten Nationen für Umwelt und Entwicklung (UNCED) in Rio de Janeiro im Juni 1992 von allen Regierungen angenommenen Grundsatzerklärung über die Wälder dieses Konzept voll aufgenommen.

In diesem Zusammenhang und kurz vor der Abhaltung des Erdgipfels in Rio hatte Malaysia vorgeschlagen, dass die Waldfläche weltweit, die damals 27,6 % betrug, bis zum Jahr 2000 durch massive Aufforstungsmassnahmen und -programme auf 30 % erhöht werden solle. Wir hatten gemeint, dass die Massnahmen die Waldarten aller Zonen umfassen sollten - nämlich jene der borealen, gemässigten und tropischen Zonen – da es unerheblich ist, wie die verschiedenen Waldarten Kohlenstoff speichern, das Klima stabilisieren, die Umwelt schützen, die Artenvielfalt bewahren, Ressourcen für die Industrie liefern und die Existenz von im und am Rande des Waldes lebenden Bevölkerungsgruppen sichern. Wir hatten auch gemeint, dass Industrieländer mit wenig Waldbestand aufgrund des Raubbaus vergangener Jahrhunderte, die jedoch nun über eine starke Wirtschaft verfügen, auch Anstrengungen zur Begrünung der Erde unternehmen sollten. Wir hatten weiters gemeint, vielleicht in unserer Naivität, dass wirtschaftlich mächtige Länder, die über enorme Ressourcen verfügen, aktive Beiträge zu Aufforstungsprogrammen in den ärmeren Ländern leisten würden.

Acht Jahre nach dem Gipfel von Rio sind alle zur Tagesordnung übergegangen. Aller Enthusiasmus, der in Rio erzeugt worden und zu spüren war, ist beinahe über Nacht verschwunden. Nicht einmal das kleinste Anzeichen für eine gemeinschaftliche Bewegung für eine grüne Erde ist mehr zu sehen. Es wurde praktisch jeder Nation selbst überlassen, ihre Forstprogramme umzusetzen. Es wurde mir mitgeteilt, dass die jährlichen Durchschnittskosten, die notwendig sind, um die in der Agenda 21 von UNCED verlangten Forstprogramme umzusetzen, sich auf US$32 Mrd. belaufen. Davon sollte ein Grossteil von den Industrieländern aufgebracht werden. Trotz der Tatsache, dass die Agenda 21 sowie die Forstlichen Grundsätze die Rahmenbedingungen für die verstärkte Kooperation zwischen den einzelnen Ländern fördern sollen, ist es nun offensichtlich, dass der Grossteil der für die Aufforstungsprogramme notwendigen Geldmittel von den Entwicklungsländern selbst auftgebracht werden muss.

Malaysia ist und war immer proaktiv, was die Behandlung globaler Themen anlangt, wie Wald und Umwelt. Wir haben uns aktiv an den Verhandlungen beteiligt, die schliesslich zur UNCED, einschliesslich der Agenda 21, der Grundsatzerklärung über den Wald, der Konvention zur Artenvielfalt und der Rahmenkonvention über Klimaänderung führten. Wir haben aktiv an diesen Entwicklungen seit Rio mitgearbeitet. Wir sind dem Konzept einer “grünen Erde” stark verbunden, obwohl viele Wälder in der Zeit der Kolonialherrschaft gerodet wurden, und auf den so entstandenen Flächen Plantagen errichtet wurden. Trotzdem sind noch immer 58 % unserer Landesfläche von Naturwald bedeckt. Rechnet man auch Gummi- und Ölplamenplantagen dazu, so würden 72 % der Fläche von Wald bedeckt sein. Wir haben uns dafür eingesetzt und wir werden uns auch weiterhin dafür einsetzen, dass für immer mindestens 50 % der Landesfläche Malaysias mit Wald bedeckt sein sollen. Das wird unser Betrag für die Menschheit sein.

In diesem Zusammenhang haben wir alles unternommen, um die forstliche Praxis zu verbessern und diese nach den Grundsätzen der nachhaltigen Bewirtschaftung auszurichten. Wir haben z.B. die Grösse unseres permanenten Waldbesitzes von 12,7 auf 14,1 Millionen Hektar ausgedehnt, die Nationale Forstpolitik im Jahre 1992 neu gestaltet und das Nationale Forstgesetz 1993 novelliert. So wurden Gesetze verschärft und höhere Strafen für Vergehen im Zusammenhang mit dem Wald verhängt. Wir verstärken unsere Bemühungen im Bereich Forschung und Entwicklung, um die Holzindustrie auf eine Basis zu stellen, die das Prinzip Nachhaltigkeit berücksichtigt. Auf der Makroebene wird die 1998 verabschiedete Nationale Politik für Artenvielfalt die Richtung für die Bewahrung der Artenvielfalt und nachhaltigen Bewirtschaftung seiner Komponenten weisen.

Auf internationaler Ebene habe wir auch weiterhin versucht, zum Prozess des Zwischenstaatlichen Panels für Wälder (IPF) und des Zwischenstaatlichen Forums für Wälder (IFF) beizutragen. Wir sind auch aktive Teilnehmer an der derzeitigen Umsetzungsphase der Konvention für Artenvielfalt und der Konvention für Klimaänderung, die beide eng mit forstlichen Themen verbunden sind.

Wir sind wohl alle einer Meinung, dass Forstwirtschaft für Wirtschaft und Gesellschaft und auch für die Umwelt eines Landes und der Erde von grosser Bedeutung ist. Dementsprechend hat sich die Forstwirtschaft auch als Thema auf den nationalen und internationalen Tagesordnungen durchgesetzt, die sich mit der forstlichen Gesetzgebung befassen. Wir kennen nur allzugut die Argumente, die sich gegen eine solche Gesetzgebung aussprechen. Dieses Problem muss noch gelöst werden. Wir sind heute weiter denn je davon entfernt.

Malaysias Position ist die, dass gesetzlich bindende Instrumente für alle Waldarten eine Notwendigkeit darstellen, denn sie berücksichtigen die ganze Palette der Themen aus Forst- und Holzwirtschaft in einem ganzheitlichen, integrierten und umfassenden Ansatz. Wir glauben auch, dass derartige Gesetze eine nachhaltige Bewirtschaftung aller Wälder fördern würden, verglichen mit den aktuellen "ad-hoc" Massnahmen, in einer nicht gesetzlich bindenden internationalen Umwelt, die eigentlich eine Behinderung für die beste forstliche Praxis darstellt. Wir glauben auch, dass so ein Instrument Aktionen auf internationaler Ebene begünstigen würde, die sich verschärfenden Faktoren wie Waldrückgang und -degradierung in Übergangsbereichen sowie das Schuldenproblem und Konsumgewohnheiten, die die Nachhaltigkeit nicht fördern. Dieses Instrument würde auch die Kooperation bezüglich des Technologietransfers fördern und beschleunigen.

Derzeit ist der fehlende Konsens bezüglich der Notwendigkeit gesetzlich bindender Instrumente darin begründet, dass wir uns bei den kritischen Bereichen wie Finanzen, Technologietransfer und Handelsbeziehungen in einer Sackgasse befinden. Diesbezüglich möchte ich die Industrieländer dringend ersuchen, endlich ihre Verpflichtungen zu erfüllen und den Entwicklungsländern konkrete finanzielle Unterstützung und Technologien zu geben, die sie benötigen, um ihre Wälder nachhaltig bewirtschaften zu können. Überdies muss eine nachhaltige Waldbewirtschaftung durch gegenseitige Unterstützung durch den Handel und Umweltstandards für den Marktzugang gefördert werden. Alle anderen Aktionen werden den Wald nur wertlos machen und die Folge werden Kahlschläge für andere Zwecke sein. Handelsbeschränkungen und Umweltauflagen werden der Entwaldung nicht Einhalt gebieten können. Nur ein Zugang zum freien Markt wird nachhaltige Waldbewirtschaft fördern können durch die Erbringung der dafür notwendigen Einnahmen.

Seit Menschengedenken ist die Gesellschaft vom Wald abhängig. Die frühen Gesellschaften waren primitiv und die Ansprüche einfach. In vielen Teilen der Welt, zumeist in den Entwicklungsländern sind die Ansprüche der Gesellschaft immer noch einfach. Anderswo sind die Bedürfnisse gestiegen, der mit der Weiterentwicklung der Gesellschaft verbundene ressourcenverschwendende Lebensstil hat viel zum vermehrten und unstillbaren Verlangen von sich entwickelnden Gesellschaften beigetragen. Aber Bedürfnisse sind mehr als nur materiell und so lautet die Maxime, 'Waldressourcen und Waldflächen sollten nachhaltig bewirtschaftet werden, um die sozialen, wirtschaftlichen, ökologischen, kulturellen und geistigen Bedürfnisse des Menschen der heutigen und zukünftigen Generationen befriedigen zu können".

Ich bin sehr froh, dass ich heute die Gelegenheit habe, Sie alle hier zu treffen, und diese Rede an einem Kongress vor Wissenschaftlern zu halten, die ihr Leben der forstlichen Forschung verschrieben haben, sodass direkt oder indirekt, Sie es sind, die zur Deckung der Bedürfnisse der Gesellschaft beitragen, heute und in der Zukunft. Die jüngste Vergangenheit hat gezeigt, dass Investitionen in Forschung und Entwicklung in jedem Bereich gute Ergebnisse zeitigen. Es ist mein sehnlichster Wunsch, dass ihre Bemühungen zu Ergebnissen führen mögen, die eine bessere Gesellschaft zur Folge haben können und insgesamt auch den ärmeren Schichten der Bevölkerung zugute kommen. Sie vertreten hier sowohl die Industrie- als auch die Entwicklungsländer, und IUFRO fungiert als Bindeglied dieser Nord-Süd-Partnerschaft .

Ich hoffe, dass alle Ihre Bemühungen dazu beitragen mögen, eine gerechte Forstwirtschaft auf die Tagesordnung der internationalen Konferenzen zu bringen und die von Ihnen entwickelten Technologien in gerechter Art und Weise mit den Entwicklungsländern zusammen genutzt werden können, um die forstliche Praxis weltweit zu verbessern. Wenn die Welt eine nachhaltige Waldbewirtschaftung will, so muss sie auch den Technologietransfer von Norden nach Süden, wie in den Abkommen von Rio festgeschrieben, zulassen. Leider war dies bis jetzt nicht der Fall und die Entwicklungsländer werden ohne Zugang zu diesen Technologien nicht in der Lage sein, ihren Verpflichtungen zur nachhaltigen Waldbewirtschaftung nachzukommen. IUFRO kann daher eine wichtige Rolle bei diesem Technologietransfer spielen, und ich hoffe, dass dieser Kongress dazu beitragen wird, nicht nur den Austausch von Forschungsergebnissen zu fördern, sondern auch ein konkreteres Netz für den Technologietransfer Nord-Süd zu bilden. Ich wünsche Ihnen deshalb alles Gute bei Ihren Bemühungen und hoffe, dass Sie einen erfolgreichen Kongress erleben werden.

Abschliessend möchte ich noch einmal allen Teilnehmern dieses Kongresses alles Gute wünschen. Ich hoffe, dass Sie die Zeit finden werden, im Rahmen der Exkursionen nach dem Kongress nicht nur die Artenvielfalt unserer Tropenwälder sondern auch das multikulturelle, multiethnische und multikonfessionelle Malaysia kennenzulernen. In Malaysia werden Sie Asien finden.

Damit erkläre ich den 21. IUFRO-Weltkongress für eröffnet.

Ansprache von

Prof. M. Hosny El-Lakany

Stellvertr. Generaldirektor,
Forstabteilung, FAO

Sehr geehrte Gäste,
Sehr geehrter Herr Präsident,
Geehrte Mitglieder des IUFRO Direktoriums,
Meine Damen und Herren,

Im Namen des Generaldirektors und der Mitarbeiter der Organisation für Ernährung und Landwirtschaft der Vereinten Nationen, und im speziellen im Namen meiner Kollegen von der Forstabteilung möchte ich alle Teilnehmer an diesem XXI IUFRO Weltkongress sehr herzlich begrüssen. Es ist für mich persönlich eine grosse Freude und Ehre, dass ich heute hier bei Ihnen in Kuala Lumpur sein darf!

Zuerst möchte ich den Kongressorganisatoren und im speziellen unseren malaysischen Gastgebern für die hervorragende Organisation gratulieren. Gewiss ist Malaysia mit seiner langen und fundierten forstwissenschaftlichen Tradition ein Beitrag zur Entwicklung und ein äusserst geeigneter Rahmen für diese beeindruckende Zusammenkunft.
Wenn ich hier in die Runde blicke und diese vielfältige und hochkarätige Gruppe von Teilnehmern sehe, so wird mir immer mehr der grundlegende Wert von IUFRO als Organisation bewusst. IUFRO bietet ein Forum für Forstwissenschaftler zum gegenseitigen Austausch von Gedanken und Wissen im Sinne der Verbreitung der Sache der nachhaltigen Forstwirtschaft und des persönlichen Weiterkommens. Diese Gelegenheit für junge Wissenschaftler am Beginn ihrer Karriere einen Gedankenaustausch mit erfahrenen Forschern vorzunehmen und von diesen Kontakten zu profitieren, ist aussergewöhnlich und sucht ihresgleichen, und die Möglichkeit, Zugang zu Forschungsergebnissen aus der ganzen Welt zu bekommen, ist von unermesslichem Wert. Für wieviele von uns, die wir heute hier versammelt sind, war dies nicht ein grosser Vorteil!

Dies gilt auch für mich. Ich erinnere mich lebhaft an meine erste Teilnahme an einem IUFRO Kongress, und zwar war das 1976 in Oslo, und an mein Zusammentreffen mit vielen Forstwissenschaftlern, von denen glücklicherweise noch viele heute unter uns sind. Und ein Teil meiner Doktorarbeit beschäftigte sich mit Saatgutgewinnung im Rahmen des IUFRO – Douglasien- Herkunftsversuches von 1966.

Daher ist es eine grosse Ehre für mich, die FAO bei diesem wichtigen Ereignis – dem ersten IUFRO Weltkongress im neuen Millenium - vertreten zu dürfen. IUFRO hat eine besondere Beziehung zu seinen Mitgliedern und die Beziehungen zur FAO sind einzigartig. Seit der Gründung der FAO gibt es eine gute Kooperation und Symbiose zwischen FAO und IUFRO – wobei IUFRO die um ein halbes Jahrhundert „ältere Schwester" der FAO ist. IUFRO stellt die Verbindung zwischen Wissenschaftlern und Forschern her, und die FAO ist bei der Umsetzung der wertvollen Resultate der forstlichen Forschung in die Praxis behilflich – und auch dass der „Herzschlag" der Arbeit im Gelände auf die Wissenschaftler übertragen wird.

Alle Forstbeamten der FAO haben direkten und ständigen Kontakt mit IUFRO und den jeweiligen Forschungs- und Arbeitsgruppen. Zusätzlich fördert die FAO im Rahmen seines „Partnership Programmes" den Austausch von Wissenschaftlern, und speziell von jungen Wissenschaftlern, die sonst keine Gelegenheit zum direkten Erfahrungsaustausch haben. Auf Länderebene hilft die FAO durch seine Rolle als neutrales Forum bestimmte Bereiche gemeinsam zu erschliessen, wo weltweite zusätzliche Forschungsarbeit notwendig ist, und dadurch den Einsatz der Wissenschaftler weltweit auf ein gemeinsames Ziel zu konzentrieren. In dieser Hinsicht bin ich immer wieder erfreut, wenn den Nationalen Delegationen zu den zweimal pro Jahr stattfindenden Sitzungen des FAO Komitees für Forstwirtschaft auch Forstwissenschaftler angehören. Damit ergibt sich ein Informations- und Wissensaustausch über die Vielzahl der Adern des Netzwerks zwischen FAO und IUFRO zugunsten aller Beteiligten.

Aus der Sicht der FAO ist das Thema des Kongresses, „Wald und Gesellschaft: die Rolle der Forschung", besonders gelungen. In seiner forstlichen Arbeit ist die FAO einem Ansatz verbunden, der auf der bestmöglichen Nutzung der Umweltwirkungen und des wirtschaftlichen Potentials durch die nachhaltige Forstwirtschaft beruht. Tatsächlich entspricht diese Verpflichtung der FAO Strategie für die Forstwirtschaft, die in Zusammenarbeit mit FAO Mitgliedsstaaten, Partnerinstitutionen und –organisationen einschliesslich IUFRO, in mehr als zwei Jahren erarbeitet und vom Komitee der FAO für Forstwirtschaft im März 1999 angenommen wurde. Der Strategische Plan für Forstwirtschaft der FAO beschreibt das Aufgabengebiet, die Ziele und die mittelfristigen Zielsetzungen, laufende Schwerpunktaktivitäten und die Visionen für die Forstwirtschaft. Die Aufgabe besteht darin, "das Wohl der Menschheit zu fördern durch die Unterstützung der Mitgliedsstaaten bei der nachhaltigen Bewirtschaftung der Bäume und Wälder der Erde". Es sind der Mensch und die Gesellschaft, denen die grösste Bedeutung zukommt.

Unsere Schwerpunktaktivitäten konzentrieren sich auch auf den Wald und die Gesellschaft. Zum Beispiel bemühen wir uns, im Rahmen der partizipativen Forstwirtschaft grössere Anteile der Bevölkerung direkt an forstlichen Massnahmen und Entscheidungsprozessen zu beteiligten. Ich sollte hier noch hinzufügen, dass dies nicht nur jene betrifft, die in oder in der Nachbarschaft von Waldgebieten leben, sondern im speziellen auch andere, die vom Wald und seinen Leistungen abhängen.

Eine anderer Schwerpunkt der FAO hat direkte Relevanz für das Thema Wald und Gesellschaft in unserer Arbeit, Ländern dabei zu helfen, nationale Forstprogramme durchzuführen. Diese Programme, die aus den UNCED folgenden zwischenstaatlichen Prozessen hervorgegangen sind, zielen darauf ab, einen praktikablen sozialen und politischen Rahmen zu bilden für die Erhaltung, das Management und die nachhaltige Entwicklung aller Waldarten.

Eine dritte Priorität des forstwirtschaftlichen Bereichs der FAO unterstützt den weltweiten Zugang zu verlässlicher und aktueller forstlicher Information. Der erste Artikel der Verfassung der FAO gibt uns den Auftrag, Information zu sammeln, zu analysieren, auszuwerten und zu verbreiten. In der Forstwirtschaft beinhaltet dies die Entwicklung gemeinsamer Ausdrücke und Definitionen, und die Harmonisierung der Definitionen, die Sammlung von Statistiken im Bereich Produktion, Konsum und Handel, und unsere Beurteilung der forstlichen Ressourcen weltweit. Bei all diesen Aspekten arbeiten wir eng mit IUFRO zusammen. Es ist daher angebracht, dass wir die ersten Ergebnisse der Beurteilung der forstlichen Ressourcen 2000 durch die FAO hier bei diesem Kongress veröffentlichen. Ich möchte hier auch unsere umfassende Webseite und die Zusammenarbeit zwischen FAO und IUFRO bei der Entwicklung des Weltweiten Forstinformationsdienstes erwähnen.

Ein anderer wichtiger Bereich der Zusammenarbeit FAO-IUFRO betrifft das Sonderprogramm für Entwicklungsländer – das SPDC. Vor einem Monat, am 7. Juli, wurde das Netzwerk für forstliche Forschung für Afrika südlich der Sahara (FORNESSA) offiziell gegründet und Dr. Konuche aus Kenya übernahm die Leitung desselben. In diesem Zusammenhang bin ich sehr froh zu sehen, dass der stellvertretende Koordinator für Afrika des SPDC seinen Sitz im Regionalbüro für Afrika der FAO hat. Deshalb sind enge, ständige Beziehungen mit der FAO gesichert.

Bei diesem Kongress werden zahlreiche Vorträge von FAO Mitarbeitern gehalten werden und viele Veranstaltungen wurden zusammen mit der FAO organisiert.
Die gebrachten Beispiele zeigen, wie ich hoffe, die langfristige Verpflichtung der FAO zur bestmöglichen Förderung der positiven Beziehungen zwischen Wald und Gesellschaft. Und das Thema dieses Kongresses weist deutlich darauf hin, dass IUFRO und ihre Mitglieder auch in dieser Richtung tätig sind.

Welche Rolle nimmt die Forschung nun auf diesem Weg ein, aus der Sicht der FAO? Gewiss ist eine stärkere Konzentration auf die sozialen Aspekte der nachhaltigen Forstwirtschaft nötig. Wir müssen mehr über die Art der Durchführung der Waldbewirtschaftung erfahren und im speziellen über die Instrumente und die wissenschaftlichen Grundlagen, die nötig sind, um den Anforderungen so gut wie möglich gerecht zu werden.

Wir benötigen mehr Forschung auch darüber, wie die Informationen am effizientesten an diese Menschen weitergegeben werden können, um sie in die Lage zu versetzen, besser an den Entscheidungsprozessen in der Forstpolitik teilhaben zu können. Ebenso brauchen wir spezielle Forschungsarbeiten zum Bereich Konfliktmanagement.

Und wir brauchen auch besonders Forschung zum Potential und zu den Modalitäten internationaler Kooperation in der Forstwirtschaft. Die vergangene Dekade war gekennzeichnet von einer Unmenge von internationalen Abkommen, die sich direkt auf die Zukunft der Weltforstwirtschaft beziehen, aber jene, die mit der Einbindung und Umsetzung der Forschung betraut sind, bewegen sich auf Neuland. Wir müssen aus den Erfahrungen der anderen Sektoren, die diesen Weg vor uns beschritten haben, lernen, sie studieren und analysieren, sodass die Abkommen, die wir für die Forstwirtschaft schliessen, sowohl praktikabel in der Umsetzung als auch ehrlich in der Absicht bleiben.

Es sind dies grosse Herausforderungen und sie werden umso grösser, wenn man bedenkt, dass sie Forschung ergänzen, jedoch nicht traditionelle forstliche Forschung ersetzen sollen. Meiner Meinung nach sind sie jedoch wesentlich für die Erreichung unseres gemeinsamen Ziels der nachhaltigen Nutzung von Waldökosystemen. Und ich kann mir keine andere Organisation vorstellen, die besser für diese Aufgabe geeignet ist als IUFRO.

Zum Schluss, meine Damen und Herren, möchte ich dem scheidenden Direktorium und insbesondere seinem Präsidenten, der ein enger Kollege und guter Freund ist, Professor Jeff Burley für ihre kompetente Kollaboration danken. Und erlauben Sie mir auch, dem neuen Vorstand und dem neuen Präsidenten, Professor Risto Seppälä, mein Vertrauen auszusprechen sowie die Altpräsidenten und hier besonders Dr. Salleh Mohd Nor herzlich zu begrüssen.

Herr Vorsitzender, im Auftrag des Generaldirektors der FAO, Jacques Diouf, und in meinem eigenen Namen, und besonders im Namen des Forstprogrammes der FAO, hoffe ich sehr, dass dies ein erfolgreicher Kongress sein wird und ein gelungener Start für die Weltforstwirtschaft im neuen Millenium.

Ich danken Ihnen.

Fünfjahres Bericht
Schlusssitzung

Professor Jeffery Burley

IUFRO Präsident

Sehr geehrte Gäste, liebe Kollegen, meine Damen und Herren,
am Ende dieses beeindruckenden und produktiven Kongresses möchte ich mich kurz als amtierender Präsident an Sie wenden. Professor Risto Seppälä wird als designierter Präsident eine Rede halten. Ich werde Ihnen einen Überblick über die Aktivitäten und Erfolge IUFROs in den letzten fünf Jahren meiner Präsidentschaft geben, während Professor Seppälä Ihnen seine Visionen zukünftiger Entwicklungen in der forstlichen Forschung und in IUFRO darlegen wird.

Die Resolutionen von 1995 und ihre Herausforderungen
Bei unserem 20. Kongress, der 1995 stattfand, wurden die folgenden Resolutionen akzeptiert: - a) Erhaltung und Verstärkung zielgerichteter Forschung in den Bereichen Forstwirtschaft und Forstprodukte; b) Steigerung der Forschungskapazität, speziell in den Entwicklungsländern; c) Förderung breitgefächerter Partnerschaften zur Erhöhung der Forschungseffizienz und verbesserte Kommunikation zwischen wissenschaftlichen und nichtwissenschaftlichen Gruppen; d) Verbesserung der politik- und problemorientierten Forschung in den Wirtschafts- und Sozialwissenschaften. Als ich zum Präsidenten gewählt wurde, habe ich dem Direktorium meine persönliche Sicht der Rolle IUFROs dargelegt, der Entwicklungen und Aktivitäten, und ich möchte diese nun für Sie zusammenfassen und Ihnen zeigen, wie IUFRO auf die von mir gestellten Herausforderungen und Kongress-Resolutionen reagiert hat.

Ich habe darauf hingewiesen, dass im letzten Jahrzehnt des letzten Milleniums einschneidende Änderungen im Bereich Forstpolitik, forstliche Praxis und forstliches Berufsbild stattgefunden haben. Forstliche Themen wurden zum globalen und internationalen Anliegen und betrafen immer mehr auch Bevölkerungsgruppen, die nichts mit der traditionellen Forstwirtschaft zu tun haben. Sozioökonomische Wissenschaften gewannen an Einfluss in den Entscheidungsprozessen. Ein globaler Druck war zu bemerken, die Rolle des Waldes zu überdenken und zu evaluieren und seinen Zustand zu überwachen. Entscheidungsträger bemühten sich nun (a) um Informationen über die Rolle, die Werte und den Zustand der Wälder und Bäume in bezug auf Erhaltung und Entwicklung, (b) um neue Sichtweisen zu den Zusammenhängen zwischen Wäldern, Artenvielfalt, Klima und anderen Umweltfragen und (c) um Beratung hinsichtlich nachhaltiger Waldwirtschaft einschliesslich Strukturförderung.

Schon damals war mir klar (und ich bin noch immer dieser Meinung), dass IUFRO auf diese Änderungen reagieren sollte, jedoch unter Beibehaltung seiner Vorreiterrolle als ein Netzwerk von auf freiwilliger Basis arbeitenden Wissenschaftlern, IUFRO sollte auch weiterhin die wichtigste Quelle von Wissen und Erfahrungen im Bereich forstlicher Forschung für spezielle Themen sein, wobei auch die Intensität und Häufigkeit interdisziplinärer Zusammenarbeit innerhalb des Verbandes selbst und mit anderen Organisationen ausserhalb des traditionellen Forstbereichs erhöht werden sollte.

Aufgrund dieser Verbindungen konnte auch die Arbeit IUFROs unter Anwendung moderner Technologien bekanntgemacht werden, Geldquellen erschlossen und eine produktive Zusammenarbeit zur Vermeidung von Überschneidungen etabliert werden. Schwerpunktthemen wurden früh durch das Direktorium erkannt und erwiesen sich als äusserst wichtig für die Herstellung von Kontakten mit einer Reihe anderer Institutionen. IUFRO hat versucht, die Leiter der Mitgliedsorganisationen zu unterstützen durch die Durchführung und Vebreitung von politik-orientierter Forschung und durch die Unterstützung der Direktoren für die Sensibilisierung von Regierungen und Organisationen für forstliche Themen.

Die neue Rolle IUFROs auf der internationalen Bühne
Das Direktorium machte grosse Anstrengungen, um die globale Bedeutung IUFROs herauszustreichen. Die hochgelobte IUFRO Broschüre wurde am Weltkongress in der Türkei 1997 verteilt und die gleichermassen anerkannte IUFRO Webseite hat Homepages für alle Forschungseinheiten, die auf Servern in einzelnen Ländern gespiegelt und mit anderen Internetseiten verküpft sind. Viele dieser Webpages enthalten Raum für Berichte über den Stand der Wissenschaft in der jeweiligen Disziplin der Forschungseinheit. Wie Sie wahrscheinlich bei diesem Kongress bemerkt haben, wurde grosses Augenmerk auf die Verbreitung von Forschungsresultaten und Berichten über den Stand der Wissenschaft gelegt.

Wir haben uns auch bemüht, die Rolle des Verbandes in der internationalen Debatte und Entwicklung zu stärken. Ich und andere IUFRO Funktionäre haben Tagungen von anderen Organisationen besucht, so z.B.: - das Zwischenstaatliche Forum für Wälder (IFF); das Weltwaldforum; den Weltforstkongress; das Komitee für Forstwirtschaft der Organisation der Vereinten Nationen (COFO/FAO); die Generalversammung von IUCN; zahlreiche Tagungen einer

Reihe von internationalen Initiativen zur Ausarbeitung von Kriterien und Indikatoren für nachhaltige Waldbewirtschaftung; das Direktorium des Zentrums für internationale forstliche Forschung (CIFOR) und das internationale Zentrum für agroforstliche Forschung (CGIAR); die Nationale Ausstellung in Kunming, China; und zahlreiche Treffen und Ausstellungen anderer Organisationen. Mit besonderer Genugtuung haben wir die Empfehlungen der 4. Sitzung des IFF wahrgenommen, die zur Verbesserung der Beziehungen zwischen forstlicher Forschung und forstpolitischen Prozessen, zur besseren Förderung der forstlichen Forschung (speziell in den Entwicklungsländern) und zu einem besseren Zugang zu forstlich-orientierter Information und Zusammenarbeit mit IUFRO im Rahmen von GFIS aufrief.

Das von Renate Prüller koordinierte und von Japan finanzierte Terminologieprojekt IUFROs (SilvaVoc) hat sich gegenüber der FAO vertraglich verpflichtet, Definitionen zu den wichtigsten Ausdrücken, die bei den internationalen Debatten zum Thema „nachhaltige Forstwirtschaft“ verwendet werden, bereitzustellen. Es hat mich auch sehr gefreut, dass mein eigenes Institut in der Lage war, im Namen von IUFRO für die Weltkommission für Wälder und Nachhaltige Entwicklung ein Dokument über forstpolitische Fragen auszuarbeiten, das von der Overseas Development Administration von Grossbritannien (nun Abteilung für Internationale Entwicklung) finanziert wurde.

IUFRO hat seine Forschungseinheiten ermutigt, aktuelle Schwerpunktthemen aufzugreifen. Ein aussergewöhnlicher Beitrag IUFROs zu den internationalen Prozessen war seine Rolle bei der Organisation und Bekanntmachung der Internationalen Konsultation über Forschung und Informationssysteme in der Forstwirtschaft (ICRIS), die von den Regierungen von Österreich und Indonesien in Zusammenarbeit mit CIFOR und der Forstabteilung der FAO finanziert wurde. Diese Konferenz war eine Aktivität zur Unterstützung des Zwischenstaatlichen Forums für Wälder (IFF) der Kommission der Vereinten Nationen für nachhaltige Entwicklung (UNCSD) und fand im Sepember 1998 in Österreich statt. Eines der wichtigsten Ergebnisse für IUFRO waren die Gründung der Sonderarbeitsgruppe für den weltweiten forstlichen Informationsdienst (GFIS) und die Sonderarbeitsgruppe über die Verknüpfung von forstlicher Forschung mit der Politik.

IUFROs verbesserte Struktur und Aktivitäten

IUFRO nimmt auch weiterhin eine Vorreiterrolle bei der Förderung forstlicher Forschung durch die Zusammenarbeit im Rahmen des Netzwerkes von fast 700 Mitgliedsorganisationen und 15.000 Wissenschaftlern in ihren jeweiligen Disziplinen ein; 268 Forschungseinheiten und 8 Sonderarbeitsgruppen hielten 335 Tagungen in 65 Ländern ab, darunter befinden sich 41 Entwicklungsländer oder Reformstaaten. Zu Beginn der Amtsperiode des Direktoriums wurden zwei neue Abteilungen gegründet, um dem wachsenden Forschungsbedarf gerecht zu werden und das Arbeitsvolumen der einzelnen Abteilungskoordinatoren und ihrer Stellvertreter zu reduzieren (die ja, wie alle IUFRO-Funktionäre, Freiwillige sind). Das Direktorium hat eine Reihe von Sonderprogrammen, Projekten und Sonderarbeitsgruppen ins Leben gerufen, die spezielle Themen oder Fragestellungen aufgreifen. Sie wurden ermutigt, Schwerpunkte zu setzen, besonders im Bereich Ausbau der Forschungskapazität. In einer so kurzen Rede ist es natürlich nicht möglich, auf alle Einzelheiten einzugehen oder auch nur Kurzdarstellungen dieser Aktivitäten zu geben, aber ich werde einige besondere Errungenschaften der Sonderarbeitsgruppen herausstreichen.

Wie bereits erwähnt, war eine der grössten Veränderungen im vergangenen Jahrzehnt der vermehrte Bedarf an interdisziplinären Ansätzen zur Lösung von Forschungsproblemen. IUFRO hat immer versucht, alle wissenschaftlichen Bereiche in einzelnen Forschungseinheiten (Biophysik und Sozioökonomie) abzudecken. In den letzten fünf Jahren wurde die Verflechtung untereinander durch die Abhaltung interdivisionärer Veranstaltungen in Zusammenarbeit mit anderen Organisationen und durch die Arbeit der Sonderarbeitsgruppen gefördert. Wir müssen einsehen, wie schwierig es ist, fremde Fachdisziplinen zu verstehen und universitäre oder berufliche Anerkennung für multidisziplinäre Arbeit zu bekommen, aber das ist klar ein wichtiges Ziel, das wir anstreben müssen.

Die Abteilungen

In Seoul, Südkorea, fand 1998 eine interdivisionäre Tagung über forstliche Ökosysteme und Landnutzung im Gebirge statt. Sie wurde von den Abteilungen 1,4,6 und 8 organisiert. 350 Delegierte aus 24 Ländern nahmen daran teil. Innerhalb der Abteilung 1 war die Forschungsgruppe 1.17.00 (Wiederherstellung degradierter Standorte) sehr stark in einem vom USDA Forstdienst, der Weltbank, CIFOR und der British Overseas Development Administration finanzierten internationalen Forschungsprogramm involviert, das sich mit der Rolle und den Auswirkungen beschleunigten natürlichen Waldwuchses auf degradierte tropische Flächen auseinandersetzte.

Abteilung 2 organisierte eine grosse Veranstaltung zum Thema Forstgenetik in Peking, 1998 und ihre Arbeitsgruppe

2.04.06 hielt 1999 eine Tagung über genetische Veränderungen in Oxford ab, wobei IUFROs kontinuierliche Auseinandersetzung mit aktuellen Themen von politischer Relevanz besonders zum Tragen kam. Die Teilnehmer an dieser Tagung waren sich darin einig, dass der Bereich genetischer Veränderungen immer noch nicht über genügend Finanzmittel verfügt, jedoch auch neue Techologien zur Erhöhung der Effizienz verwendet werden sollen. Derzeit sollten genetisch veränderte Organismen nur für Laborzwecke verwendet werden und solange der ethische Gesichtspunkt in der Öffentlichkeit nicht abgeklärt ist, keine sonstige Verbreitung erfahren.

Abteilung 3 organisierte eine Reihe von Abteilungstreffen und interdivisionären Treffen mit der Abteilung 1 in Bolivien, 1997; der Abteilung 6 in Japan, 1998, Kanada, 1998 und Australien, 2000; der Abteilung 8 in Japan, 1998 und der Sonderarbeitsgruppe für Nachhaltige Waldbewirtschaftung in Australien, 1998. Sie hielt auch eine Reihe von Treffen mit externen Organisationen wie CIFOR und FAO ab. Einzelne Forschungsgruppen erarbeiteten Berichte über den Stand der Wissenschaft.

Abteilung 5 bemühte sich sehr um mehr Verständnis um die sich ändernde Ressourcenbasis im Wald, um die vermehrte Ausnutzung von Ressourcen und um den Einsatz von umfreundlichen und sozial verträglichen Technologien. Die Konferenz der gesamten Abteilung 1997 legte den Schwerpunkt auf Waldprodukte für nachhaltige Waldwirtschaft und wurde von 222 Teilnehmern aus 42 Ländern besucht.

Abteilung 7 wurde geschaffen, um spezifisch eine Resolution von 1995 anzusprechen, die sich mit Forschung zum „…..Ausmass, der Produktivität und der Gesundheit von Wäldern…“ auseinanderzusetzt. In den letzten fünf Jahren hielt die Abteilung Veranstaltungen in Europa, Nordamerika und Asien ab, die mit sich mit Entomologie, Pathologie, Luftverschmutzung und den Wechselwirkungen Wirt-Schädling befassen.

Sonderarbeitsgruppen

Ein Schlüsselthema weltweit war die Entwicklung von Kriterien und Indikatoren für die nachhaltige Waldbewirtschaftung. Die von Alain Franc koordinierte Sonderarbeitsgruppe für die nachhaltige Forstwirtschaft hat wechselweise mit CATIE, CIFOR, Ecofor, EFI und der FAO bei der Organisation von drei grossen internationalen Veranstaltungen in Australien 1998, Costa Rica 1999 und Frankreich 1999 (in Kooperation mit Ecofor und EFI) zusammengearbeitet. Jede dieser Veranstaltungen vereinte 100-200 Teilnehmer mit dem Ziel, Wissenslücken zwischen Wissenschaflern und Interessensgruppen zu schliessen und gleichzeitig die Beziehungen zwischen Kriterien, Indikatoren, Zertifizierungssystemen und Biodiversität zu klären. Besonderes Augenmerk wurde dabei auf die Rolle der Sozialwissenschaften gelegt.

Aufgrund der Beiträge vieler Wissenschaftler entwickelte die von John Innes koordinierte Sonderarbeitsgruppe für Umweltveränderungen herausragende Berichte zum Stand der Wissenschaft. Zwei davon wurden in der IUFRO Research Series veröffentlicht, der Rest wird im Laufe des Jahres fertiggestellt werden. Die Sonderarbeitsgruppe war im speziellen verantwortlich für eine Resolution der Ministerkonferenz zum Schutz der Wälder in Europa, auch als „Helsinki 4“ bekannt, die sich mit der Koordination von Massnahmen zum Klimaschutz in Europa befasst.

Die von Martin Price koordinierte Sonderarbeitsgruppe über die Bewirtschaftung von Gebirgswäldern hat den ersten Bericht zum Stand der Wissenschaft zu diesem Thema geliefert, mit Beiträgen von 124 Autoren aus der ganzen Welt. Ein kritischer Punkt war die Definition, wie gross die Waldfläche weltweit ist; Schwerpunkte waren die Erstellung einer Weltwaldkarte (nach objektiven Kriterien) und einer Karte mit Bergwäldern, die 28 % der Weltwaldfläche ausmachen.

Die von Rob Vertessy koordinierte Sonderarbeitsgruppe für Wasser und Wald wurde ins Leben gerufen, um den aktuellen Wissensstand und Hypothesen über Süsswasserökosysteme in Wäldern und die Auswirkungen von Waldbau und Waldbewirtschaftung auf Wasserquantität und –qualität zu überprüfen. Zu dem Thema wurde eine umfangreiche Publikation verfasst.

Die von Lauri Valsta koordinierte Sonderarbeitsgruppe über Internet-Ressourcen hat ein einzigartiges Instrument von unschätzbarem Wert für die Kommunikation zwischen Wissenschaftlern untereinander und für die weltweite Verbreitung von Information über IUFRO entwickelt.

Die von Risto Päivinen koordinierte Sonderarbeitsgruppe für den weltweiten forstlichen Informationsdienst ist ein Konsortium von internationalen, regionalen und nationalen Organisationen, die eine Strategie für eine internet-gestützte Metadatenbank entwickelt, die weltweiten Zugriff auf forstlich relevante Informationen bieten soll. Die Sonderarbeitsgruppe hat Grundkonzepte für Datensammlung und technische Lösungen inklusive eines Prototyps erarbeitet. Ein von der Europäischen Kommission finanziertes EU-Projekt für Afrika, die Karibik und den Pazifischen Raum deckt den Bereich Entwicklungsländer ab.

Die Sonderarbeitsgruppe für die Bewirtschaftung und Erhaltung forstlicher Genressourcen wird von Veikko Koski koordiniert und besteht aus Vertretern der meisten IUFRO-Abteilungen, von CIFOR, FAO und IPGRI. Sie sammelt wissenschaftliche Informationen über Wechselwirkungen zwischen allen Faktoren, die die Verteilung, Integrität und Erhaltung forstlicher Genressourcen beeinflussen. Es wurde ein Bericht über den Stand der Wissenschaft erstellt.

Die von Rich Guldin koordinierte Sonderarbeitsgruppe für die Verknüpfung von forstlicher Forschung und Forstpolitik trug zur Gestaltung der Konferenz der Abteilung 6 über die Beiträge der Wissenschaft zur Entwicklung der Forstpolitik in Südafrika bei und organisierte zwei Nebenveranstaltungen bei der dritten und vierten IFF-Sitzung. Drei Konferenzen, die in den nächsten drei Jahren stattfinden sollen, werden 40-50 Fallstudien durchführen, die zeigen sollen, wie Forschung erfolgreich auf die Forstpolitik Einfluss nimmt.

IUFRO unterstützt Entwicklungsländer

Die Arbeit des bis zum Juni dieses Jahres von Bob Szaro koordinierten Sonderprogramms für Entwicklungsländer (SPDC) war immer darauf ausgerichtet, den Aus- und Aufbau fachlicher Kapazitäten in Entwicklungs- und Reformstaaten zu fördern. Zusätzlich wurden Anstrengungen unternommen, um Wissenschaftler, die in den Bereichen Wissenschaft und Management als Funktionäre von Forschungseinheiten tätig sind, zu unterstützen. Das SPDC organisierte Workshops zum Thema Management und Planung von Forschung, Formulierung von Forschungsanträgen und Strategische Planung. Mehr als 200 Wissenschaftler und 35 Veranstaltungen in mehr als 60 Ländern wurden durch dieses Programm finanziert und die ersten zwei Bände einer Reihe kostengünstiger Handbücher wurden publiziert.

IUFRO dankt für Zuwendungen der Regierungen der Vereinigten Staaten von Amerika, von Kanada und von Dänemark, die jeweils den Koordinator, den stellvertretenden Koordinator und einen stellvertretenden Koordinator für Afrika für das SPDC finanzierten. Das BIOREFOR-Programm wurde grosszügig von der Japanischen Regierung unterstützt. Dieses Programm trug zur Förderung der Zusammenarbeit zwischen vielen Institutionen in der Asien-Pazifik-Region auf dem Gebiet der Nutzung der Biotechnologie für Aufforstungsvorhaben bei. Wir sind gleichfalls verbunden für die grosszügige Unterstützung, die die Europäische Kommission unserem GFIS-Afrika Projekt angedeihen liess. Dieses Projekt soll die Verbreitung forstlicher Information in Afrika fördern. Andere Agenturen, die Unterstützung in Form von Finanz- oder Personalmitteln für IUFRO zur Verfügung stellten, waren: AusAid (Australien), der Deutsche Verband forstlicher Versuchsanstalten (Deutschland), die Königliche Dänische Botschaft, der USDA Forstdienst (USA), die Regierung von China Taipei, und die Regierung von Grossbritannien.

Verbreitung von Forschungsresultaten

Forschung sollte nicht im luftleeren Raum betrieben werden und es ist anzustreben, die Ergebnisse dieser Forschung so weit wie möglich zu verbreiten. IUFRO hat sich sehr bemüht, die Arbeit, die Ergebnisse, den Wert und die Bedeutung forstlicher Forschung im allgemeinen und von IUFRO im speziellen bekanntzumachen. Zusätzlich zu den bereits erwähnten Webseiten und zu insgesamt 91 Tagungsberichten, die von den Forschungseinheiten herausgegeben wurden, haben wir auch versucht, die IUFRO World Series und die IUFRO Occasional Paper Series fortzusetzen (vom Sekretariat herausgegeben) sowie auch die IUFRO Research Series zu ergänzen (von CAB International herausgegeben).

Evaluierung von IUFRO-Struktur und Management

Das im Amt befindliche Direktorium ist ständig mit der Evaluierung der Struktur und der Aktivitäten IUFROs befasst. Zu diesem Zweck wurde auch eine externe Expertenkommission beauftragt, das Sekretariat, das SPDC und das Sonderprojekt zu evaluieren. Wir haben uns sehr bemüht, Zuwendungen für die Unterstützung von Mitgliedern aus Entwicklungsländern zu bekommen und gleichzeitig auch IUFROs eigene Projekte wie das Terminologie-Projekt SilvaVoc zu etablieren. Einer eingehenden Prüfung wurde auch die Investitionspolitik in Hinblick auf die Probleme, die manche Mitgliedsorganisationen bei der Aufbringung des Mitgliedsbeitrags haben, unterzogen. Als Reaktion auf den kürzlich zu verzeichnenden Rückgang der Anzahl der Mitgliedsorganisationen hat der Internationale Rat die Änderung des englischen Namens IUFROs von „Forestry“ auf „Forest“ genehmigt. Hier wird der Bedarf sichtbar, die breite Palette der Disziplinen und Institutionen, die Leistungen von IUFRO erhalten oder die Beiträge leisten, zu erfassen. Es wird auch der unterschiedlichen Wahrnehmung des Begriffes „Forstwirtschaft“ durch Teile der Öffentlichkeit Rechnung getragen, die diesen nur mit massiven Abholzungen oder Plantagen mit fremdländischen Baumarten in Zusammenhang bringen. Und das zu einer Zeit, wo IUFRO alles unternimmt, um auf die überwirtschaftlichen Funktionen des Waldes wie Erholungs- und Umweltwirkung hinzuweisen.

Das Direktorium hat die Mitgliedsorganisationen und Wissenschaftler angewiesen, sich als Teil des Politik- und

Planungsprozesses von IUFRO zu verstehen. Viele haben zur Entwicklung des Strategischen Planes beitragen, der die Arbeit des Direktoriums in den letzten fünf Jahren begleitet hat. Der Internationale Rat wurde auch zur Entwicklung der IUFRO-Politik, der Neufassung der Statuten IUFROs und der Wahl des nächsten Direktoriums herangezogen.

Das Direktorium hat die Regionalisierung des IUFRO Managements und der wissenschaftlichen Kooperation durch die Anerkennung von Kapiteln wie der Asia Pacific Association of Forest Research Institutes (APAFRI), dessen Sekretariat derzeit in Malaysia seinen Sitz hat, ermutigt. Zusätzlich leistete IUFRO zusammen mit der FAO proaktive Unterstützung für andere regionale Aktivitäten, die die Kooperation zwischen nationalen Institutionen wie dem Forestry Research Support Programme for Asia and the Pacific (FORSPA) und dem Forestry Research Network for Sub-Saharan Africa (FORNESSA) unterstützen, wobei letztere in enger Zusammenarbeit mit der African Academy of Sciences (AAS) erfolgen.

Herausforderungen für die Zukunft

Meine Damen und Herren, ich hoffe, Sie erkennen aus dem Gesagten, dass IUFRO, geführt vom Direktorium und kompetent unterstützt vom Sekretariat (mit der grosszügigen Unterstützung der österreichischen Bundesregierung), sich in den letzten fünf Jahren weiter entfaltet und mit Erfolg die Resolutionen des letzten Kongresses vertreten hat. Als scheidender Präsident möchte ich dem nächsten Präsidenten und Vorstand eine Reihe von Herausforderungen mit auf dem Weg geben:
∑ Weiterführung der Entwicklung von internationel akzeptablen Standards für Forschungsmethoden

- Unterstützung der Netzwerkbildung zwischen den Mitgliedern
- Entwicklung von GFIS, Normung von Terminologien und Berichte zum Stand der Wissenschaft
- Verbesserung der Beziehungen zwischen Wissenschaft, Politik, Management und Nutzung von Wald, Holzprodukten und Waldfunktionen.
- Identifizierung und Weiterverfolgung des disziplinären und interdisziplinären Forschungsbedarfs
- Gewinnung neuer Mitglieder
- Reorganisation des Direktoriums und Sekretariats zur Verbesserung der finanziellen Sicherheit, mehr Unterstützung für Mitglieder und Verbesserung der Möglichkeiten zur Verbreitung von Information.

Ansprache des
Vorsitzenden
des Kongress-Organisationskomitees

Dr. Abdul Rahim Nik

Sehr geehrter Herr Professor Jeffery Burley, Präsident von IUFRO,
Sehr geehrter Herr Tan Sri G.K. Rama Iyer, Vorsitzender des Malaysischen Beirats für Forstliche Forschung und Entwicklung,
Sehr geehrter Herr Dato' Dr. Abdul Razak Mohd Ali, Generaldirektor von FRIM,
Sehr geehrter Herr Professor Risto Seppälä, designierter IUFRO Präsident,
Geschätzte Gäste und Kongressteilnehmer,
Meine Damen und Herren,

Ich bin sehr froh, dass wir nun bei der Schlusssitzung des 21. IUFRO Weltkongresses angelangt sind. In den vergangenen sechs Tagen fanden an diesem Kongressort eine Fülle von Aktivitäten statt, angefangen von den Fach- und Arbeitssitzungen, Nebenveranstaltungen bis hin zu Ausstellungen, Empfängen und Exkursionen. Als Organisatoren dieser hochkarätigen Veranstaltung haben wir unser bestes versucht, alle Ihre Erwartungen und Anforderungen zu erfüllen, um sicherzustellen, dass Ihre Beteiligung an den Sitzungen und Ihr Aufenthalt in der letzten Woche so angenehm und bequem wie möglich werden.

Vor fünf Jahren wurde ich zum Vorsitzenden des Kongress-Organisationskomitees (COC) ernannt und es wurde mir die monumentale Aufgabe übertragen, diesen Kongress zu organisieren. Ich hatte nicht die leiseste Ahnung von der Grösse der Herausforderung und Verantwortung, die auf mich zukommen würde. Drei Jahre später kam die Sache ins Rollen und die Organisation nahm Formen an. Schliesslich wurden wir sechs Monate vor dem Kongress mit den tatsächlichen Herausforderungen konfrontiert. Ich muss gestehen, dass wir aus der Organisation dieses Kongresses eine Menge gelernt haben. In diesem Zusammenhang waren die verfügbaren modernen Technologien von unschätzbarem Wert und hilfreich während der Vorbereitungsarbeiten. Ich kann mir nicht vorstellen, wie wir diese Veranstaltung ohne elektronische Kommunikationstechnologien hätten organisieren können.

Während das Thema des Kongresses "Wald und Gesellschaft – die Rolle der Forschung" in vielen Fachsitzungen erschöpfend diskutiert wurde, haben wir, die Organisatoren, für uns ein Motto für die Organisationsarbeit festgesetzt. Dieses Motto lautet: "Wir haben uns verpflichtet, einen denkwürdigen und guten Kongress zu organisieren". Sie haben wahrscheinlich den Aufdruck dieses Mottos überall bei den Kongressständen gesehen. Dieses einfache Motto enthält zwei Botschaften. In Anerkennung der Tatsache, dass dies der erste Kongress in der hundertjährigen Geschichte IUFROs ist, der in einem Entwicklungsland abgehalten wird, wollten wir sichergehen, dass dieser XXI IUFRO Weltkongress, der hier in Malaysia stattfindet, einen lang anhaltenden Eindruck und auch angenehme Erinnerungen bei den Teilnehmers, die heute hier anwesend sind, hinterlassen wird. Zweitens benötigt eine grosse Veranstaltung wie diese hier ein effizientes und gut organisiertes System, um auf die Teilnehmer einen guten Eindruck zu machen und ihnen das Gefühl zu geben, dass sie ihr Geld und ihre Zeit nicht umsonst aufgewendet haben. Angesichts dieses Mottos haben wir mit grossem Engagement gearbeitet, um diesen Auftrag zu erfüllen. Es ist nun an Ihnen, verehrte Kongressteilnehmer, über die Leistungen zu urteilen!

Meine Damen und Herren,

Bei dieser Schlusssitzung möchte ich Ihnen einige wichtige statistische Daten nennen, die mit dem Kongress in Zusammenhang stehen, sowie einige unserer Beobachtungen, die nützlich für den nächsten Kongress sein könnten.

Am Kongress nahmen insgesamt 1906 Delegierte aus 96 Ländern teil, einschliesslich 209 Teilnehmer, die als Begleitpersonen registriert waren. Wir haben auch positive Reaktionen auf alle Exkursionsveranstaltungen erhalten. Insgesamt nahmen 1127 Personen an den neun Kongressexkursionen am Donnerstag und mehr als 700 Personen nahmen am Begleitprogramm teil. Die Leuchtkäfertour zählte die meisten Teilnehmer. Unmittelbar nach diesem Kongress werden 324 Delegierte an den 12 mehrtägigen Exkursionen teilnehmen, die hauptsächlich in die Provinzen von Malaysia und Nachbarstaaten einschliesslich Brunei, Indonesien und Thailand führen werden.

Die wissenschaftlichen Präsentationen wurden wie geplant abgehalten. Bei einigen Sitzungen waren die Vortragenden verhindert, doch die Moderatoren konnten andere Teilnehmer einladen, um die Lücken zu füllen. Jedoch gab es eine Reihe von Sitzungen, die abgesagt werden mussten, da keiner der vorgeschlagenen Vortragenden anwesend war, um über die Themen zu sprechen. Es fiel uns auf, dass vorwiegend in den Entwicklungsländern die Finanzierung ein Problem war. Von den 833 ausgewählten Postern wurden nur 55 % präsentiert. Die meisten Absagen kamen von Forschern aus Entwicklungsländern, die nicht genug Reisemittel auftreiben konnten. Die technische Unterstützung des Kongresses bestand in 120 Rapporteuren und beinahe 270 Kongresshelfern, die dazu beitrugen, dass der Kongress problemlos über die Bühne gehen konnte.

Um den Anforderungen des Kongresses gerecht zu werden wurden 6,6 Millionen Seiten gedruckt, wobei auch die früheren Ankündigungen und Werbematerial inkludiert sind. Ich bin nicht sicher, wieviele Bäume dafür gefällt werden mussten. Trotzdem glaube ich, dass es der Mühe wert war.

Erlauben Sie mir, ihre Aufmerksamkeit auf ein Thema zu lenken, dass mir besonders wichtig erscheint und dass beim nächsten Kongress berücksichtigt werden sollte. Wenn wir wollen, dass Teilnehmer aus Entwicklungsländer sich aktiver beteiligen, so sollten wir versuchen, schwerpunktmässig die Bereitstellung von Geldmitteln für das Programm zur Unterstützung von Wissenschaftlern zu forcieren. Für diese Veranstaltung wurden 91 von den gemeldeten 169 SAP-Kandidaten teilweise oder ganz mit Hilfe von Geldmitteln der malaysischen Regierung gesponsert. Meiner Meinung nach sollte die Bereitstellung von genügend Mitteln aus den Industrieländern gefördert werden. Bei diesem Kongress war dies nicht der Fall, mit Ausnahme der Geldmittel, die vom SPDC und einigen Ländern wie den Vereinigten Staaten von Amerika, dem Grossbritannien, Schweden und Finnland bereitgestellt wurden. Das neue Direktorium und das nächste Gastgeberland sollten ernstlich über dieses Thema nachdenken.

Ich muss zugeben, dass es ein grosses Vergnügen und eine reiche Erfahrung für uns war, diesen Kongress zu organisieren, und ich hoffe sehr, dass dieser Kongress nicht nur Ihrer wissenschaftlichen Karriere zugute kommen wird, sondern auch eine sinnvolle und zufriedenstellende Erfahrung ist. Trotz der grossen Anstrengungen, einen perfekten Kongress zu erreichen, gab es immer noch hie und da Schwachstellen und Pannen. Dafür hoffe ich auf Ihre Nachsicht. Die Zeit ist nun gekommen, um die Fahne an den Gastgeber des nächsten 22. IUFRO Weltkongresses zu übergeben.

Wie Ihnen wohl aufgefallen ist, waren viele Organisationen, Institutionen und Sponsoren an der Organisation dieses Kongresses beteiligt. Ihnen allen möchte ich meinen tiefsten Dank und meine Wertschätzung für Ihre freundliche Unterstützung, Zusammenarbeit und Hilfe aussprechen, ohne die wir diese schwierige Aufgabe nicht hätten bewältigen können. Im besonderen möchte ich dem Malaysischen Beirat für Forschung und Entwicklung sowie FRIM, und hier im speziellen ihrem Vorsitzenden und Generaldirektor für die Unterstützung und Ermutigung während der Planungs- und Durchführungsphase dieses Kongresses aussprechen. An alle Mitglieder des Direktoriums und des IUFRO-Sekretariats in Wien geht mein herzlichster Dank für Ihre Beratung und Hilfe bei der Aufgabe, diesen Kongress erfolgreich zu gestalten. Und nicht zuletzt danke ich als Vorsitzender des COC allen COC-Mitgliedern, den Subkomitees und Komitees und Kongresshelfern. Sie sind die Motoren, die unglaubliche Arbeit hinter der Bühne leisteten, um dem Kongress zum Erfolg zu verhelfen. Ich bitte Sie alle um einen grossen Applaus……..

Ich wünsche allen Freunden aus Übersee eine angenehme und sichere Heimreise.

Bon Voyage und vielen Dank.

Ansprache des designierten IUFRO-Präsidenten

Dr. Risto Seppälä

Vereehrte Mitglieder des Internationalen Rates und des Direktoriums von IUFRO,
sehr geehrte Gäste, Kollegen,
Meine Damen und Herren.

Es ist mir eine grosse Ehre, die Wahl zum IUFRO Präsidenten durch den Internationalen Rat annehmen zu können. Ich verspreche, dass ich mein bestes tun werde, um die hohen Erwartungen, die mit dieser Position verbunden sind, voll zu erfüllen.

Bei seiner Antrittsrede vor fünf Jahren sagte der amtierende Präsident, dass er drei Wünsche für IUFRO hätte: nämlich einen Präsidenten aus den Tropen, einen Weltkongress in einem Entwicklungsland und eine Frau als IUFRO-Präsident. Zwei dieser Wünsche haben sich erfüllt, aber wenn Jeff Burley als seinen Nachfolger eine Frau als Präsident wollte, so bin ich wohl nicht die richtige Person, obwohl auch ich gerne eine Frau als meine Nachfolgerin sehen würde und dieses Ziel mit aller Kraft anstreben werde.

Bei einer Antrittsrede ist es üblich, dass der gewählte Präsident seine Visionen über die zukünftige Struktur und Aktivitäten der Organisation vorstellt. Da der amtierende Präsident bei dieser Gelegenheit bereits eine umfassende Liste mit zukünftigen Herausforderungen präsentierte, werde ich nur zwei Punkte herausheben, die ich für besonders wichtig erachte. Es sind dies die IUFRO Mitgliedschaft und die Rolle IUFROs als Informationszentrale für forstliche Forschung und Fachwissen.

IUFRO umfasst nunmehr 680 Mitgliedsorganisationen, die das Fundament des Verbandes darstellen. In den vergangenen Jahren gewannen wir zwar viele neue Mitglieder dazu, aber zur gleichen Zeit können oder wollen viele unserer früheren Mitglieder nicht mehr für ihre Mitgliedsbeiträge aufkommen. Wenn wir eine Mitgliedsorganisation verlieren, so verlieren wir auch die dazugehörigen Wissenschaftler, da es für einzelne Wissenschaftler mühsam und teuer ist, IUFRO Mitglied bei IUFRO zu werden.

Es mag wohl an der Zeit sein, das Gesamtkonzept der IUFRO-Mitgliedschaft zu überdenken. Zunächst einmal müssen wir uns fragen, wozu wir Mitglieder haben wollen. Geld ist ein einleuchtender Grund. Obwohl IUFRO eine Organisation von Freiwilligen ist, können wir nicht ohne Mitgliedsbeiträge überleben. Wenn sich der Verband jedoch aus externen Quellen finanzieren kann, brauchen wir dann immer noch Mitglieder, um unsere Aufgabe als Förderer der internationalen Zusammenarbeit in der forstlichen Forschung und auf verwandten Gebieten zu erfüllen? Die Anwort ist ja. Wir brauchen Mitglieder auch in diesem Fall, da Zusammenarbeit nicht möglich ist ohne jene, die zusammenarbeiten und unsere Mitgliedsorganisationen und ihre Mitarbeiter bilden das effizienteste Netzwerk internationaler Kooperation in der forstlichen Forschung.

Laut einer kürzlich veröffentlichten Studie des Europäischen Forstinstitutes (EFI) gibt es allein in Westeuropa mehr als tausend Institutionen, die mit forstlicher Forschung und verwandten Gebieten befasst sind. Davon sind 176 IUFRO Mitglieder. Ich glaube, dass in anderen Teilen der Welt die Situation ähnlich ist. So ist das Potential für den Beitritt neuer Organisationen grösser als wir uns vorstellen können. Es liegt nun an uns, zu überlegen, wie wir dieses Potential nutzen sollen. In der im Wandel begriffenen Welt von heute gibt es viele Spieler, mit denen IUFRO noch keine Partnerschaften eingegangen ist.

Wir brauchen engere Beziehungen auch zu den einzelnen Wissenschaftlern. Die Tatsache, dass IUFRO ein Verband von Organisationen ist, ist keine Garantie dafür, dass alle Wissenschaftler, die in unseren Mitgliedsorganisationen beschäftigt sind, über IUFRO Bescheid wissen oder Informationen über IUFRO bekommen. Für Wissenschaftler, die in Nicht-Mitgliedsorganisationen arbeiten, gibt es praktisch keine Kommunikation mit IUFRO. Nun hat sich die Situation offenbar beträchtlich geändert, da viele Besucher unserer Internetseiten und eine grosse Anzahl Teilnehmer an diesem Kongress nicht von einer Mitgliedsorganisation kommen. Mir scheint, dass dies wiederum ein Zeichen für ein enormes Potential ist, da es zeigt, wie attraktiv IUFRO und seine Kongresse sind. Eine wichtige Voraussetzung für die steigende Zahl von Einzelmitgliedern ist, dass wir ihnen den Beitritt zum Verband erleichtern, im speziellen jenen, die nicht aus der Forstwirtschaft kommen.

Bis jetzt hat IUFRO das Wissen und die Expertise seines Netzwerkes nur marginal genutzt. Wir haben extern finanzierte Sonderprojekte und –programme wie das SPDC oder Silvavoc, aber wir müssen das gesamte Informations- und Wissenspotential unserer Wissenschaftler und Experten mobilisieren, das einzigartig und derzeit noch nicht ausgeschöpft ist. Erste Schritte in diese Richtung sind die Berichte über den Stand der Wissenschaft, die in dieser Woche präsentiert werden und der Weltweite Forstliche Informationsdienst, dessen Prototyp hier auf diesem Kongress vorgestellt wurde.

Sehr geehrte Damen und Herren,

Meine eigene Vision ist, dass IUFRO eine Zentrale für forstliche Information und Expertise werden soll. Unsere Funktionäre nehmen Schlüsselstellungen in diesem Prozess ein, aber sie stellen nur einen Bruchteil des Potentials an Menschen dar. Wir müssen einen direkten Kontakt zu allen Personen aufnehmen, die in den Forschungsgruppen tätig sind oder Beziehungen mit ihnen haben. Erst wenn wir relevante Informationen über ihr Fachgebiet haben, sind wir in der Lage, als Vermittlungsmechanismus zu fungieren und auf die Anfragen von Interessenten zu antworten, die z.B. den Stand der Wissenschaft in einem speziellen Gebiet forstlicher Forschung wissen wollen, oder wenn ein internationales Team zusammengestellt werden soll, um Lösungsmöglichkeiten für ein aktuelles Problem der forstlichen Forschung zu finden.

Die Rolle IUFROs als Zentrale für forstliche Information und Expertise wird den Bekanntheitsgrad IUFROs noch erhöhen. Es würde IUFRO auch für Sponsoren und Interessenten attraktiv machen, indem es einen Schneeballeffekt hervorruft, der auch zu einer Ressourcenvermehrung IUFROs führen würde.

Liebe Freunde,

Als neuer Präsident sehe ich eine meiner wichtigsten Aufgaben darin, als IUFRO Botschafter zu agieren, der unsere Organisation und ihre Leistungen auf dem Markt anbietet und verkauft. Die internationale forstliche Gemeinschaft braucht unser Fachwissen und ist auch bereit, dafür zu bezahlen. Wir brauchen eine gute Marketingstrategie, um neue Mitglieder zu gewinnen. Zusätzlich zu unserem Bemühen, unseren jetzigen Mitgliederstand zu halten, müssen wir neue Mitglieder werben, im speziellen jene, die nicht dem Forstsektor angehören. Ein ausgedehnter und qualifizierter Mitgliederstock ist eine wichtige Voraussetzung, um unsere Dienstleistungen an jene zu verkaufen, die sie brauchen und die dafür bezahlen können.

Obwohl ich nun meine Ansichten über eine mögliche Zukunft für IUFRO dargelegt habe, möchte ich doch noch eine Minute in der Vergangenheit verweilen. In meiner Eigenschaft als amtierender Vizepräsident für Programme möchte ich die Gelegenheit wahrnehmen, um allen IUFRO Funktionären für die wertvolle Arbeit, die sie seit dem Tampere Kongress geleistet haben, zu danken. Mein besonderer Dank geht an das Wissenschaftliche Kongress-Komitee und das IUFRO-Sekretariat für ihren enormen Einsatz bei der Vorbereitung des wissenschaftlichen Programmes des Kongresses. Und schliesslich möchte ich den malaysischen Gastgebern herzlich danken. Gerade weil ich mit dem vorherigen Kongress befasst war, weiss ich genau, wieviel Arbeit notwendig ist, um eine solche Veranstaltung zu realisieren. Ich möchte Ihnen hiermit zu diesem äusserst erfolgreichen Kongress gratulieren. Saya ucapkan setinggi-tinggi tahniah kepada tuan rumah Malaysia di atas kejayaan kongres ini.

Wir Finnen sind bekannt als wortkarge Menschen – auch wenn wir etwas zu sagen haben. Wir ziehen es vor zu handeln, obwohl auch Reden wichtig sind, um den Weg in eine Richtung vorzuzeigen. Ich werde hier Schluss machen, aber Sie werden noch von mir hören, vielleicht nicht sosehr durch meine Reden, sondern hoffentlich durch meine Taten. Was ich auch für IUFRO tue, möchte ich zusammen mit Ihnen allen tun.

Ansprache von

Prof. Russell Haines

Queensland Forestry Research Institute
Organisator des nächsten IUFRO Weltkongresses 2005

Die Bevölkerung Australiens mit seiner vierzigjährigen Geschichte der Nutzung von Wäldern und ihrer forstlichen Ressourcen freut sich, alle Forstwissenschaftler zum XXII IUFRO Weltkongress in Brisbane im Jahre 2005 willkommen zu heissen.

Australien hat eine grosse Vielfalt anWäldarten, von der gemässigten über die tropische zur ariden Zone und rasch wachsende Plantagenbestände. Bei der Bewirtschaftung dieser Wälder begegnen wir ähnlichen Herausforderungen wie jenen, mit denen auch Forstmanager weltweit befasst sind und die bei diesem Kongress schwerpunktmässig hervorgehoben wurden.

Die australische Bundesregierung und die Regierungen der einzelnen Staaten haben sich voll und ganz der nachhaltigen Nutzung der Waldressourcen zugunsten der jetzt lebenden und der zukünftigen Generationen verschrieben und anerkennen, dass diese Nutzung auf einer fundierten wissenschaflichen Grundlage geschehen muss. Wir haben uns verpflichtet, in internationalen forstlichen Foren mitzuarbeiten und uns an der internationalen wissenschaftlichen Zusammenarbeit zu beteiligen. Wir unterstützen insbesondere auch den Internationalen Verband Forstlicher Forschungsanstalten. Mit einigem Stolz möchte ich erwähnen, dass mein guter Freund und Kollege, Dr. Garth Nikles, der kürzlich nach 50 Jahren Wirken für die Forstwissenschaft in den Ruhestand trat, zusammen mit Professor Jeffrey Burley 1971 die erste Arbeitsgruppe im Bereich der Tropen initiierte.

Ich glaube, dass wir in einer für Forstwissenschaftler spannenden Zeit leben. Niemals zuvor haben sich Beteiligte aus so unterschiedlichen Bereichen so leidenschaftlich für die Bewirtschaftung und Nutzung der Wälder und Waldressourcen interessiert. Niemals zuvor hatte internationale Zusammenarbeit einen derart hohen Stellenwert unter den Forstwissenschaftlern.

Wir hoffen, dass wir im Jahre 2005 den Delegierten die australische Gastfreundschaft nahebringen können, und im besonderen möchten wir die Gastfreundschaft, die wir hier in Malaysia erfahren haben, erwidern.

Die australischen Delegierten haben die ausgezeichnete Vorbereitung des 21st IUFRO Weltkongresses in Malaysia sehr genossen. Wir sehen nun, dass unsere malaysischen Kollegen die Latte hoch gelegt haben und die Erfahrungen in Malaysia werden uns bei der Organisation des Kongresses in Brisbane im Jahr 2005 gute Dienste leisten.

Wir freuen uns schon darauf, zusammen mit der internationalen IUFRO Gemeinschaft den 22. IUFRO Weltkongress zu organisieren, und die IUFRO Flagge für die nächsten 5 Jahre voranzutragen. Und ganz besonders freuen wir uns darauf, Sie alle in Brisbane im Jahr 2005 begrüssen zu dürfen.

Schlussrede, Samstag, 12. August 2000,

Professor Jeffrey Burley
IUFRO Präsident

Exzellenzen, verehrte Gäste,
Liebe IUFRO Mitglieder,
Kollegen und Freunde,
Meine Damen und Herren,

Wir kommen nun zur Schluss-Sitzung des XXI IUFRO Weltkongresses in Kuala Lumpur, Malaysia. Obwohl die meisten Teilnehmer wohl froh sein werden, nach Hause zu fahren, so weiss ich doch, dass bei vielen auch bisschen Wehmut dabei ist, ein so schönes Land mit so netten Leuten zurückzulassen umso mehr als auch das zu Ende gehende Programm voller interessanter Vorträge, Postersessions, Diskussionen, Ausstellungen und Exkursionen war. Sie werden auch bedauern, dass Sie ihre alten und neu gewonnenen Freunde zurücklassen müssen, aber ich hoffe, dass die beruflichen und persönlichen Kontakte nach der alten IUFRO-Tradition der wissenschaftlichen und persönlichen Zusammenarbeit fortgeführt werden.

Die Organisatoren jedes Kongresses sind immer etwas besorgt darüber, dass ihr Kongress nicht mit dem letzten, sowohl was die Qualität als auch, was die Quantität betrifft, mithalten könne. Ich war jedoch immer der Meinung, dass es hierbei nicht darum geht, mitzuhalten, sondern einfach anders zu sein. Nach dem Montreal-Kongress 1990 dachten die finnischen Organisatoren, dass der Tampere-Kongress 1995 nicht dem vorherigen das Wasser würde reichen können. Nach Tampere dachten die malaysischen Organisatoren, dass dieser Kongress 2000 nicht so erfolgreich werden könne wie der vorherige. Ich glaube jedoch, dass es ihnen gelungen ist, dieses Ziel zu erreichen. Die Vorbereitungen sowohl auf administrativem als auch auf politischem und technischem Gebiet waren ausgezeichnet, und das Hilfspersonal aussergewöhnlich freundlich.

Bei meinen Rundgängen am Kongressort in dieser Woche habe ich viele Teilnehmer nach ihren Eindrücken oder ihrer Kritik gefragt. Wir werden nun sehen, ob sich diese Meinungen mit dem Fragebogen decken, den wir ausgesandt haben. Ich glaube jedoch, dass dem so ist. Doch wird das Direktorium immer an Ihrer Meinung interessiert sein, auch nachdem Sie bereits zu Hause sind und Zeit hatten, das Gesehene und Gehörte nachwirken zu lassen.

Es ist wohl nicht möglich, jedem von Ihnen einzeln und jeder Organisation dafür zu danken, dass sie zum Erfolg dieses Kongresses beigetragen haben. Aus diesem Grund möchte ich kollektiv in Ihrem Namen der Regierung von Malaysia danken, dem Direktorium der IUFRO, dem Kongress-Steuerungskomitee unter der Leitung von Dr. Razak, dem Kongress-Organisationskomitee unter der Leitung von Dr. Rahim Nik, dem Wissenschaftlichen Kongress-Komitee unter der Leitung von Dr. Teissier du Cros, dem IUFRO-Sekretariat unter der Führung von Heinrich Schmutzenhofer , den zahlreichen Mitarbeitern von FRIM, den nationalen und staatlichen Forstabteilungen, den Universitäten, die uns in vielen Bereichen unterstützt haben, den Photographen, der Presse, für Ihre verantwortungsbewusste Berichterstattung, den Dolmetschern, ohne die man die Hauptredner wahrscheinlich nicht so gut verstanden hätte; dem Zeremonienmeister ohne den die Eröffnungs- und Schluss-Sitzungen wahrscheinlich nicht so effizient und vergnüglich abgelaufen wären, und nicht zuletzt Ihnen, den Teilnehmern selbst. Wie dies so oft der Fall ist im Leben, bekommt man das zurück, was man investiert, und ich weiss, dass sich die meisten Teilnehmer voll und ganz mit den Aktivitäten des Kongresses identifiziert haben und deshalb auch sowohl persönlich als auch beruflich davon profitieren konnten.

Ich persönlich möchte allen für die Unterstützung in den letzten fünf Jahren danken, allen voran meiner Frau Jean und dem IUFRO-Sekretär, Heinrich Schmutzenhofer. Ohne sie wäre ich nie in der Lage gewesen, das Amt des Präsidenten zu bekleiden. Glücklicherweise muss ich nur einen von ihnen nach Hause mitnehmen. Für den anderen habe ich ein kleines Geschenk, einen Oxford-Wecker, der immer auf 18.00 abends eingestellt ist, sodass er weiss, wann er nach Hause zu seiner Frau Edith gehen soll.

Ich wünsche Ihnen allen eine gute Heimreise, möge Gott mit Ihnen sein. Der XXI IUFRO Weltkongress ist hiermit offiziell beendet.

Discursos en las ceremonias de inauguración y de clausura

Discurso de bienvenida pronunciado por el
Presidente del Comité Directivo de Congreso,

Dato' Dr. Abdul Razak Mohd. Ali

YB Dato' Seri Dr Lim Keng Yaik, Ministro de Industrias Primarias,
Profesor Jeff Burley, Presidente de IUFRO,
Distinguidos huéspedes, señoras y señores:

Es un verdadero honor para mí dar la bienvenida a todos Uds. al XXI Congreso Mundial de IUFRO en nombre del Comité Directivo del Congreso. Quisiéramos expresar nuestra gratitud particular al Honorable Sr. Ministro de Industrias Primarias de Malasia por haber consentido en participar e inaugurar oficialmente este Congreso en nombre del Honorable Sr. Primer Ministro que no puede estar con nosotros esta mañana. Me gustaría decir a todos los delegados y especialmente a los que vienen de lejos 'Selamat Datang ke Malaysia' o 'Bienvenidos a Malasia'.

Durante la reunión del Comité Ejecutivo de IUFRO en Madrid en abril 1995, Malasia sometió su oferta para ser el anfitrión del XXI Congreso en Kuala Lumpur. Recuerdo todavía muy vivamente el momento de triunfo de hace más de cinco años cuando me encargaron con la tarea de encabezar la delegación de Malasia para presentar nuestra oferta junto con las ofertas de Sudáfrica, China e Indonesia.

Malasia se enorgullece mucho de ser el primer país en desarrollo que es anfitrión de un Congreso Mundial de IUFRO. El congreso es, sin duda, la reunión forestal mayor en toda la historia del país. En cuanto a los números de participantes y personas acompañantes registrados y en cuanto a los discursos y pósters que se presentarán, excede la XIV Conferencia Forestal de la Mancomunidad celebrada en Kuala Lumpur en septiembre de 1993.

Estamos agradecidos al Gobierno de Malasia y al Consejo Internacional de IUFRO por haber tenido la confianza de encargar el Instituto de Investigación Forestal de Malasia (FRIM) con esta responsabilidad enorme de organizar el Congreso de IUFRO. Quisiéramos dar las gracias a la Secretaría de IUFRO en Viena y al Comité de Investigación y Desarrollo Forestales de Malasia (MFRDB) por su apoyo y consejo inestimables. El Comité Organizador de Congreso (COC) y sus sub-comités han trabajado duramente para asegurar que el progreso en todos los aspectos de organización sea controlado exactamente.

Señoras y señores:

Celebramos anunciar que tenemos 1906 participantes registrados en total y más de 209 personas acompañantes de 96 países. En los días siguientes se presentarán 5 discursos keynote, 99 ponencias subplenarias, 500 ponencias y 833 pósters en las sesiones plenarias y subplenarias, sesiones de grupos, de pósters y discusiones paneles de pósters. Quisiéramos que las presentaciones de pósters dieran la oportunidad a los científicos de intercambiar sus ideas y experiencias con sus pares sobre temas de interés común.

A través del Programa de Asistencia Científica (SAP) podemos dar apoyo financiero a 138 científicos de 38 países en desarrollo para que pueden asistir al Congreso. Además, el gobierno de Malasia nos ha generosamente dado los fondos para que otros 31 científicos más de Asia y la región del Pacífico puedan participar.

Estamos agradecidos al Honorable Sr. Ministro de Industrias Primarias de Malasia que va a dirigirse a nosotros e inaugurar el Congreso en nombre del Primer Ministro. Otros momentos culminantes en el curso de esta ceremonia inaugural serán la presentación del sello conmemorativo del XXI Congreso Mundial de IUFRO, el show cultural y la presentación de los premios y distinciones de IUFRO. Quisiéramos también dar las gracias a los conferenciantes que presentarán los discursos keynote durante las sesiones plenarias.

Señoras y señores:

Espero sinceramente que este Congreso sirva de foro útil para los científicos de todo el mundo para discutir el papel de la investigación en relación con los bosques y la sociedad. Tradicionalmente, los bosques han sido considerados como fuente de madera. La investigación ha de veras desempeñado un papel importante en cambiar esta percepción y actitud acerca de los bosques que ofrecen una gran cantidad de bienes y servicios indispensables para el bienestar de la sociedad.

Por favor, aprovechen toda oportunidad durante este Congreso para discutir cuestiones y necesidades de investigación y forjar colaboraciones beneficiosas para la investigación y el desarrollo. Las reuniones pre-Congreso, satélite y administrativas en el programa sirven precisamente a este fin.

Como todo queda dicho y hecho, les ruego perdonar cualquier deficiencia de organización en nombre del Comité Directivo del Congreso y del Comité Organizador del

Congreso. Finalmente, espero que encuentren el tiempo durante las excursiones en medio del Congreso y después del Congreso para visitar el país fascinante de Malasia con su riqueza y diversidad biológica y cultural.

Gracias.

Discurso pronunciado por el
Presidente de IUFRO

Profesor Jeffery Burley

Ministro Honorable de Industrias Primarias,
Dato' Seri Dr. Lim Keng Yaik,
Sr. Ministro Adjunto Honorable,
Sr. Secretario General,
Dato' Dr. Abdul Razak,
Presidente del Comité Directivo del Congreso,
Dr. Hosny El-Lakany,
Director General Adjunto del Departamento Forestal de la FAO;
distinguidos huéspedes;
señoras y señores:

Es un gran honor y placer para mí darles la bienvenida a este XXI Congreso Mundial de la Unión Internacional de Organizaciones de Investigación Forestal (IUFRO, como es el acrónimo bien conocido). Excelencia, lo sentimos mucho no tener el honor de la presencia del Primer Ministro, pero entendemos que no pudo participar por asuntos de Gobierno.

No obstante, me complazco en darle las gracias a Ud. por el gran honor de pronunciar el discurso inaugural que seguramente será un discurso de bienvenida y exhortación para nosotros. El tema de nuestro Congreso es "Bosque y Sociedad: el Papel de la Investigación"; este tema es muy oportuno al entrar en el nuevo milenio caracterizado por el crecimiento demográfico, la demanda creciente por los productos de los bosques, y una conciencia cada vez mayor de los muchos otros beneficios medioambientales y sociales que los bosques pueden prestar. Este tema es de relevancia especial aquí en Malasia, un país de gran riqueza y variedad en recursos forestales y sus servicios asociados y un país de una tradición de investigación forestal reconocida en todo el mundo. Sr. Ministro, nosotros nos conocemos personalmente desde hace muchos años y sé que Ud. siempre ha sido un pensador y hablador activo e importante en el campo forestal y en la industria forestal, sobre todo en lo que se refiere a Malasia y el Sudeste de Asia. Estamos esperando su presentación con mucho interés.

Durante los últimos cinco años he tenido el privilegio continuo de ser el Presidente de IUFRO, y me gustaría familiarizar a Uds. y a nuestros huéspedes en pocos minutos con la historia y las actividades de la Unión. Además, trataré de demostrar por qué esto debe ser de interés para un político superior y por qué los investigadores y los políticos deberían entrar en diálogos aun más estrechos.

IUFRO fue establecida en 1892 por un número pequeño de países europeos. Durante los primeros 80 años de su existencia, IUFRO creció hasta incluir la mayoría de los países de la zona templada. Sólo fue en el año 1971 que establecemos el primer Grupo de Trabajo que se dedicara exclusivamente a un tema tropical (genética forestal y mejora de árboles). Desde entonces, IUFRO se ha esforzado activamente por hacer llegar los beneficios de su colaboración internacional a instituciones y científicos en países en vías de desarrollo, incluyendo apoyo para APAFRI, FORNESSA y una Red para América Latina y el Caribe, e involucrarlos activamente en todos los niveles de su gestión. Actualmente, la Unión abarca casi 700 Organizaciones Miembros en 110 países con aproximadamente 15'000 científicos que cooperan voluntariamente en 276 Divisiones, Grupos de Investigación y Grupos de Trabajo. IUFRO es una institución internacional, no gubernamental, sin fines de lucro y multi-disciplinaria que trata seriamente de obtener el máximo valor de las inversiones de gobiernos, industrias y personas privadas en la investigación.

Me gustaría subrayar que el trabajo de IUFRO es básicamente voluntario, es decir que prácticamente todos los oficiales de la Unión y los científicos cooperantes trabajan con gran dedicación para el éxito de IUFRO porque creen en el valor añadido por esta colaboración. Solamente los miembros de la Secretaría, apoyada generosamente por el Gobierno de Austria, pueden ser considerados como "funcionarios" permanentes de la Unión. Además, los coordinadores contratados para el Programa Especial para Países en Desarrollo (SPDC) son pagados con el apoyo igualmente generoso de Canadá, Dinamarca y EEUU. La Unión Europea y los gobiernos de Japón, de Suiza y del Reino Unido han prestado también un apoyo financiero considerable a IUFRO. IUFRO mantiene relaciones estrechas con otras organizaciones, especialmente con el Consejo Internacional por la Ciencia, el Centro de Investigación Forestal Internacional, la Organización de Alimentación y Agricultura de las Naciones Unidas, y el Centro Internacional de Investigación Agroforestal; es un privilegio adicional para nosotros que el representante del Director General de FAO tomará la palabra en esta sesión inaugural.

Durante este siglo, la Unión ha estimulado y apoyado la investigación excelente en una gama amplia de temas científicos. Sin embargo, la investigación no vale nada cuando pasa independientemente; debe ser considerada como parte integral de un proceso continuo desde la ciencia pura y aplicada a la adaptación y aplicación amplia de nuevos sistemas tecnológicos y sociales que se dirigen a las cuestiones de la política internacional y nacional. A este fin, IUFRO ha establecido Grupos Especiales de Intervención para animar la integración de tal investigación y fomentar el mejor entendimiento entre investigadores y políticos. En este Congreso en Malasia que se celebra en el primer año del nuevo milenio, los científicos de IUFRO producirán informes sobre el estado actual de los conocimientos en muchos temas importantes para indicar la información que existe en este momento, las cuestiones de gestión que implica esta investigación y cualquier demanda por nuevas investigaciones.

En la década pasada hubo un aumento rápido en la conciencia política y pública de la importancia de los bosques y árboles para el bienestar humano. Los bosques y árboles suministran un número enorme de productos y servicios sociales, medioambientales y económicos para un gran grupo de interesados. Además de los libros y revistas forestales profesionales, muchos países tienen una cantidad de publicaciones en diarios y revistas, programas de televisión y radio sobre temas forestales. Hay una interdependencia estrecha y a menudo hasta una competencia entre la variedad de productos y servicios exigidos por los bosques; la investigación abarca muchas disciplinas que no son cohesivas por naturaleza. IUFRO se esfuerza fuertemente por estimular la colaboración interdisciplinaria entre los científicos biofísicos y sociales.

El número 2000 es un hermoso número redondo por lo menos según el sistema matemático decimal. También es altamente importante en ciertos calendarios religiosos. Sin embargo, es de suma importancia para todos los vivos y billones que están por nacer, porque es el año en que las agencias internacionales, los gobiernos nacionales, las organizaciones civiles de la sociedad, los educadores, investigadores y gerentes de negocios y recursos deben realizar la necesidad urgente de manejar los recursos del mundo de manera sabia, equilibrada, ética y sostenida. Los bosques y árboles jugarán un papel mayor en el desarrollo sostenible, e IUFRO va a continuar a hacer lo posible para animar la investigación y los investigadores a dirigirse a cuestiones relevantes y presentar sus resultados en una forma que los políticos y todos los interesados puedan comprender y aplicar. El Comité Ejecutivo de IUFRO está seguro que este Congreso va a contribuir mucho a la promoción de estos objetivos.

Excelencia: todos los participantes del XXI Congreso IUFRO están muy agradecidos al Gobierno de Malasia y la Ciudad de Kuala Lumpur por ser nuestros anfitriones y ofrecer su hospitalidad tan amable y generosa, y por organizar excursiones tan interesantes y agradables en su país tan hermoso para los científicos y sus acompañantes. Me gustaría dar las gracias también a todos los empleados del Instituto de Investigación Forestal, los Departamentos Forestales Federales y Estatales, y varias Universidades y otras instituciones que han trabajado intensamente para asistir IUFRO con la organización de este acontecimiento de cada cinco años. Mientras temo que la investigación en Malasia haya sufrido un poco de esto en los últimos años, me preocupo aun más ahora que desaparezca completamente si todos estos empleados trabajarán como organizadores profesionales de conferencias y excursiones de ahí en adelante.

Excelencia: tengo el placer de dirigirme respetuosamente a Ud. para que inaugure este XXI Congreso IUFRO y nos presente sus puntos de vista sobre el papel y la necesidad de la investigación forestal. Además, me gustaría preguntarle más tarde el honor de presentar el premio supremo de IUFRO, la distinción de Miembro Honorario, a dos líderes destacados de nuestra Unión.

Discurso pronunciado por
el Primer Ministro

YAB Dato' Seri Dr Mahathir bin Mohamad

Presentado por

Dato' Seri Dr. Lim Keng Yaik,

Ministro de Industrias Primarias de Malasia

Profesor Jeffery Burley, Presidente de IUFRO,
Datuk Haron Siraj, Secretario General del Ministerio de Industrias Primarias de Malasia,
Dato' Dr. Abd. Razak Mohd Ali, Presidente del Comité Directivo del Congreso,

Distinguidos Huéspedes, Señoras y Señores:

En primer lugar me gustaría dar las gracias a los organizadores de este congreso forestal importante por invitarme y darme la oportunidad de inaugurar oficialmente el XXI Congreso Mundial de la Unión Internacional de Organizaciones de Investigación Forestal (IUFRO). También quisiera dar una bienvenida muy cordial a todos nuestros huéspedes y participantes y desear a todos una reunión muy productiva y una estancia muy agradable en Malasia.

Entiendo que IUFRO es una organización no gubernamental y sin fines de lucro que fue establecida hace más de cien años en el 1892, y que tiene como misión la promoción de la cooperación internacional en la investigación forestal y las ciencias relacionadas. Entiendo también que, aunque IUFRO tiene alrededor de 700 Organizaciones Miembros en 105 países, ésta es la primera vez que se celebra el Congreso en un país en desarrollo. Por lo tanto debería felicitar a los organizadores por el éxito que ha tenido la oferta de Malasia para ser anfitrión de este Congreso Mundial y por las preparaciones necesarias que nos permiten reunirnos ahora en el mayor evento forestal que ha tenido lugar en nuestro país. Espero que de ahí en adelante más Congresos Mundiales de IUFRO se celebren en países en desarrollo.

Como sabemos todos, los bosques juegan un papel importante para la vida de los ciudadanos de muchos países en desarrollo y contribuyen al progreso económico de estos países. Por lo tanto es un gran placer para mí que Malasia haya abierto el paso para los países en desarrollo para presentar sus ofertas como anfitriones de tales congresos, porque los asuntos forestales son importantes para muchos ciudadanos débiles y pobres en todo el mundo. En este sentido me gustaría felicitar IUFRO por el tema muy oportuno para este Congreso que une la sociedad con los bosques mediante la investigación.

Señoras y señores:

Sería echar agua en el mar si yo les hablara sobre el papel y las funciones del bosque. Uds. son los expertos en este tema. Uds. conocen muy bien el hecho de que en el pasado los bosques fueron vistos separados de la gente que vivió en ellos o en sus lindes y que los bosques sólo fueron considerados por la madera que suministraron. En los últimos años, sin embargo, se ha notado una tendencia mundial hacia el reconocimiento de que los bosques y las sociedades, tanto rural como urbana, representan dos caras de la misma moneda y que, además de la madera, los bosques suministran una cantidad de bienes y servicios importantes para el bienestar de la sociedad.

¿Cuáles son, pues, las lecciones que hemos aprendido del pasado no tan lejos, lecciones forestales que han causado este cambio de vista y han preparado el terreno para el debate actual internacional sobre bosques? Sabemos que al comienzo de la revolución industrial a principios del siglo XXI se cortaron aun más vastas áreas de bosques de la zona templada en Europa después de haber reducido los bosques en los siglos anteriores para obtener la madera necesaria para el proceso de industrialización. En el mismo siglo IXX, se perdieron también grandes superficies de bosques al otro lado del Océano Atlántico, en América. En pocas décadas, millones de hectáreas de bosques fueron destruidos para obtener pastos, cultivar tierras, y tener madera y leña.

En el mundo occidental, la revolución industrial produjo efectos muy negativos para el medio ambiente. Se aceleraron la contaminación del aire y del agua así como también la degradación del suelo. El crecimiento económico rápido después de la Segunda Guerra Mundial en los países desarrollados de hoy dio impulso a una degradación medioambiental ulterior. La Conferencia de las Naciones Unidas sobre el Medio Ambiente Humano en 1972 en Estocolmo vino y fue, pero la degradación medioambiental continuó incesantemente. El aumento mundial de la temperatura, la reducción de la capa de ozono, la contaminación de los mares, la lluvia ácida, la deforestación y la degradación de la tierra – en la mayoría de los casos a consecuencia de las actividades industriales – llegaron a convertirse en grandes preocupaciones a principios de los años ochenta.

En este contexto, la Declaración de Langkawi sobre el Medio Ambiente de la reunión de los Jefes de Gobierno de la Mancomunidad (CHOGM) en Kuala Lumpur en octubre de 1989, plantó la semilla para un concepto que vino formándose en las reuniones mundiales que siguieron. El concepto de “hacer el mundo verde” fue adoptado como principio de la Declaración de París en el X Congreso Forestal Mundial en 1991. Luego, en la Conferencia de las Naciones Unidas sobre el Medio Ambiente y el Desarrollo (UNCED) en Río de Janeiro en junio de 1992, la Declaración de Principios sobre Bosques fue aceptada por todos los gobiernos y captó este concepto completamente.

Poco antes de la Cumbre de Río, fue Malasia que sugirió que la superficie cubierta de bosques sea aumentada del 27,6% al 30% hasta el año 2000 mediante programas vigorosos de forestación y reforestación en todo el mundo. Hemos pensado en aumentar la superficie de todos los tipos de bosques – boreales, templados y tropicales - porque no hay discriminación en la manera de cómo los diferentes tipos de bosques secuestran carbono, estabilizan el clima, protegen el medio ambiente, conservan la biodiversidad biológica, producen recursos industriales y forman la base de subsistencia para la vida de las comunidades en o cerca de los bosques. También tuvimos la idea de que los países desarrollados que tienen una pequeña superficie de bosques a consecuencia de una destrucción forestal desconsiderada, pero que tienen economías fuertes, vastos recursos y los conocimientos técnicos ahora deberían encabezar el esfuerzo de hacer el mundo más verde. Además, nos hemos imaginado, tal vez por ingenuidad, que estos países económicamente fuertes reunirían sus recursos amplios para ayudar activamente a implementar los programas de forestación y reforestación en los países más pobres del mundo.

Sin embargo, después de haber pasado ocho años desde Río, todo sigue igual. Todo el entusiasmo antes de Río y en Río mismo ha prácticamente desaparecido de la noche a la mañana. No existe ningún concepto ni siquiera embrionaria para hacer el mundo más verde. Cada nación queda prácticamente aislada para implementar sus programas forestales. Según mi información, el costo medio total por año que se necesita para implementar los programas forestales bajo la Agenda 21 de UNCED fue estimado a US$32 billones, y una parte mayor de esto debe haber venido de los países desarrollados. A pesar del hecho de que la Agenda 21 y los Principios Forestales suministraron un marco para fortalecer la cooperación entre los países, queda claro ahora que la mayoría de los fondos necesarios para los programas forestales debería ser generado por los países en desarrollo mismos.

Malasia ha siempre sido y sigue siendo proactivo en las cuestiones mundiales que conciernen los bosques y el medio ambiente. Hemos participado activamente en las negociaciones que llevaron a la Conferencia UNCED, abarcando la Agenda 21, la Declaración de Principios sobre Bosques, la Convención sobre la Diversidad Biológica y la Convención de Marco sobre el Cambio Climático; hemos continuado a participar activamente en los desarrollos desde Río. Nos aferramos mucho al concepto de hacer el mundo más verde. Aunque durante nuestro período de ocupación colonial, bosques fueron cortados para establecer plantaciones, el 58% de nuestra tierra está todavía cubierta de bosques. Cuando incluimos las plantaciones de árboles de caucho y palmas oleíferas, el 72% de nuestra tierra está cubierta de bosques. Nos hemos comprometido y seguimos comprometiéndonos a que la cobertura forestal nunca caiga bajo un nivel mínimo del 50% de toda nuestra tierra y que este compromiso será nuestra contribución para los ciudadanos del mundo.

En este respecto nos hemos esforzado también por reforzar nuestras prácticas forestales lo que queda en línea con el concepto del manejo forestal sustentable. Por ejemplo, hemos expandido la superficie de la propiedad forestal estatal permanente de 12,7 millones de hectáreas a 14,1 millones de hectáreas; hemos revisado la Política Forestal Nacional en 1992 y enmendado la Ley Forestal Nacional en 1993 para fortalecer sus estipulaciones e introducir penas más rígidas para ofensas forestales. Estamos potenciando nuestros esfuerzos en la investigación y el desarrollo en todos los campos forestales relevantes, incluyendo esfuerzos para desarrollar industrias de base forestal que trabajarían de manera sustentable. En el macro nivel, la Política Nacional sobre la Diversidad Biológica que fue aprobada en 1998 va a dar la dirección para la conservación de la diversidad biológica y la utilización sustentable de sus componentes.

A nivel internacional hemos continuado a hacer contribuciones a los procesos del Panel Intergubernamental sobre Bosques (IPF) y el Foro Intergubernamental sobre Bosques (IFF). Participamos también activamente en la fase actual de implementar la Convención sobre Diversidad Biológica y la Convención sobre el Cambio Climático, ambos siendo de relevancia directa para los asuntos forestales.

Reconocemos que el sector forestal es importante tanto para la economía y la sociedad de una nación como para el medio ambiente nacional y mundial. Consiguientemente, la creación de un instrumento legal para los bosques se ha convertido en un tema dominante tanto a nivel doméstico como internacional. Estamos demasiado conscientes de los argumentos que no permitieron largas debates sobre tal instrumento; pues, la cuestión de legislación para bosques está todavía por resolver. Todavía no nos hemos acercado a ningún instrumento legal.

Malasia representa la posición de que una legislación obligatoria para todo tipo de bosque sería una necesidad para dirigirse a una gama amplia de asuntos relacionados con el sector forestal y la madera en una manera holística, integral y comprensiva. Creemos que un instrumento legal facilitara lograr el manejo sustentable para todos los bosques mientras que la situación actual internacional de decisiones “ad hoc” sin legislación obligatoria puede ser un obstáculo para las mejores prácticas forestales. Creemos también que tal legislación posibilitaría tomar acciones a nivel internacional para dirigirse a los factores que están detrás de la reducción y degradación de bosques en áreas transnacionales, como, por ejemplo, la deuda internacional y los modelos de consumo no sustentable. Tal instrumento estimularía y aceleraría también la cooperación en la transferencia de tecnología.

En la actualidad, la falta de consenso frente a la necesidad de una legislación obligatoria se debe al empate en los asuntos cruciales como las finanzas, la transferencia de tecnología y el comercio. En este respecto me gustaría invitar a los países desarrollados a reafirmar y poner en acción sus compromisos para dar ayuda financiera concreta y suministrar tecnologías a los países en desarrollo para que logren el manejo sustentable de sus bosques. Además, el manejo forestal sustentable debería ser fomentado por negocios de apoyo mutuo y por estándares medioambientales para el acceso al mercado. De otra forma, los bosques perderían su valor y serían taladas por otros fines. Restricciones comerciales y medioambientales no van a reducir la deforestación. Es más bien el acceso mejorado al mercado que va a ayudar a fomentar el manejo forestal sustentable suministrando los ingresos tan necesarios para este fin.

La dependencia de la sociedad de los bosques existe desde los tiempos inmemoriales cuando la sociedad fue primitiva y sus necesidades fueron sencillas. En muchos lugares del mundo, sobre todo en los países en desarrollo, las necesidades de la sociedad son todavía sencillas. En otras partes, las demandas han crecido con el desarrollo de las sociedades, y formas de vida no sustentables han contribuido mucho a las necesidades mayores y muchas veces insaciables de las sociedades crecientes. Pero las necesidades no sólo son materiales, y por lo tanto vale el lema de que “los recursos forestales y las tierras forestales deberían ser manejados de una manera sustentable para cumplir con las necesidades sociales, ecológicas, económicas, culturales y espirituales de la humanidad a favor de las presentes y futuras generaciones.”

Es un honor para mi encontrarme con Uds. aquí y dirigirme a este Congreso de científicos que se han dedicado a la investigación forestal de manera que contribuyen directa o indirectamente a las necesidades de la sociedad en el presente y en el futuro. La historia reciente ha demostrado que la inversión en la investigación y el desarrollo en cualquier campo puede dar altas ganancias. Deseo sinceramente que sus esfuerzos den un buen rendimiento que mejoraría el destino de la sociedad en general y de sus partes más pobres y débiles en particular. Uds. son representantes tanto del mundo desarrollado como del mundo en desarrollo e IUFRO les vincula por este tipo de relación entre el Norte y el Sur.

En este respecto espero que sus esfuerzos ayuden a elaborar una agenda forestal más justa en la arena internacional y que las tecnologías que Uds. desarrollarán en su trabajo sean compartidas de forma más justa y más generosa con los países en desarrollo para mejorar las prácticas forestales en todo el mundo. Si el mundo debe llegar a manejar los bosques de manera sustentable, la transferencia de tecnología del Norte al Sur debe efectuarse bajo condiciones de preferencia como fue acordado en Río. Desgraciadamente, esto no es el caso por el momento, y por lo tanto los países en desarrollo que no tienen acceso a estas tecnologías no serán capaces de cumplir con sus compromisos en el ámbito del manejo forestal sustentable de lo que no se beneficiará nadie. IUFRO puede, pues, jugar un papel importante para facilitar esta transferencia de tecnología. Espero que este Congreso ayude a fomentar no sólo el intercambio de experiencias sino también a desarrollar redes más concretas que servirán de canales para el transporte de la tecnología del Norte al Sur. Por eso les deseo todo lo mejor para sus esfuerzos y espero que tengan un congreso productivo.

Finalmente me gustaría expresar otra vez mis mejores deseos a todos los delegados del congreso. Espero que encuentren el tiempo en las excursiones post-congreso para conocer no sólo la biodiversidad de nuestros bosques forestales sino también da diversidad de razas, culturas y religiones de nuestro país. En Malasia Uds. verán Asia.

Ahora tengo el gran honor de inaugurar el XXI Congreso Mundial de IUFRO.

Discurso del Director General Adjunto,
Departamento de Montes, FAO

Prof. M. Hosny El-Lakany

Distinguidos huéspedes,
Sr. Presidente y Miembros del Comité Ejecutivo de IUFRO,
Señoras y señores:

En nombre del Director General y de los demás empleados de la Organización de Alimentación y Agricultura de las Naciones Unidas, y particularmente en nombre de mis colegas del Departamento de Montes, me gustaría saludar cordialmente a todos los participantes de este XXI Congreso Mundial IUFRO. Es un gran privilegio y un gran honor para mí poder estar aquí en Kuala Lumpur con Uds. hoy.

Ante todo quisiera felicitar a los organizadores del Congreso y sobre todo a los anfitriones de Malasia por las preparaciones magníficas. Naturalmente, Malasia con su tradición larga y fuerte de una ciencia forestal que contribuye al desarrollo del país es el lugar perfecto para celebrar este evento impresionante.

Al mirar a los participantes en esta sala y al ver este público tan eminente y diverso, siento fuertemente el valor fundamental de la organización de IUFRO. IUFRO ofrece a los científicos e investigadores forestales los medios para compartir experiencia y conocimientos tanto para el avance del manejo forestal sostenible como para su desarrollo individual. Es una oportunidad sin igual para científicos jóvenes que están al principio de su carrera poder intercambiar ideas con y beneficiar de los miembros más eruditos de la comunidad forestal internacional. Además, la posibilidad de tener acceso a resultados de investigación de todo el mundo es de valor inconmensurable. ¿Cuántos de nosotros pueden confirmar que esta oportunidad ha sido una ocasión propicia para ellos?

En mi caso es ciertamente así. Tengo memorias muy vivas de mi primera participación en un Congreso IUFRO en 1976 en Oslo y de mi encuentro directo con muchos científicos forestales, algunos de los cuales están con nosotros hoy, afortunadamente. Además, una parte de mi tesis doctoral se basó en una colección de semillas hecha bajo los auspicies de IUFRO – la Colección de Procedencia de Abeto Grande en 1966.

Por lo tanto es un gran honor para mi representar la FAO en esta reunión importante – el primer Congreso Mundial de IUFRO del nuevo milenio. IUFRO tiene una relación especial con sus miembros, y la relación con FAO es también extraordinaria. A nivel de institución, FAO e IUFRO han mantenido una relación cooperativa y simbiótica desde la fundación de FAO cuando IUFRO, por supuesto, fue la "hermana mayor" con más de medio siglo de edad. IUFRO entrelace a científicos e investigadores, y FAO entrelace IUFRO con el campo, es decir que asegura que los resultados valiosos sean puestas en práctica y que el "pulso" del campo sea transmitido a los investigadores.

En FAO, todos los oficiales forestales tenemos contacto directo y permanente con IUFRO y sus Grupos de Investigación y Trabajo. A través de su Programa de Socios, FAO facilita también visitas de académicos, investigadores y sobre todo de profesionales jóvenes que probablemente no tuvieran otra oportunidad de compartir experiencia y pericia de cara a cara. Además, la FAO en su función de foro neutral, ayuda a países a identificar conjuntamente las áreas que requieren más investigación y concentrar de esta manera los esfuerzos de los científicos forestales en todo el mundo. En este respecto es siempre un gran placer para mí cuando se encuentran científicos e investigadores forestales en las sesiones bianuales del Comité de FAO. De esta manera, la información y el conocimiento pueden fluir en una red de múltiples canales entre FAO e IUFRO en beneficio de todos nuestros componentes.

Desde el punto de vista de la FAO, el tema de este Congreso "Bosque y sociedad: el papel de la investigación" es especialmente apropiado. En su trabajo forestal, la FAO se compromete completamente a aumentar al máximo los beneficios sociales, ambientales y económicos del manejo forestal sostenible. De hecho, este compromiso consta explícitamente en la Visión Estratégica Forestal de la FAO que ha sido desarrollado en cooperación con los Estados Miembros de FAO, instituciones asociadas y organizaciones, entre ellas IUFRO, en un período de más de dos años, y aprobado por el Comité Forestal de FAO en marzo de 1999. El Plan Estratégico Forestal de la FAO describe la misión, las metas, los objetivos a medio plazo, las actividades prioritarias actuales y la visión para el sector forestal de la organización. He aquí la misión: "Aumentar el bienestar de los seres humanos mediante el apoyo a los Estados Miembros en la ordenación sostenible de los árboles y bosques del mundo." La gente y la sociedad vienen primero.

Nuestras actividades prioritarias enfocan también los bosques y la sociedad. Nuestros esfuerzos en el campo de las actividades forestales participativas y comunitarias se centran en involucrar a un grupo más amplio de la sociedad más directamente en el proceso del manejo forestal y de la toma de decisiones. Debería añadir que esto afecta no sólo a las personas que viven actualmente dentro o cerca de los bosques sino también a los que dependen de los recursos y productos forestales. Otra prioridad de la FAO que es de relevancia directa para el tema de los bosques y la sociedad es nuestro apoyo para los países en seguir un programa forestal nacional. Estos programas son reconocidos por procesos intergubernamentales emergidos de UNCED y aspiran a establecer un marco social y político funcional para la conservación, el manejo y el desarrollo sostenible de todos los tipos de bosques.

Una tercera prioridad para la FAO es fortalecer el acceso a información forestal fidedigna y oportuna en todo el mundo. El primer artículo de la Constitución de la FAO nos da el mandato para "coleccionar, analizar, interpretar y diseminar información.". En el sector forestal, esto abarca el desarrollo de términos y definiciones comunes y la armonización de definiciones, la colección de estadísticas sobre producción, consumo, y negocios, y nuestra evaluación de los recursos forestales del mundo. En todos estos aspectos estamos colaborando estrechamente con IUFRO. Por lo tanto es muy oportuno que hayamos decidido publicar los primeros resultados de la Evaluación de los Recursos Forestales Mundiales 2000 de la FAO aquí en este Congreso. Me gustaría mencionar también nuestro sitio Web forestal importante y la colaboración entre FAO e IUFRO en el desarrollo de un Servicio Mundial de Información Forestal.

Otro área importante y duradera de la cooperación entre FAO e IUFRO es el Programa Especial para Países en Desarrollo, el SPDC. Hace un mes, el 7 de julio para ser preciso, se estableció oficialmente la Red de Investigación Forestal para la África Sub-sahariana (FORNESSA), y se eligió al Dr. Konuche de Kenia como primer presidente. En este contexto me complazco en notar que el Coordinador Adjunto del SPDC tiene su oficina en la Oficina Regional de la FAO para África, lo que asegura aun más la continuación de las relaciones estrechas entre FAO e IUFRO.

En este Congreso, miembros de FAO presentarán varias ponencias, y muchas sesiones han sido organizadas conjuntamente con FAO.

Espero que los ejemplos que les he dado hagan manifiesto que FAO se ha comprometido a largo plazo a aumentar las relaciones positivas entre los bosques y la sociedad a un máximo. Y el tema de este Congreso sugiere fuertemente que IUFRO y sus miembros hayan tomado el mismo rumbo.

¿Cuál es, pues, el papel de la investigación en avanzar en este camino como lo percibe la FAO? Por supuesto, necesitamos enfocar más los aspectos sociales del desarrollo de un manejo forestal sostenible. Debemos saber más sobre la manera en que la gente puede acercarse al manejo forestal y como lo hace, y es de importancia especial conocer las herramientas y desarrollos científicos que la gente necesita para cumplir con esta responsabilidad más eficazmente.

Necesitamos más investigación sobre la mejor manera de suministrar la información a la gente que la necesita para poder participar mejor en la toma de decisiones forestales. También hace falta una investigación especial sobre el manejo de conflictos.

Sobre todo necesitamos investigación sobre el potencial y las modalidades de la cooperación internacional en el sector forestal. En los últimos diez años hemos visto una cantidad de acuerdos internacionales de relevancia directa para el futuro del sector forestal en el mundo, pero los que tienen la responsabilidad de ponerlos en un marco e implementarlos se encuentran verdaderamente en nuevos territorios. Debemos estudiar, analizar y aprender de las experiencias de otros sectores que han tomado este camino antes de nosotros para que los acuerdos que forjamos sean prácticos de alcance y nobles de intención.

Estas son tareas exigentes, de veras, y serán aun más exigentes dado el hecho de que deben complementar en vez de sustituir la investigación en otras áreas forestales más tradicionales. Sin embargo, creo que son tareas esenciales si debemos lograr nuestra meta común del uso sostenible de los ecosistemas forestales. Y no veo ninguna otra organización que esté más capaz y lista para asumir este desafío que IUFRO.

Finalmente, señoras y señores, quisiera dar mis gracias personales al Comité Ejecutivo saliente y, particularmente, al Presidente Profesor Jeff Burley, que es un muy buen colega y amigo mío, por su dirección fuerte y competente. Les ruego permiso también para expresar mi plena confianza en el nuevo Comité y el nuevo Presidente, el Profesor Risto Seppälä, y saludar cordialmente a los Presidentes anteriores, especialmente al Dr. Salleh Mohd Nor.

Sr. Presidente, en nombre del Director General de FAO, Jacques Diouf, en mi propio nombre, y especialmente en nombre del Programa Forestal de la FAO, me gustaría expresar mis sinceros deseos que este Congreso tenga éxito y sea un comienzo apropiado del nuevo milenio para el sector forestal del mundo.

Gracias.

Discurso de análisis de cinco años de Presidencia
Sesión de Clausura

Profesor Jeffery Burley

Presidente de IUFRO

Distinguidos huéspedes, colegas, señoras y señores:
Al llegar a la clausura de este Congreso impresionante y productivo, escucharán breves discursos de mí como Presidente actual y de Risto Seppälä, el Presidente electo. Me gustaría hacer un resumen de las actividades y del progreso de IUFRO en los cinco años de mi Presidencia, mientras el Profesor Seppälä trazará su visión de los desarrollos futuros en la investigación forestal y en IUFRO.

Las resoluciones y los desafíos de 1995

En nuestro XX Congreso en 1995 se aceptaron las siguientes resoluciones: -a) mantener y fomentar la investigación aplicada a los bosques y a los productos forestales con objetivos bien definidos; b) potenciar la capacidad de investigación, sobre todo en países en desarrollo; c) ampliar la colaboración para fomentar la eficacia de la investigación y mejorar la comunicación entre las comunidades científicas y la sociedad; y d) fomentar la investigación orientada hacia problemas y políticas concretas en las ciencias económicas y sociales. Cuando fui elegido Presidente, presenté mi vista personal del papel de IUFRO y de su desarrollo y actividades al Comité Ejecutivo, y ahora me gustaría hacer un resumen para Uds. con el fin de mostrar cómo IUFRO ha respondido a los desafíos que expresé y a las resoluciones de Congreso.

Destaqué el hecho de que en la última década del último milenio hubo cambios significantes en la política forestal, la práctica forestal y la profesión forestal. Los asuntos forestales se convirtieron en asuntos mundiales e internacionales y tuvieron una base política más amplia formada por personas e instituciones que no eran forestales tradicionales. Las ciencias socioeconómicas hicieron cada vez mayor contribuciones a los procesos de decisión. Hubo una presión mundial exigiendo que se evalúe el papel de los bosques a la luz de todos sus beneficios y monitorear su estado. Los políticos buscaron siempre (a) información sobre el papel, el valor y el estado de los bosques y árboles en relación a la conservación y el desarrollo, (b) opiniones sobre los vínculos entre bosques, biodiversidad, clima y otros asuntos medioambientales, y (c) consejos sobre el manejo sustentable de los bosques incluyendo cuestiones institucionales.

Pensé (y sigo pensando) que IUFRO debería tratar de responder a estos cambios manteniendo al mismo tiempo su papel primordial como red de sus científicos voluntarios afiliados. Debería continuar a ser la fuente principal de conocimientos y experiencia sobre la investigación forestal en temas especializados y aumentar simultáneamente la intensidad y la frecuencia de su cooperación interdisciplinaria dentro de la Unión misma y con organizaciones y disciplinas fuera del grupo de sus miembros tradicionales.

Estos vínculos contribuyeron también a hacer el trabajo de IUFRO más público, asegurar su relevancia a las necesidades modernas, identificar fuentes de fondos para la investigación y buscar colaboración productiva reduciendo toda duplicación innecesaria. Fue de importancia vital que el Comité Ejecutivo reconociera los asuntes emergentes muy temprano, lo que le resultó más fácil gracias a los contactos fuertes con un número de otras instituciones. IUFRO ha intentado a apoyar a los Directores de las Organizaciones Miembro directamente por realizar y publicar ciencia relevante para la política y asistir a los Directores con sus argumentos en favor del bosque y la investigación forestal ante los gobiernos y agencias.

El nuevo papel internacional de IUFRO

El Comité Ejecutivo de IUFRO se ha esforzado extremamente por hacer publicidad para la existencia, las actividades y la importancia de la Unión. El folleto IUFRO fue recibido con gran éxito cuando fue presentado en el Congreso Forestal Mundial en Turquía en 1997. Igualmente, el sitio Web de IUFRO con sus páginas para cada unidad de investigación copiado en servidores espejos en muchos países y relacionado con muchas instituciones más tiene muy buena reputación. Muchas de las páginas Web reservan espacio para informes sobre el estado de los conocimientos en la disciplina correspondiente a la unidad de investigación; como Ud. se habrá dado cuenta en el curso de este Congreso, se ha prestado mucha atención a la divulgación de los resultados de investigación y los informes sobre el estado de conocimientos.

Hemos tratado también a asegurar un papel para IUFRO en los debates y desarrollos internacionales. Yo u otras personas que desempeñan cargos dentro de IUFRO asistieron a reuniones tales como: el Panel Intergubernamental sobre Bosques (IPF); el Foro Intergubernamental sobre Bosques (IFF); el Foro Forestal del Mundo; el Congreso Forestal Mundial; el Comité Forestal de la Organización para Alimentación y Agricultura de las Naciones Unidas (COFO/FAO); la Asamblea General de IUCN; varias reuniones de iniciativas internacionales para desarrollar criterios e indicadores para el manejo forestal sustentable; el Comité de Síndicos del Centro de Investigación Forestal Internacional (CIFOR); el Centro Internacional para la

Investigación Agroforestal (ICRAF); la Semana de Centros del Grupo Consultativo para Investigación Agricultural (CGIAR); la Exposición Nacional en Kunming, China; y varias reuniones y exposiciones de otras organizaciones. Estuvimos especialmente encantados con que las recomendaciones de la IV sesión del IFF abogaron por mejores vínculos entre los procesos de ciencia y política forestales, por financiamiento de la investigación (sobre todo en los países en desarrollo), por mejorar el acceso a información sobre bosques y colaboración con IUFRO en el GFIS (Servicio Mundial de Información Forestal).

El Proyecto Especial de IUFRO sobre Terminología (SilvaVoc), coordinado por Renate Prüller y apoyado por Japón, entró en contrato con FAO para suministrar definiciones de términos importantes usados en los debates internacionales sobre el manejo forestal sustentable. Me encantó ver que mi propio Instituto pudo representar IUFRO en la preparación de un documento sobre asuntos de política forestal aptos para ser investigados. Aquel documento fue financiado por la Overseas Development Adminstration (ahora el Departamento para Desarrollo Internacional) del Gobierno Británico para la Comisión Mundial sobre Bosques y Desarrollo Sostenible.

La Unión ha también estimulado las unidades de investigación a dedicarse a temas específicos relacionados con las nuevas cuestiones internacionales. El papel que IUFRO desempeñó en la organización y publicidad de la Consulta Internacional sobre Sistemas de Investigación e Información Forestales (ICRIS), patrocinada por los Gobiernos de Austria e Indonesia en cooperación con CIFOR y el Departamento Forestal de FAO, fue una contribución destacada a los procesos internacionales. Aquella conferencia fue una actividad internacional en apoyo del Foro Intergubernamental sobre Bosques (IFF) de la Comisión de las Naciones Unidas sobre el Desarrollo Sostenible (UNCSD) y tuvo lugar en Austria en el mes de septiembre de 1998: sus repercusiones mayores para IUFRO mismo fueron el establecimiento de los Grupos Especiales de Intervención sobre el Servicio Mundial de Información Forestal (GFIS) y sobre la Interface entre Ciencia y Política Forestales.

La estructura y las actividades avanzadas de IUFRO

El papel principal de IUFRO sigue siendo el avance del valor de la investigación a través de su red de casi 700 Organizaciones Miembros y 15’000 científicos en sus especialidades correspondientes; las 268 unidades de investigación y 8 Grupos Especiales de Intervención tuvieron 335 reuniones en 65 países, 41 de ellos países en desarrollo o con economías emergentes. Se crearon dos Divisiones nuevas al principio del período del Comité Ejecutivo para reconocer la gran amplitud de actividades de investigación y reducir la carga de trabajo de ciertos Coordinadores y Coordinadores Adjuntos de División (que son, como todos los que desempeñan cargos dentro de IUFRO, voluntarios). El Comité Ejecutivo estableció un número de Programas Especiales, Proyectos, Grupos especiales de intervención y comités ad hoc para dirigirse a temas o asuntos especiales y les estimuló a ponerse metas significantes específicas incluyendo más énfasis sobre la creación de capacidades. En un discurso corto es prácticamente imposible dar los detalles o hasta resúmenes adecuados para todas estas iniciativas, pero me gustaría escoger algunos puntos culminantes.

Como he indicado antes, uno de los cambios mayores de la última década ha sido el aumento de la necesidad de enfocar asuntos y temas capaces de ser investigados desde un punto de vista interdisciplinario y con el objetivo de solucionar problemas. IUFRO ha siempre tenido un amplio rango de unidades de investigación biofísicas y socio-económicas. En los últimos cinco años hemos tratado de animar la interacción entre aquellas unidades a través de reuniones interdivisionales, colaboración con otras organizaciones, y el trabajo de los Grupos Especiales de Intervención. Todos tenemos que reconocer las dificultades implícitas de aprender a entender el uno la disciplina del otro y de recibir reconocimiento académico o profesional para tal trabajo multi-disciplinario, pero existe claramente una obvia necesidad.

Las Divisiones

Hubo una mayor conferencia interdivisional sobre ecosistemas forestales y el uso de tierras en zonas montañosas en Seoul, Korea, en el 1998. Esta conferencia fue organizada por las Divisiones 1, 4, 6 y 8 y atrajo a 350 participantes de 24 países. Dentro de la División 1, el Grupo de Investigación 1.17.00 (Restauración de sitios degradados) fue involucrado estrechamente en el programa de investigación internacional patrocinada conjuntamente por el Servicio Forestal del USDA, el Banco Mundial, CIFOR, y la British Overseas Development Administration, que examinaron el papel y las implicaciones de plantaciones para acelerar la recuperación natural del bosque en tierras tropicales degradadas.

La División 2 organizó una gran conferencia sobre genética forestal en Beijing en 1998, y su Grupo de Trabajo 2.04.06 organizó una reunión sobre modificación genética en Oxford en 1999, demostrando cómo IUFRO se ocupa continuamente de asuntos actuales de importancia pública y política y cómo da consejos. Los participantes de estas reuniones reconocieron que la mejora genética clásica sigue careciendo esfuerzos mayores de financiamiento mientras debe usar nuevas tecnologías para aumentar la eficiencia; actualmente, los organismos modificados genéticamente deben ser considerados como herramientas de laboratorio y no deben ser difundidas hasta que el público les acepte desde el punto de vista de la ética.

La División 3 celebró algunas reuniones divisionales e interdivisionales: con la División 1 en Bolivia en 1997, con la División 6 en Japón, 1997, en Canadá 1998 y Australia 2000; con la División 8 en Japón en 1998; y con el Grupo Especial de Intervención sobre Manejo Sustentable Forestal en Australia en 1998. También se celebraron varias reuniones con organizaciones externas como CIFOR y FAO, por ejemplo. Algunos Grupos de Investigación elaboraron informes sobre el estado de conocimientos.

La División 5 se dedicó intensamente a comprender el cambio de recursos forestales extendiendo los recursos e implementando tecnologías que estén en armonía con el medio ambiente y la sociedad. La conferencia de toda la División en 1997 se centró en los productos forestales a favor de un manejo forestal sustentable y tuvo 222 delegados de 42 países.

La División 7 fue creada como respuesta a una resolución específica del Congreso en 1995 que impulsó la investigación sobre“…la extensión, productividad y estado sanitario de los bosques …”. En los últimos cinco años, la División ha celebrado importantes reuniones de investigación en Europa, Norteamérica y Asia sobre entomología, patología, contaminación atmosférica e interacciones entre huésped y plaga.

Grupos Especiales de Intervención

Un asunto clave en todo el mundo ha sido el desarrollo de criterios e indicadores para el manejo forestal sustentable. El Grupo Especial de Intervención sobre el Manejo Forestal Sustentable, coordinado por Alain Franc, colaboró con CATIE, CIFOR y FAO para organizar tres reuniones internacionales importantes en Australia (1998), Costa Rica (1999) y Francia (1999), en asociación con Ecofor y EFI; cada una de las reuniones atrajo entre 100 y 200 participantes y tendió un puente entre los científicos y otros grupos interesados en el bosque mientras clarificó las relaciones entre criterios, indicadores, sistemas de certificación y biodiversidad. Se prestó mucha atención al papel de las ciencias sociales.

El Grupo Especial de Intervención sobre el Cambio Medioambiental, coordinado por John Innes, desarrolló informes excepcionales sobre el estado de conocimientos basados en las contribuciones de muchos científicos. Dos de estos informes han sido publicados ya en la serie de investigación IUFRO Research Series, y el restó será terminado durante este año. El Grupo Especial de Intervención representó también los intereses de IUFRO en muchas reuniones promoviendo los vínculos entre la ciencia y la política. El Grupo especial de intervención tenía, en especial, la responsabilidad para una resolución de la Conferencia Ministerial sobre la Protección de los Bosques en Europa, conocida como “Helsinki 4”, que se ocupa de coordinar los esfuerzos para mitigar los efectos del cambio climático sobre los bosques europeos.

El Grupo Especial de Intervención sobre el papel del Bosque en el Desarrollo Sostenible de las Zonas Montañosas, coordinado por Martin Price, preparó su primer informe sobre el estado actual de conocimientos basado en las contribuciones de 124 autores de todas partes del mundo. Un punto crítico fue la definición de la extensión de los bosques en zonas montañosas en el mundo; los elementos más importantes del informe fueron un mapa con las montañas del mundo (según reglas objetivas) y un mapa de los bosques en zonas montañosas que forman el 28% del área total de bosques en el mundo.

El Grupo Especial de Intervención sobre Agua y Bosques, coordinado por Rob Vertessy, fue establecido para revisar el conocimiento científico actual y las hipótesis existentes sobre ecosistemas de agua potable en bosques y las implicaciones de la selvicultura y el manejo forestal para la cantidad y calidad de agua. El Grupo ha producido una publicación importante sobre este tema.

El Grupo Especial de Intervención sobre los Recursos en Internet, coordinado por Lauri Valsta, ha desarrollado un medio único e inestimable para la comunicación entre los científicos y la diseminación de información sobre IUFRO en todo el mundo.

El Grupo Especial de Intervención sobre el Servicio Mundial de Información Forestal, coordinado por Risto Paivinen, es un consorcio de organizaciones internacionales, regionales y nacionales que están desarrollando una estrategia e implementando un servicio de meta-datos basado en Internet para suministrar en todo el mundo el acceso coordinado a información relacionada con los bosques. Se han desarrollado ya los conceptos básicos para la colección y las soluciones técnicas incluyendo un prototipo en función y un proyecto financiado por la Comunidad Europea para África, el Caribe y el Pacífico.

El Grupo Especial de Intervención sobre Gestión y Conservación de Recursos Genéticos Forestales es coordinado por Veikko Koski. Su comité se compone de representantes de la mayoría de las Divisiones de IUFRO, de CIFOR, FAO e IPGRI. Colecciona información científica sobre interacciones entre todos los factores que afecten la distribución, integridad y conservación de recursos genéticos forestales y ha escrito un informe sobre el estado de conocimientos.

El Grupo Especial de Intervención sobre la Interface entre Ciencia y Política, coordinada por Rich Guldin, ayudó a realizar la conferencia de la División 6 en Sudáfrica sobre las contribuciones de la ciencia al desarrollo de políticas forestales y organizó dos eventos satélites en la tercera y la cuarta sesión del IFF. Tres conferencias planeadas para el año que viene van a unir unos 40-50 estudios de casos que demostrarán cómo la investigación ha tenido una buena influencia en la política forestal.

IUFRO en apoyo de países en desarrollo

El trabajo del Programa Especial para Países en Desarrollo (SPDC), coordinado por Bob Szaro hasta junio de este año, ha tratado consistentemente a ayudar con el desarrollo de los recursos humanos en los países en desarrollo y países con economías en transición. Además, IUFRO se ha esforzado mucho por apoyar a científicos de tales países para que puedan desempeñar cargos en la ciencia y la gestión de las unidades de investigación de IUFRO. El SPDC organizó talleres de trabajo sobre la gestión y planificación de la investigación, la redacción de solicitudes de subvenciones, y el desarrollo de propuestas, y sobre la planificación estratégica. El Programa dio apoyo a más de 200 científicos y 35 organizadores de reuniones en más de 60 países e inició y publicó los dos primeros tomos de una serie de libros de texto a bajo costo.

IUFRO está muy agradecida al Gobierno de los Estados Unidos de América por haber puesto a disposición a un Coordinador, al Gobierno del Canadá por haber mandado a un Coordinador Adjunto del SPDC, y al Gobierno de Dinamarca para hacer posible que haya un Coordinador Adjunto en África también. El Gobierno de Japón ha sido muy generoso en apoyar el programa BIOREFOR que ha estimulado la colaboración entre muchas instituciones en la región Asia-Pacífica para contribuir conocimientos sobre el uso de la biotecnología para la reforestación. Estamos también muy agradecidos a la Comisión Europea por su apoyo generoso para nuestro proyecto GFIS-África que quiere mejorar la forma de compartir información relacionada con los bosques en África. Otras agencias también dieron contribuciones generosas en forma de dinero o en especie a IUFRO: AusAid (Australia), Deutscher Verb. FVA (Alemania), la Embajada Real de Dinamarca, el Servicio Forestal de EEUU (USDA), los Gobiernos de China-Taipei y del Reino Unido.

Diseminación de los resultados de la investigación

La investigación no debe realizarse en un vacío sino es importante que se divulguen sus resultados ampliamente. IUFRO se ha esforzado valiosamente por hacer publicidad para el trabajo, los resultados, el valor y la relevancia de la investigación forestal en general y de IUFRO en particular. Además de las páginas Web mencionadas anteriormente y los 91 tomos de memorias publicadas por las unidades de investigación, hemos seguido expandiendo las series de IUFRO como IUFRO World Series y IUFRO Occasional Papers (publicadas por la Secretaría), y añadido la serie IUFRO Research Series (publicada por CAB International).

Revisión de la estructura y gestión de IUFRO

Durante sus cinco años de función, el Comité Ejecutivo actual ha revisado constantemente la estructura y las actividades de IUFRO y ha encargado también un grupo externo para revisar la Secretaría, el SPDC y el Proyecto Especial. Nos hemos esforzado fuertemente por atraer subvenciones, sobre todo para apoyar miembros de países en vías de desarrollo, pero también para establecer los propios proyectos de IUFRO como el Proyecto de Terminología Silvavoc. Hemos revisado la estrategia de inversiones de IUFRO, sobre todo en vista de las dificultades que tienen algunas Organizaciones Miembros con el pago de sus cuotas. Como una respuesta a la reducción del número de miembros últimamente, el Comité Ejecutivo y el Consejo Internacional han aprobado un ligero cambio del nombre de IUFRO en la versión inglesa de “Forestry” a “Forest”; esto reconoce la necesidad de abarcar una gama más amplia de disciplinas e instituciones que sacaran beneficios de IUFRO y contribuyeran a la Unión. Reconoce también la percepción de algunos miembros del público de que “forestry” sólo se refiere a la eliminación masiva de bosques naturales o el desarrollo igualmente amplio de plantaciones de especies exóticas; esto pasa en un tiempo en que IUFRO está haciendo mucho más para suministrar investigación y consejo sobre los beneficios sociales y medioambientales del bosque.

El Comité Ejecutivo ha invitado a las Organizaciones Miembros y científicos a sentirse más integrados en los procesos de política y planificación de IUFRO. Muchos contribuyeron al desarrollo del Plan Estratégico que ha guiado el trabajo del Comité Ejecutivo en los últimos cinco años. El Consejo Internacional también ha sido involucrado estrechamente en el desarrollo de la política de IUFRO, la revisión de los Estatutos de IUFRO y la elección de su futuro Comité Ejecutivo.

El Comité Ejecutivo ha estimulado una regionalización de la gestión y cooperación científica de IUFRO mediante el reconocimiento de Capítulos como la Asociación de Institutos de Investigación Forestal de la Asia Pacífica (APAFRI), la secretaría de la cual se encuentra actualmente en Malasia. Adicionalmente, IUFRO ha sido pro-activa en apoyar, junto con FAO, otras actividades regionales que quieren fomentar la cooperación entre instituciones nacionales, incluyendo el Programa de Apoyo de la Investigación Forestal en Asia y el Pacífico (FORSPA) y la Red de Investigación Forestal para la Africa Sub-sahariana (FORNESSA) en la que coopera también estrechamente la Academia Africana de Ciencias (AAS).

Desafíos del futuro

Señoras y señores, espero que se den cuenta después de haber escuchado mis palabras, que IUFRO, bajo el liderazgo del Comité Ejecutivo y con la asistencia valiosa de la Secretaría (con el apoyo generoso del Gobierno de Austria), ha florecido en los cinco años pasados y ha respondido con éxito a las resoluciones del Congreso anterior. El Comité Ejecutivo mismo ha contestado muy activamente a los desafíos con que yo lo confronté. Como Presidente saliente sería fácil para mí ofrecer al futuro Presidente y el Comité Ejecutivo los desafíos que tendrán que considerar. Entre ellos, yo destacaría los siguientes:

- Continuar con el desarrollo de estándares de métodos de investigación que pueden ser aceptados a nivel internacional.
- Fortalecer la red de miembros.
- Desarrollar GFIS, normalizar terminologías e informes sobre el estado de conocimientos.
- Forjar y reforzar los vínculos entre ciencia, política, gestión y uso de los bosques, productos forestales y servicios.
- dentificar y cumplir con las necesidades de investigación disciplinarias e interdisciplinarias.
- Aumentar el número de miembros.
- Reorganizar y reforzar el Comité y la Secretaría para asegurar una seguridad financiera, un apoyo mayor por parte de los miembros y mejores facilidades para la divulgación de información.

Discurso de bienvenida pronunciado por
el Presidente del Comité Organizador del Congreso,

Dr. Abdul Rahim Nik

Profesor Jeffery Burley, Presidente de IUFRO,
Tan Sri G.K. Rama Iyer, Presidente del Comité de Malasia para la Investigación y Desarrollo Forestales,
Dato' Dr. Abdul Razak Mohd Ali, Director General de FRIM,
Dr. Risto Seppälä, Presidente electo,
Distinguidos huéspedes y delegados,
Señoras y señores:

Celebro mucho que hayamos llegado a la clausura del XXI Congreso Mundial de IUFRO. Durante los 6 días pasados hubo una abundancia de actividades en este sitio de Congreso de las sesiones científicas, reuniones satélite y administrativas a las exposiciones, recepciones y excursiones. Como organizadores de este evento prestigioso, hicimos todo lo posible para cumplir con todas sus esperanzas y deseos para asegurar que su participación en las reuniones y su estancia durante la semana pasada fuesen muy agradables y cómodas para Uds.

Hace cinco años que fui nominado Presidente del Comité Organizador de Congreso (COC) y que fui encargado con la tarea monumental de organizar este Congreso. Entonces no tuve ni la mínima idea sobre el tamaño del desafío y de la responsabilidad que ha sido confiado a mí. Tres años más tarde empecemos realmente a acalorarnos y acelerar nuestra velocidad de organización. Finalmente, en los últimos seis meses antes del Congreso estuvimos completamente absortos en los desafíos reales. Tengo que admitir humildemente que hemos aprendido mucho organizando este Congreso. En este respecto, la tecnología moderna de la que disponemos hoy en día nos ha venido muy valiosa y nos ha ayudado mucho en la preparación. No puedo imaginarme organizar esta reunión sin facilidades como el correo electrónico y el fax.

Mientras el tema del Congreso de "Los Bosques y la Sociedad – El Papel de la Investigación" ha sido bien elaborado y discutido en muchas sesiones técnicas, nosotros los organizadores adoptamos un lema propio en el curso de las preparaciones del Congreso. El lema es "Nos comprometemos a asegurar un Congreso memorable y bien organizado". Uds. habrán visto este lema en todas nuestras estaciones de servicio. Este lema sencillo transporta dos mensajes importantes. Reconociendo que esta es la primera vez que un Congreso de este carácter sea celebrado en un país en desarrollo en los más de cien años de la historia de IUFRO, queríamos asegurar que este XXI Congreso Mundial de IUFRO celebrado aquí en Malasia dejaría una impresión fuerte y duradera y también recuerdos agradables en las memorias de los delegados que están presentes hoy. En segundo lugar, una reunión tan grande como ésta necesita un sistema bien organizado para impresionar a los participantes y compensar el valor de tiempo y dinero que han invertido para participar. Fijados en este lema hemos trabajado con todo entusiasmo y gran dedicación para rendir los servicios. Uds., estimados delegados, deben juzgar nuestro trabajo ahora.

Señoras y señores:

En esta sesión de clausura me gustaría compartir con Uds. algunos datos estadísticos importantes acerca de este Congreso y algunas de nuestras observaciones que pueden ser de interés para el anfitrión del próximo Congreso.

El número total de delegados registrados para el Congreso fue 1906 de 96 países, entre ellos 209 participantes registrados como personas acompañantes. Recibimos también un eco muy alentador para todos los programas de visitas y excursiones. En total, 1127 personas se registraron y participaron en los nueve programas de excursiones durante el Congreso el jueves, y más de 700 personas asistieron al programa para acompañantes. La visita de los luciérnagas tuvo el mayor éxito. Inmediatamente después del Congreso, 324 delegados en total van a participar en los próximos días en las 12 excursiones post-Congreso que les llevarán a casi todos los estados de Malasia así como también a países vecinos como Brunei, Indonesia y Tailandia.

En cuanto a las presentaciones científicas constatamos que la mayoría de las sesiones tuvieron lugar según el programa. En algunas sesiones hubo vacíos por conferenciantes que no podían asistir, pero los moderadores de las sesiones pudieron invitar a otras conferenciantes para llenar estos vacíos. Hubo, sin embargo, pocas sesiones que tenían que ser canceladas porque ninguno de los conferenciantes apareció para presentar sus investigaciones. Nos dimos cuenta de que la mayoría de los que no aparecieron fueron científicos de países en desarrollo que tenían problemas financieros. En cuanto a las presentaciones de pósters, sólo el 55% de los presentadores de los 833 pósters seleccionados estuvieron presentes. La mayoría de los presentadores de pósters que no llegaron fueron también de países en desarrollo y no tuvieron los fondos para asistir al Congreso. En lo que se refiere al personal técnico empleado en este Congreso, hubo 120 especialistas técnicos y casi 270 asistentes para asegurar que no hubiera inconvenientes.

Por si les interesa saber, hemos producido 6.6 millones de páginas de impresos, incluyendo los anuncios previos y el material de publicidad. No conozco exactamente cuántos árboles necesitamos para todo esto pero estoy convencido que ciertamente valió la pena.

Permítanme ahora que comparte con todos Uds. brevemente mi punto de vista sobre un tema que puede ser útil y que puede tomarse en consideración para lo organización del próximo Congreso. Si se quiere una participación más activa por parte de los países en desarrollo es necesario hacer mayores esfuerzos para asegurar los fondos suficientes para el SAP o Programa de Asistencia Científica. Para esta reunión, la participación de 91 de los 169 candidatos SAP fue financiada parcialmente o completamente por el Gobierno de Malasia. En mi opinión, es importante esforzarse más por asegurar fondos suficientes de países desarrollados, lo que no fue el caso en este Congreso, con algunas excepciones como fondos del SPDC y de países como los Estados Unidos de América, el Reino Unido, Suecia y Finlandia. El nuevo Comité de IUFRO y el próximo anfitrión de Congreso deberían reflexionar sobre esta situación.

Tengo que admitir que ha sido un gran placer y una excelente experiencia para nosotros haber organizado este Congreso. Espero sinceramente que este Congreso no sólo haya sido beneficioso para su carrera científica sino que ha sido también una experiencia valiosa y útil. A pesar de los grandes esfuerzos que hicimos para tenerlo todo perfecto, hubo algunas faltas y puntos débiles que les ruego disculpar, por favor. Ahora es tiempo ya para pasar la bandera a los próximos anfitriones del XXII Congreso Mundial de IUFRO.

Por fin, señoras y señores, se habrán dado cuenta de que muchas organizaciones, agencias y muchos patrocinadores han tomado parte en este Congreso. Tengo el gusto de expresar mi profunda gratitud y apreciación por todo su apoyo, cooperación y asistencia sin el cual no hubiéramos conseguido cumplir con nuestra tarea tan difícil. Particularmente, quisiera dar las gracias al Comité de Malasia para la Investigación y el Desarrollo Forestales y a FRIM, y sobre todo a su Presidente y Director General por su apoyo estimulante durante toda la planificación y realización de este Congreso. Gracias también a los miembros del Comité Ejecutivo y a la Secretaría de IUFRO en Viena por sus consejos y su dirección para asegurar el éxito de este Congreso. Los últimos, pero no por orden de importancia, a los que quisiera dar las gracias como Presidente del Comité Organizador de Congreso son los miembros del Comité y los Sub-comités y los asistentes de Congreso. Les invito a todos a darles fuertes aplausos conmigo.

A todos que tienen que viajar lejos para llegar a casa les deseo un buen y seguro viaje.

Bon Voyage y Gracias.

Discurso pronunciado por
el Presidente electo

Dr. Risto Seppälä

Presidente Burley,
Excelencias, Miembros del Consejo Internacional de IUFRO y del Comité Ejecutivo de IUFRO,
Distinguidos Huéspedes, Colegas Científicos,

Señoras y Señores,

Es un gran honor para mí aceptar la elección como Presidente de IUFRO por el Consejo Internacional. Les prometo que voy a hacer los mejores esfuerzos para cumplir con las grandes esperanzas vinculadas con esta posición.

En su discurso de aceptación hace cinco años, el Presidente actual dijo que siempre tenía tres ambiciones para IUFRO: que IUFRO tenga un Presidente de los trópicos; que se celebre un Congreso Mundial en un país en desarrollo, y que haya una mujer como Presidenta. Ahora hemos alcanzado las dos primeras metas, pero si Jeff Burley quería que una mujer le siga en la posición de Presidente, yo no soy la persona justa. Sin embargo, puedo seguir obrando en su sentido para alcanzar esta tercera meta.

Es por tradición que un discurso de aceptación contenga algunas de las visiones que el Presidente entrante tiene acerca de la estructura y las actividades de la organización en el futuro. Dado que nuestro Presidente actual les ha presentado ya en esta misma ocasión una larga lista de desafíos para el futuro, me gustaría escoger sólo dos asuntos que me parecen muy importantes: son la afiliación a IUFRO y el papel que juega IUFRO como “clearing house” o centro de información y pericia en la investigación forestal.

IUFRO tiene actualmente 680 Organizaciones Miembros que nos proveen con los fondos básicos. Aunque hemos acogido a nuevos miembros en los últimos años, demasiado de nuestros miembros antiguos ya no podían o querían pagar sus cuotas de miembro. Cuando perdemos una Organización Miembro, sin embargo, perdemos también a muchos científicos porque para personas individuales resulta más difícil y caro hacerse miembro de IUFRO.

Probablemente ya es tiempo para revisar todo el concepto de la afiliación a IUFRO. Primero debemos preguntar para qué necesitamos los miembros. Una razón obvia es el dinero. Aunque IUFRO es una organización voluntaria, no pudiéramos sobrevivir sin las cuotas de los miembros. Sin embargo, si recibiéramos dinero de otras fuentes que las cuotas, ¿necesitaríamos todavía los miembros para cumplir con nuestra misión de promover la cooperación internacional en la investigación forestal y las ciencias relacionadas? La respuesta es que sí. Necesitamos los miembros para eso también porque no hay cooperación sin cooperadores, y nuestras instituciones miembros y sus científicos forman la mejor red posible de cooperadores en la investigación forestal a nivel internacional.

Según una investigación realizada recientemente por el Instituto Forestal Europeo, solamente en la Europa Occidental hay más de mil instituciones que se ocupan de investigaciones relacionadas con los bosques. De este número, sólo 176 son miembros de IUFRO. Me imagino que en otras partes del mundo la situación será semejante. Por eso el potencial para reclutar nuevas organizaciones miembros es probablemente más grande que pensamos. Depende de nosotros cómo aprovechamos este potencial para aumentar el número de Organizaciones Miembros. Hay muchos actores que juegan papeles cada vez más importantes en este mundo en cambio y con los que IUFRO no ha todavía establecido relaciones.

También necesitamos establecer mejores vínculos con los científicos individuales. El hecho de que IUFRO es una organización de organizaciones no garantiza automáticamente que todos los científicos que trabajan en nuestras Organizaciones Miembros sepan de IUFRO y reciban información sobre la Unión. Para los científicos que trabajan en instituciones fuera de IUFRO, el flujo de información fue prácticamente nulo antes. Ahora, pues, la situación ha mejorado considerablemente porque la mayoría de los visitantes de nuestro sitio Web y un número considerable de los participantes de este Congreso no vienen de Organizaciones Miembros de IUFRO. Para mí, esto es también una indicación de un potencial enorme de miembros porque muestra el gran interés por IUFRO y su Congreso. Una condición previa muy importante para aumentar el número de miembros individuales será facilitar su afiliación a IUFRO, especialmente cuando no vienen de las disciplinas forestales.

Hasta ahora, IUFRO ha aprovechado muy modestamente los conocimientos y la pericia de su red de miembros. Tenemos algunos proyectos y programas especiales de financiación no reembolsable como, por ejemplo, el SPDC y SilvaVoc, pero lo que necesitamos hacer es movilizar la base entera de información y conocimiento de nuestros científicos y expertos que es un recurso único pero actualmente muy poco aprovechado. Los Informes sobre el Estado de los Conocimientos que fueron presentados en el curso de la semana de Congreso son un buen paso hacia esta dirección, y el Servicio Mundial de Información Forestal del que hemos visto un prototipo durante este Congreso es otro.

Señoras y Señores:

Mi propia visión de IUFRO es que se vuelva en “clearing house” o centro de información y pericia de la investigación forestal. Las personas que tienen cargos dentro de IUFRO son las personas claves en este proceso, pero representan solamente una pequeña fracción de nuestros recursos humanos. Tenemos que establecer vínculos directos con todos los individuos que actúan en nuestras unidades de investigación o son relacionados con ellas. Después de recibido información relevante en sus especialidades, podremos servir como “clearing house” y contestar a las solicitudes de nuestros clientes cuando, necesitan un informe sobre el estado de conocimientos en un cierto campo de la investigación forestal, por ejemplo, o cuando hace falta establecer un grupo internacional para solucionar un problema actual de investigación.

Si IUFRO recibe una buena reputación como “clearing house” de información y pericia forestales, nuestra visibilidad aumentará considerablemente. Esto atraería a donantes y clientes y produciría un efecto de bola de nieve que adelantaría también las finanzas de IUFRO.

Estimados amigos:

Como Presidente nuevo veo que una de mis tareas más importantes es servir como embajador de IUFRO que hace publicidad para nuestra organización y vende nuestros productos. La comunidad del sector forestal internacional necesita nuestra pericia y está dispuesta a pagar para nuestros servicios. También necesitamos el márketing para reforzar la afiliación a IUFRO. Además de animar a nuestros miembros actuales a quedarse con nosotros, tenemos que encontrar nuevos miembros, sobre todo en áreas fuera del sector forestal tradicional. Una base de miembros amplia y de alta calidad es también la condición previa para vender nuestros servicios a aquellos que los necesitan y pueden pagar para ellos.

Aunque he estado ahora en medio de presentar mi vista del camino que tenemos adelante, me gustaría dedicarme por un minuto al pasado. En mi capacidad de Vice Presidente actual de Programas, quisiera aprovechar esta oportunidad para decir las gracias a todos que desempeñan un cargo dentro de IUFRO por su trabajo valioso desde el Congreso de Tampere. Me gustaría dar mis gracias particulares al Comité Científico del Congreso y la Secretaría de IUFRO por sus contribuciones extraordinarias a la preparación del programa científico de este Congreso. Finalmente, quisiera expresar mi gratitud a nuestros anfitriones de Malasia. De mi experiencia personal con la organización del Congreso anterior sé exactamente cuánto trabajo Uds. han invertido para que este evento pueda tener lugar. Les felicito a Uds. por el gran éxito de este Congreso. Saya ucapkan setinggi-tinggi tahniah kepada tuan rumah Malaysia di atas kejayaan kongres ini.

Los finlandeses somos conocidos como gente de pocas palabras aun cuando tengamos algo que decir. Preferimos las acciones a las palabras sabiendo que los discursos también son importantes cuando se trata de mostrar la dirección para ir adelante. Me gustaría concluir mi discurso ahora pero Uds. oirán de mí tal vez no tanto a través de lo que digo sino, ojalá, a través de lo que hago. Todo lo que haga por IUFRO lo quisiera hacerlo junto con todos Uds.

Discurso pronunciado por
el anfitrión del Congreso IUFRO en 2005

Prof. Russell Haines
Queensland Forestry Research Institute

En vista de la historia de cuarenta mil años de utilización de bosques y recursos forestales en nuestro país, será un gran placer para nosotros los australianos dar la bienvenida a los investigadores forestales de todo el mundo en el XXII Congreso Mundial IUFRO en Brisbane en 2005.

Australia tiene una gran variedad de tipos de bosques tanto de la zona templada como tropical y árida y una superficie de plantaciones que está creciendo rápidamente . Los desafíos que se nos plantean en el manejo de estos bosques son semejantes a los de otras partes del mundo que se han puesto de relieve en este Congreso.

El gobierno federal y los gobiernos de los estados de Australia se han comprometido fuertemente al uso sabio de los recursos forestales en beneficio de las generaciones actuales y futuras reconociendo que hace falta una base de conocimientos científicos profundos. Nos hemos comprometido fuertemente a participar en foros forestales internacionales. Particularmente, nos hemos comprometido fuertemente a la cooperación científica a nivel internacional y apoyamos vigorosamente la Unión Internacional de Organizaciones de Investigación Forestal. Tengo cierto orgullo en mencionar que fue mi buen amigo y colega Dr. Garth Nikles, recién jubilado después de haber contribuido 50 años a la ciencia forestal, quien, junto con el Dr. Geoff Burley, inició el primer Grupo de Trabajo IUFRO tropical en 1971.

Creo que vivimos en tiempos muy interesantes para la investigación forestal. El grupo de personas interesadas ávidamente en el manejo y la utilización de los bosques y sus recursos ha nunca sido mayor, y la cooperación internacional entre los científicos forestales ha nunca sido más importante.

Esperamos para el 2005 que podamos mostrar a los delegados nuestra hospitalidad australiana y particularmente devolver la hospitalidad con que nos han acogido aquí en Malasia.

Los delegados de Australia han apreciado mucho la organización excelente del XXI Congreso Mundial IUFRO en Malasia. Reconocemos que nuestros colegas de Malasia han establecido estándares muy altos para el próximo Congreso y estamos convencidos de que la organización del Congreso en Brisbane en 2005 se orientará mucho en la experiencia de Malasia.

Esperamos con gran alegría unirnos con la comunidad internacional amplia de IUFRO en la organización del XXII Congreso Mundial IUFRO y llevar la bandera de IUFRO adelante en los próximos cinco años. Sobre todo, por supuesto, nos alegraríamos verlos a todos Uds. en Brisbane en 2005

Discurso de Clausura pronunciado por el Presidente de IUFRO,

Profesor Jeffery Burley

Excelencias, Distinguidos Huéspedes,
Miembros de IUFRO, Colegas y Amigos
Señoras y Señores:

Estamos llegando a la clausura formal del XXI Congreso Mundial de IUFRO en Kuala Lumpur, Malasia. Aunque la mayoría de la gente siempre se alegra de poder volver a casa, sé que hay muchos participantes que son un poco tristes por haber que despedirse de un país tan hermoso y un pueblo tan amable y terminar un programa tan lleno de presentaciones, pósters, discusiones, exposiciones y excursiones de campo interesantes y estimulantes. También serán tristes por tener que despedirse de amigos antiguos y nuevos a que encontraron aquí, pero espero que los contactos profesionales y sociales sean mantenidas en la tradición de un siglo de colaboración científica y personal dentro de IUFRO.

Los organizadores de cada Congreso siempre están preocupados al principio por saber si pueden competir con el Congreso anterior en cuanto a la calidad y la cantidad, pero yo siempre he pensado que no tienen que competir sino que tienen que diferir. Después de Montreal en 1990, los organizadores finlandeses del Congreso de Tampere en 1995 pensaron inicialmente que no pudieran competir pero lo lograron. Después de Tampere, los organizadores de Malasia pensaron que no hubiera manera de competir, pero creo que demostraron que sí lo pudieron. La calidad de los arreglos administrativos, políticos y técnicos ha sido estupenda, y la amabilidad de todos los empleados de apoyo ha sido extraordinaria.

He caminado por el sitio del Congreso durante toda la semana buscando las opiniones de muchos participantes y no he encontrado a ninguno que hubiera expresado críticas graves. Vamos a ver si esto se refleja también en el resultado del cuestionario aleatorio, pero estoy convencido que sí. No obstante, el Comité Ejecutivo de IUFRO tendrá mucho interés por conocer sus puntos de vista una vez que hayan vuelta a casa y hayan tenido el tiempo para reflejar sobre todos los aspectos del Congreso.

Por supuesto, no es posible para mí dar las gracias a todas las personas y organizaciones que han contribuido al éxito de este Congreso. Por lo tanto me permito dar las gracias colectivamente en nombre de todos Uds. al Gobierno de Malasia; al Comité Ejecutivo de IUFRO; al Comité Directivo de Congreso encabezado por el Dr. Razak; al Comité Organizador del Congreso presidido por el Dr. Rahim; al Comité Científico del Congreso presidido por el Dr. Teissier du Cros; a la Secretaría de IUFRO encabezada por Heinrich Schmutzenhofer; a los empleados de FRIM, a los Departamentos Forestales nacionales, a las Universidades que han ayudado en muchas maneras; a los fotógrafos, a las personas de información y los empleados del organizador profesional de Congreso; a la prensa que informó tan concienzudamente durante toda la semana; a los intérpretes sin los cuales no todos hubieran podido escuchar bien a los discursos keynote; al maestro de ceremonias sin el que las ceremonias de inauguración y clausura así como las cenas hubieran sido menos eficientes y menos agradables; a los patrocinadores de muchos participantes; y, sobre todo, a los participantes mismos. Como es el caso con la mayoría de las actividades en la vida, se extrae de un evento tanto como se invierte, y sé que la mayoría de los participantes sumergieron completamente en el espíritu y las actividades del Congreso y sacaron, por consecuencia, mucho placer y muchos beneficios personales.

Me gustaría extender mis gracias personales a todos Uds. por su apoyo continuo durante los últimos cinco años, especialmente a mi esposa Jean y al Secretario de IUFRO, Heinrich Schmutzenhofer. Sin ellos no hubiera podido servir como su Presidente. Por suerte, sólo tengo que volver a casa con uno de los dos. Para el otro tengo un pequeño regalo, un reloj de Oxford con despertador fijado en las 6 de la tarde para que sepa siempre cuando es tiempo para irse a casa a su esposa Edith a que igualmente agradezco su apoyo.

Quisiera desearles a todos Uds. un buen viaje y que su Dios esté con Uds. Declaro el XXI Congreso Mundial de IUFRO terminado.

Congress Resolutions

RESOLUTIONS

of the 21st Congress
International Union of Forestry Research Organizations
12 August 2000

	CONSIDERATIONS	RESOLUTIONS
Role of forests and trees in human welfare	**Recognizing** the great contributions made by forests, trees, industries and the forestry profession to human, environmental, economic and socio-cultural welfare, **further recognizing** the contributions to poverty alleviation, the stimulating of development and reversing environmental decline, **further recognizing** the importance of cultural diversity, and **further recognizing** that research is undertaken at different intensities depending on the geographical extent of a problem, the level at which it is approached, and the inter-relationships with other problems,	IUFRO should continue and expand its stimulation and support for research, and provide the knowledge necessary to achieve sustainable forest management within differing physical and social landscapes; it should seek to reconcile conflicting demands for wood and non-wood products, environmental services and social benefits; IUFRO should also seek appropriate knowledge, particularly from indigenous people.
Attention by policy-makers	**Noting** the increasing attention paid to forests by international and national agencies, international NGOs, commercial enterprises and academic institutions, and the need for reliable information by decision-makers in such organizations,	research should be increasingly directed towards forest policy-related issues in the major environmental and social conditions including urban, mountain and dry environments; IUFRO has a major role in enhancing the interface of science, policy and industry, aiming at better provision of all forest benefits, goods and services.
Role in inter-governmental processes	**Being** aware of the place of forestry in the considerations of several inter-governmental processes, and of IUFRO's unique capacity to mobilize a broad range of individual and collective expertise,	IUFRO should strengthen its contributions to international debates and political processes, specifically those relating to:- genetic resources and biotechnology; biodiversity; sustainable forest management; climate change and carbon sequestration; soil; water; fire; deforestation, forest degradation and desertification. It should promote the transfer of socially acceptable, environmentally sound techniques.
Research and the impacts of forestry activities	**Considering** the public concern for the possible impacts of forestry activities on global and local environments, social welfare and biodiversity, and **remembering** that IUFRO's research traditionally focuses and progresses in major disciplines,	research should increase within single disciplines while simultaneously moving towards an interdisciplinary, problem-solving approach; IUFRO should seek closer collaboration with other research organizations, while bringing its experience and networking powers to assist other research networks and consortia.

	CONSIDERATIONS	RESOLUTIONS
Information	**Appreciating** the research undertaken and the forest and forest products technologies developed, especially by IUFRO member institutions and individual scientists, **realizing** that much of this information is available in scattered sources and forms, and **observing** the rapid development and availability of information technologies,	existing information should be made available in accessible and appropriate forms for the wide range of users; forest research institutions should strive to divulge their research results; use of the IUFRO Net, and development of the Global Forest Information Service led by IUFRO, should be intensified and IUFRO research units should continue to disseminate statements of the current state of knowledge in their specific fields.
Research capacity	**Believing** that forest research capacity is low in countries with developing and emerging economies, and that women scientists are underrepresented and insufficiently supported in forest research,	IUFRO should expand its collaboration with other organizations that seek to enhance biophysical and social research capacity in countries with developing and emerging economies; it should encourage the role of women and disadvantaged researchers in forest sciences.

Congress Resolutions (French)

RESOLUTIONS
DU 21ème Congrès de
l'Union Internationale des Instituts de Recherches Forestières
12 août 2000

	CONSIDERATIONS	RESOLUTIONS
Importance des forêts et des arbres pour le bien de l'humanité	**Reconnaissant** la contribution importante apportée au bien-être environnemental, économique et socio-culturel de l'humanité par les forêts, les arbres et l'industrie forestière, **Reconnaissant** aussi les contributions à la lutte contre la pauvreté, à l'encouragement du développement et au renversement du processus de destruction de l'environnement, **Reconnaissant** aussi l'importance de la diversité culturelle, et **Reconnaissant** aussi le fait que les travaux de recherche sont menés en fonction de la portée géographique du problème, du niveau de l'approche et de leur interaction avec d'autres problèmes,	l'IUFRO devrait poursuivre et étendre ses encouragements et son soutien à la recherche, et produire la connaissance nécessaire pour concevoir une gestion forestière durable dans tout environnement social ou biophysique; elle cherchera a dépasser les conflits entre demande de produits ligneux et non-ligneux et la satisfaction des besoins environnementaux et des bénéfices sociaux; l'IUFRO devrait aussi recueillir la connaissance des peuples indigènes.
Intérêt des décideurs politiques	**Considérant** l'attention croissante apportée aux forêts par les agences internationales et nationales, les ONG internationales, les entreprises commerciales et les institutions universitaires ainsi que le besoin d'une information fiable pour les décideurs de telles organisations,	la recherche devrait de plus en plus être orientée vers les questions politiques concernant les principales conditions environnementales et sociales, y compris l'espace urbain, les zones de montagne et les zones sèches ; l'IUFRO a un rôle majeur à jouer en promouvant l'interface entre la science, la politique et l'industrie, tout en visant la sauvegarde des bienfaits et des services rendus par la forêt.
Rôle dans les processus intergouvernementaux	**Etant** conscient de la place que la foresterie occupe dans les préoccupations de plusieurs processus intergouvernementaux, et de la capacité unique de l'IUFRO de mobiliser un grand nombre d'experts,	l'IUFRO devrait maintenir et intensifier sa présence dans les débats et processus politiques internationaux, notamment ceux qui se rapportent aux thèmes suivants : ressources génétiques et biotechnologie, biodiversité, gestion forestière durable, changements climatiques, séquestration du carbone ; sols, eaux ; incendies ; déboisement, dégradation des forêts et désertification. Elle devrait promouvoir le transfert des techniques n'ayant pas d'effets nuisibles ni pour la société ni pour l' environnement
La recherche et l' impact des activités forestières	**Considérant** l'inquiétude publique quant aux retombées possibles des activités forestières sur l'environnement mondial et local, l'humanité et la biodiversité,	la recherche devrait s'éloigner de plus en plus de l'actuelle approche disciplinaire pour résoudre les problèmes par une approche interdisciplinaire; ainsi l'IUFRO devrait collaborer plus étroitement

	CONSIDERATIONS	RESOLUTIONS
	Rappelant que la recherche menée au sein de l' IUFRO est centrée traditionnellement sur les disciplines majeures où les progrès sont le plus visibles,	avec d'autres organismes de recherche tout en mettant en valeur son expérience et ses capacités de gestion de réseaux pour renforcer d'autres réseaux et consortia de recherche
Information	**Reconnaissant** la recherche entreprise et les technologies développées en matière de foresterie et de produits forestiers, notamment par les institutions membres de l'IUFRO et par les scientifiques individuels, réalisant qu'une grande partie de ces informations est disponible sous des formes diverses et disséminées, et **observant** le développement rapide et la disponibilité des technologies de l'information,	l'information existante devrait être mise à disposition du plus grand nombre d'utilisateurs de manière appropriée et accessible ; les instituts de recherche devraient s'efforcer sans cesse de diffuser leurs résultats de recherche; l'utilisation du réseau de l'IUFRO et le développement du Service mondial d'information forestière (GFIS) entrepris par l'IUFRO devraient être encouragés et les unités de recherche de l'IUFRO devraient continuer à diffuser les bilans de connaissances de leurs champs de recherche respectifs.
Compétences	**Estimant** que les moyens de la recherche forestière sont faibles dans les pays en développement et émergeants, et que les femmes dans la recherche forestière sont sous-représentées et pas assez soutenues,	l'IUFRO devrait étendre sa collaboration avec d'autres organisations qui s'efforcent de renforcer les moyens pour la recherche – en sciences sociales ou biophysiques – dans les pays en voie de développement ou émergeants.

Congress Resolutions (German)

RESOLUTIONEN DES XXI Weltkongresses des
Internationalen Verbandes forstlicher Forschungsanstalten (IUFRO)

	ERWÄGUNGEN	ENTSCHLIESSUNGEN
Die Bedeutung des Waldes und der Bäume für das Wohl der Menschheit	**In Anerkennung** der enormen Beiträge des Waldes, der Bäume und der Forstberufe für eine gesunde Umwelt, wirtschaftlichen und sozialen Wohlstand, **In weiterer Anerkennung** der Beitraege des Waldes im Kampf gegen die Armut, bei der Foerderung von Entwicklung und Umkehrung der Zerstoerungsprozesse, **In weiterer Anerkennung** der Bedeutung kultureller Vielfalt, und **In weiterer Anerkennung** der Tatsache, dass Forschung, je nach geographischer Tragweite, mehr oder weniger intensiv betrieben wird, des Niveaus der betriebenen Forschungsarbeiten und der Wechselbeziehungen mit anderen Problemfeldern,	sollte IUFRO forstliche Forschung zunehmend fördern und die nötige Wissensgrundlage zur Verfügung stellen, um eine nachhaltige Bewirtschaftung von Wäldern zu erreichen, damit diese alle Funktionen in ihrem jeweiligen physischen und sozialen Umfeld erfüllen können; IUFRO sollte einander widersprechende Ansprüche an den Wald wie Nutzung von Holz und anderen Produkten, Umweltschutz und Wohlfahrtswirkung auf einen Nenner bringen und auch das Wissen indigener Völker einbeziehen.
Beachtung durch politische Entscheidungsträger	**Eingedenk** der zunehmenden Beachtung durch internationale und nationale Institutionen, internationale Nicht-Regierungsorganisationen, kommerzielle Unternehmungen, akademische Einrichtungen und des Bedarfes an zuverlässigen Informationen für die Entscheidungsträger in solchen Organisationen,	sollte Forschung immer öfter zur Lösung politisch relevanter Fragestellungen zu den wichtigen natürlichen und sozialen Gegebenheiten, Stadt, Gebirge und Trockenzonen eingeschlossen, verwendet werden. IUFRO muss bei der Verknüpfung von Wissenschaft, Politik und Industrie eine grosse Rolle spielen und trachten, alle Wirkungen, Güter und Leistungen des Waldes sicherzustellen.
Rolle in zwischenstaatlichen Prozessen	**Im Bewußtsein** der Stellung der Forstwirtschaft bei den einzelnen zwischenstaatlichen Prozessen, und des einzigartigen Potentials IUFROs, eine grosse Zahl unterschiedlichster Wissenschaftler zu mobilisieren,	sollte IUFRO zur internationalen Debatte und politischen Prozessen auch weiterhin beitragen und diese Präsenz noch verstärken, insbesondere in den Bereichen genetische Ressourcen und Biotechnologie, Biodiversität, nachhaltige Waldwirtschaft, Klimawandel und Komplexbildung, Boeden, Wasser, Brandbekämpfung, Entwaldung, Waldzerstörung und Desertifikation. IUFRO sollte den Transfer von umweltfreundlichen und sozial verträglichen Techniken foerdern.
Auswirkungen forstlicher Eingriffe	**In Erwägung** der öffentlichen Sorge bezüglich möglicher Auswirkungen forstlicher Eingriffe auf die Umwelt, sowohl in globaler als auch in lokaler Hinsicht, auf den Wohlstand und auf die Biodiversität,	sollte Forschung sich zunehmend vom derzeitigen fachspezifisch-orientierten Ansatz entfernen und interdisziplinäre Forschung mit problemlösungs-orientierten Ansätzen verfolgen. IUFRO sollte unter Einbringung seiner Erfahrung und seines Netzwerkes eine engere Zusammenarbeit

	ERWÄGUNGEN	ENTSCHLIESSUNGEN
	In Erinnerung daran, dass IUFRO traditionell Forschung in den Hauptdisziplinen durchfuehrt,	mit anderen Forschungsorganisationen und die Einbindung in Forschungsnetzwerke und –konsortien anstreben.
Information	**In Wertschätzung** der Forschung im Bereich Forst- und Holzwirtschaft und der dabei von IUFRO Mitgliedsinstitutionen und einzelnen Wissenschaftlern entwickelten Technologien, **in der Erkenntnis**, daß ein Großteil dieser Information erhältlich ist über verschiedene Informationsquellen und –formen, und **in der Beobachtung** der raschen Entwicklung und Verfügbarkeit von Informationstechnologie,	sollte bestehende Information leicht und bequem für einen großen Anwenderkreis verfügbar sein, sollten Forstforschungsorganisationen versuchen, ihre Forschungsresultate zu verbreiten; das IUFRO Netzwerk zu nutzen, die Entwicklung des von IUFRO geleiteten weltweiten forstlichen Informationsdienstes sollte verstärkt werden und IUFRO Forschungseinheiten sollten auch weiterhin den aktuellen Wissensstand in ihren Fachdisziplinen für ein breiteres Publikum dokumentieren.
Forschungskapazität	**In der Überzeugung**, daß die forstlichen Forschungskapazitäten in Entwicklungsländern und Reformstaaten niedrig sind, und daß Frauen in der Wissenschaft unterrepräsentiert sind und in der Forstwissenschaft ungenügend unterstützt werden,	sollte IUFRO die Zusammenarbeit mit anderen Organisationen forcieren, die sich bemuehen, Forschungskapazitäten im Bereich Biophysik und Soziologie in Entwicklungs- und Schwellenländern auf- und auszubauen und Frauen und benachteiligte Forscher in der Forstwissenschaft fördern.

Congress Resolutions
(Spanish)

RESOLUCIONES
del XXI Congreso
de la Unión Internacional de Organizaciones de Investigación Forestal

12 de agosto de 2000

	CONSIDERACIONES	RESOLUCIONES
La importancia de los bosques y árboles para el bienestar humano	**Reconociendo** las grandes contribuciones de los bosques y árboles y de la profesión forestal al bienestar medioambiental, económico y socio-cultural de la humanidad, **Reconociendo** además la contribución a la lucha contra la pobreza, el estímulo al desarrollo así como a contrarrestar la degradación ambiental, y **Reconociendo** además la importancia de la diversidad cultural, **Reconociendo** además que la investigación se desarrolla con distintas intensidades dependiendo de la extensión geográfica de un problema, el nivel al cual se lo trata de solucionar, y de la relación con otros problemas,	IUFRO debería continuar y aumentar su estimulación y apoyo a la investigación, así como proporcionar los conocimientos necesarios para lograr una ordenación forestal sostenible dentro de diferentes contornos físicos y sociales; debería aspirar a conciliar las demandas de productos leñosos y productos forestales no leñosos, servicios ambientales y beneficios sociales. IUFRO también debería aspirar a obtener conocimientos apropiados, especialmente de pueblos indígenas.
La atención de los políticos	**Notando** tanto la atención creciente que las agencias internacionales y nacionales, las ONGs internacionales, empresas comerciales e instituciones académicas están prestando a los bosques, como la demanda de información confiable por parte de las personas que toman las decisiones en tales organizaciones,	la investigación debería dirigirse cada vez más a solucionar asuntos relacionados con políticas en los principales ámbitos medioambientales y condiciones sociales, incluyendo regiones urbanas, montañosas y secas. IUFRO debe desempeñar un papel clave de fomentar la interface entre la ciencia, las políticas y la industria, con el objetivo de proporcionar todos los beneficios de los bosques, los bienes y los servicios.
El papel en los procesos intergubernamentales	**Teniendo en cuenta** el rango de los temas forestales en las consideraciones de varios procesos intergubernamentales, y la capacidad excepcional de IUFRO para movilizar una amplia gama de experiencias individuales y colectivas.	IUFRO debería mantener y aumentar sus contribuciones a los debates internacionales y procesos políticos, particularmente sobre recursos genéticos y biotecnología; biodiversidad; la ordenación sostenible de los bosques; cambio climático y captura de carbono; suelo; agua; incendios; deforestación; degradación de los bosques y desertificación. Debería promover la transferenica de tecnologías sociales y ambientalmente aceptables.
Los impactos de las actividades forestales	**Considerando** las preocupaciones públicas por los posibles impactos de las actividades forestales sobre el medio ambiente a nivel mundial o local, el bienestar social y la biodiversidad,	la investigación debería aumentar en el ámbito de cada disciplina, pero simultáneamente ir evolucionando hacia un enfoque interdisciplinario dirigido a la solución de problemas; IUFRO debería tratar de colaborar más estrechamente con otras organizaciones de investigación y con-

	CONSIDERACIONES	RESOLUCIONES
	Teniendo presente que la investigación realizada por IUFRO tradicionalmente se ha orientado y desarrollado en torno a las disciplinas de mayor importancia,	tribuir con su experiencia y su gran capacidad para establecer redes en apoyo de otras redes y consorcios de investigación.
La información	**Reconociendo** la investigación realizada y las tecnologías desarrolladas, tanto en relación a los bosques como a los productos forestales, especialmente por las organizaciones miembros de IUFRO y científicos individuales, **Viendo** que gran parte de la información sobre investigación está disponible en varias fuentes y formas dispersas, y **Observando** el rápido desarrollo y la disponibilidad de tecnologías de información,	la información existente debería estar disponible en formas accesibles y apropiadas para los diversos usuarios; las instituciones forestales deberían aspirar a divulgar sus resultados de investigación; debería intensificarse el desarrollo del Servicio Mundial de Información Forestal dirigido por IUFRO, y las unidades de investigación de IUFRO deberían seguir haciendo declaraciones sobre el estado actual de los conocimientos en sus áreas específicas.
La capacidad de investigación	**Reconociendo** que la capacidad de la investigación forestal en los países en desarrollo y con economías emergentes es baja, y que las mujeres están representadas inadecuadamente entre los científicos y con apoyo insuficiente en la investigación forestal,	IUFRO debería aumentar su colaboración con otras organizaciones que aspiran a mejorar la capacidad de investigación biofísica y social en países en desarrollo y con economías emergentes; debería reforzar el papel de la mujer y de los investigadores con menos recursos en la ciencia forestal.

Report on President's Panel Discussion Friday 11 August 2000, 14.30 - 16.00

International Research Policy - Forestry and Wood Industries Comments on Congress Resolutions

Chair: Professor J Burley
Rapporteur: Mr D J Macqueen

The IUFRO President invited a Panel of distinguished persons representing several donor agencies and international organizations that had been long-term supporters of IUFRO, to offer their views on a number of major issues. To focus the discussion, the Panel members were provided with a draft version of the Congress Resolutions; at the time of the Panel meeting these Resolutions had not formally been confirmed by the International Council (although they were subsequently confirmed by the IC and published at the closing ceremony).

The Panel included Dr Yves Birot (France), Dr Robert Lewis (USA), Professor Jeff Sayer (CIFOR), Dr Yvan Hardy (Canada), Dr Peter Poschen (ILO), Dr Jacques Valeix (France) and Mr Duncan Macqueen (UK). The Panel was asked to address the six Resolutions that referred to:- the role of forests and trees in human welfare; attention by policy-makers; the role of IUFRO in inter-governmental processes; research and the impacts of forestry activities; the role of information; and strengthening research capacity. It is not possible to include all the points raised in over an hour's discussion of these major issues, but the following summary emphasizes the major views.

IUFRO's mission statement is: "To promote international co-operation in forestry research and related sciences". It is a mission statement that requires amplification. Why does IUFRO wish to promote co-operation in research? How will IUFRO achieve this? Because of this, these resolutions are extremely important; they define IUFRO's vision - not just research for research's sake, but research with a clear objective.

The first Congress Resolution is the foundation, for it defines why IUFRO promotes collaboration in research - it seeks to enhance human welfare. This is the common currency that unites us all, whether for the long-term opportunities of biodiversity and a stable environment, or for short-term commercial interests or poverty eradication, recreational interests or spiritual value. Human welfare is that common currency; it is a language understood by policy and land use decision-makers, by business, by environmental activists and by the poor. It explains why sustainable forest management and IUFRO's research activities are important.

The Panel noted that perceptions are changing, from seeing people as the problem to recognizing them as the solution. The Panel saw the need for clarity in defining who should be helped and how. The Panel discussed the need to question whether and to what degree forests can be used to eradicate poverty. They also noted that different types of forestry (from industrial to community management) have different effects on human welfare. Researchers have a pivotal role in clarifying these issues. A question from the floor questioned how IUFRO intends to address the agendas of different people, particularly of the poor and women, in defining its activities. The IUFRO President outlined a number of initiatives that IUFRO has implemented, including the Special Programme for Developing Countries, the creation of a number of Task Forces, and the establishment of a new research unit dealing with gender issues.

The Congress had highlighted the complexity of the forest sector - a complexity of agendas, of forest products and forest services. The second Resolution sought to address this complexity to enhance human welfare and recognized that IUFRO, with its broad membership base, was equal to this task. Starting at the policy level, this Resolution begins to define the "how" of IUFRO's mission statement. The Panel believed that researchers have a responsibility to link research results with policy formulation. They talked about the need for care to maintain credibility in doing this, and the important role that IUFRO might play in this regard. They also noted the communication gap between science and policy and discussed the importance of finding ways to communicate uncertainty, rather than making unsubstantiated generalizations.

The third Resolution recognizes that this is a time of opportunity for IUFRO to contribute to international debates and political processes. Never before has the value of forests been so widely recognized. For the first time we are seeing payments for carbon sequestration, environmental protection and watershed conservation. We are seeing payments for biodiversity knowledge through Intellectual Property Rights under the Convention on Biological Diversity. This Resolution charges IUFRO with seizing the initiative at the international level in the interests of human welfare. The Panel noted the importance of IUFRO in terms of intellectual input but felt that this potential was under-utilized. The sphere of relevance for forestry had become broader. IUFRO must face the challenge and engage with inter-governmental fora in order to address these current issues.

The fourth Resolution highlights the need for a problem-solving approach. Recognizing the opportunities, how does IUFRO make this a reality while keeping quality science? The answer is through collaboration - linking research organizations with each other and with a wider group of application-orientated institutions. The Panel emphasized IUFRO's role in supporting scientific break-throughs and innovation. They discussed the need for a balance between maintaining the quality of research within any single discipline and the need to engage in multi-disciplinary partnerships to address all aspects of a problem. It was recommended that IUFRO builds its Divisions around the production of tools for decision making.

In the fifth Resolution the Panel discussed one of IUFRO's principal comparative advantages - the compilation and dissemination of information. If IUFRO is to achieve its mission, it will be essential to synthesize what is already known, through state-of-knowledge papers and the Global Forest Information Service (GFIS), and to identify gaps and future research priorities. The Panel noted that the demand for forest information is increasing. At the same time they observed that newer information technologies such as the Internet were diluting the quality of research information. IUFRO can play an important role through SilvaVoc, GFIS and its state-of-knowledge papers in restoring the credibility of forest science.

In considering the sixth Resolution, the Panel recognized that the united vision or common currency of IUFRO (and ideas of how this might be accomplished), will stand or fall on the institutional and individual capacity of its members. Finding ways to enhance this capacity will be a major challenge for IUFRO over the next five years. The Panel noted the importance of encouraging equity between north and south countries and between genders but it drew attention to a bigger problem - the huge gap in investment in research between industrialized and developing countries. The Panel noted that this was self-perpetuating leading to a vicious cycle of under-investment and lack of new recruitment. IUFRO should urge donors to address this fundamental problem. It must highlight ways in which sustainable capacity development can be encouraged:- through training in writing research proposals; through increasing equity in the sharing of research finance; and through the creation of young scientist fellowships at international centres. Comments from the floor noted the pressure on developing country researchers to demonstrate impact with scarce funds and the role IUFRO could play by giving a greater platform for developing country research results.

The Panel covered a wide range of topics. We hope that the discussion, both from the Panel and the floor, has helped to clarify IUFRO's vision. It is a vision that defines why IUFRO wishes to promote collaboration in research and how it intends to do this.

Keynote Addresses

Sustainable Management of Natural Resources

Tan Sri Razali Ismail
Special Adviser to the Prime Minister of Malaysia

Mr. Chairman, Distinguished Guests,
Ladies and Gentlemen,

Introduction

Let me commence by thanking the organizers of this prestigious 21st IUFRO World Congress for inviting me to give a keynote address. It is with a mixture of delight and apprehension that I stand here. While I take enormous pleasure in being among you all, the world's leading thinkers, scientists and foresters, at the same time I feel humbled by your erudition and achievements. What can I, once a simple career diplomat, now dabbling uneasily with the corporate world and dealing with human industry and his waste too, offer here? I pretend to be no scientist, I can offer you nothing in that realm, and therefore, my remarks here will stay away from areas that I know little of. I can, however, speak from my heart, and even that only hesitatingly (although as a diplomat, we were taught to say things consistently and convincingly.)

Distinguished Guests, Ladies and Gentlemen,

The theme of the Congress, addressing issues of forests and society, especially how research can guide us through the uncertain course we are sending this planet through, is indeed apt and timely. When I say this, I am only reminding myself, and feel equally guilty, that we are destroying this planet.

Human activity is radically altering or destroying nature's support systems everywhere. The world's original forest area, about 6 billion hectares, or 40% of the world's land area has been steadily declining. In the last few hundred years we have lost one-third of it. And most of it happened in the last 50 years. Forest depletion is most significant in the tropics at present. Annually we are losing some 20 million hectares. The loss of tropical forests is a double-edged sword. Over 2 billion people depend on these forests for survival and more than half of all plants and species on earth occur within them. The rapid loss of tropical forests means both the impoverishment of more people and the rapid disappearance of our plants and animals. Scientists have estimated that at the present rate of extinction, 20% of the 10 million estimated species on earth would disappear in 15 years' time. Another way of saying it, we are killing 50 or more species every day.

More people are hungry now than ever before, and the numbers are increasing. This is partly because we are rapidly losing arable land. As a result of erosion, 6 million hectares of agricultural land are made unproductive each year. Waterlogging, salinization and alkalinization are reducing the productivity of another 1 million hectares each year.

Life on earth also depends on water. Our use of water is reaching crisis levels. Global water withdrawals have grown 35-fold in the past three centuries. Current patterns of freshwater use cannot be sustained if human populations reach 10 billion. Throughout the world, pollution and misuse have impaired water quality. Oceans cover more than two-thirds of our planet's surface. Their vastness gives the impression no harm can come to them. While we have destroyed the mangroves, saltmarshes, and coral reefs, and threw much pollution into the ocean, we are at the same time over-harvesting the oceans for fish, 100 million tonnes annually, and clearly threatening the fisheries industries. Because of our profligate use of energy derived from burning fossil fuels, "greenhouse" gases are accumulating in the atmosphere. These heat trapping gases are believed to result in global warming, by about 1 to 3 degrees in this century. This may not sound much, but it is a faster change than has occurred in the past 10,000 years. If it continues, sea levels will rise, climatic regions will shift, rain patterns will change, and droughts and storms may increase in frequency and intensity. I can go on listing many more of the problems, but suffice to say the list is long and lamentable. So, it is appropriate that we gather here and re-examine the way we manage our forests, and ultimately our environment.

More than that, it is no more an academic exercise to study this problem or that – it is now a matter of survival. Why? For an explanation, I can offer a simple analogy. When we are mildly indisposed with a cough or fever, we usually go to a pharmacist for an inexpensive drug. If the condition deteriorates further, we seek a physician, but unfortunately our earth has no such recourse. It has no pharmacist to go to, and no physician to turn to. We humans have only one place, this earth, and no where else to go. Therefore, we must make sure it remains healthy and habitable, for all, forever.

Natural Resources – The Forests

It would be far too much to talk in breadth about sustainable management of all the natural resources. Let me therefore confine myself to the forests, the one that is of concern for all of us here, and one that is closest to my heart. I however, am of the view that the principles enunciated here with the case of forests will in general apply to all natural resources. Here I wish to depart from my earlier statement that I will veer away from science, which I again claim no knowledge of.

For a change let me borrow some of your ideas, which you all know so well anyway.

Forests and woodlands occur from the seafront to the uplands, and from the tropics to the subarctic. They exist in an extraordinary diversity of forms – evergreen to deciduous, coniferous to broad-leaved, wet and dry, and open woodlands to closed-canopy forests. Most of the land that is cultivated today was once clothed in forests. Forests, natural and modified, provide a huge wealth of benefits. The forests maintain the earth's life support system. They regulate the atmosphere and climate, store carbon, and warm the subarctic zone by absorbing heat from the sun. Tropical forests play an even bigger role; they probably drive the general circulatory system of the atmosphere and distribute heat to temperate zones. Forests moderate local climate as well, making it milder, moister and less variable. Forests regulate the hydrological cycle, protecting soils from erosion, reducing silt loads in rivers, slowing runoff, and moderating floods.

Besides being a life-support system, forests also provide a variety of goods. Annually, the world obtains more than $ 300 billion dollars worth of lumber, veneer and pulpwood. In poorer countries, 20% of the energy is obtained from fuelwood. The forests also yield large amounts of forage, animal and plant food, medicines, non-wood fibers, furs, skins, essential oils, gums, latex, resins and innumerable number of other products. For example, Burkill published the Dictionary of the Economic Products of the Malay Peninsula in 1935, after a gestation of 14 years. The majority of the thousands of items mentioned in the dictionary came from the natural forests. Just to mention a few, it included: chewing gum from jelutong (Dyera), damar resin for varnishes from keruing (Dipterocarpus), gutta percha from nyatoh (Palaquium), camphor from kapur (Dryobalanops), and benzoin from kemenyan (Styrax). Many of the products have been replaced by synthetics, but some still remain, fortunately. Our ladies would like to know that their lipstick remains where it is meant to be because of a special fat that is obtained from the fruit of the engkabang tree (Shorea) from Borneo. From the first century A.D. Chinese and Indian traders were regularly coming to Malaya for gharu wood (Aquilaria), amber, camphor, and other non-timber forest products. Marco Polo's chronicles of 1299 mention the trade of camphor from the region by Arabs since the 6th century.

While the value of these non-timber goods cannot be reliably verified, they provide significant income and employment, especially for the rural poor. Of course, the forests yield fresh water, and many tropical countries depend totally on this source alone. Besides all these, forests are also a source of genetic material. All the fruit trees in Malaysia came from the forests, including durian (Durio), duku (Lansium), mangis (Garcinia), nangka (Artocarpus), petai (Parkia), and rambutan (Nephelium) to name a few . The wild ones provide the genetic material for crop improvement. Another increasingly recognized value, forests provide the resource base for tourism, and of course they are inestimable in view of their cultural value in terms of beauty, recreation, amenity, religion, art, music and poetry.

Another feature of forests that deserves special mention is the biodiversity, especially in the tropical forests. Forests do not just support life systems; they actually generate and hold the life. Life in terms of variety and form have probably reached their acme in the wet tropical forests of the world, Malaysian forests being among the top record holders for terrestrial species diversity. Typically, one hectare of the Malaysian lowland dipterocarp forest has about 230 or so tree species alone. An enumeration of a 50-hectare plot in Peninsular Malaysia unearthed about 830 tree species. This does not include the herbs, shrub and epiphytes, nor all the animal species. The numbers are astounding, and we need not go further than 30 km from this spot to reach these amazing and incredible forests. How did this myriad of plants and animals come to exist in such small areas of land when only 7% of the earth's surface is covered with wet tropical forests? Biologists say that these forests have existed without much perturbation for almost 100 million years, and the plants and animals specialized more and more, and occupied every niche available. The relationships have become so intricate and interdependent that removing one will lead to the extinction of another or a series of them. Let me switch to a South American example to illustrate this. The Brazil nut tree (Bertholettia excelsa) is pollinated by several Euglossine bees. The male bees gather organic compounds from certain species of tree-dwelling orchids to attract females before mating, but they depend on flowers of trees like Brazil nut for food. The Brazil nuts are pollinated in the process. A large rodent, the Agouti, breaks open the nut seed to allow dispersal and germination. This biological chain links the tree, bee, orchid and rodent. Is this not a reminder that we cannot exist by ourselves?

In case some of you are thinking that these are minor curiosities that excite only biologists, let me halt you. These plants and animals are incredibly important for us. In the 1990s medical doctors were surprised to learn that a chemical important in human brain activity and valuable in the control of high blood pressure is similar to the poison obtained from an Amazon forest tree which Amerindians use for hunting. Several well-known medicines were discovered from the rainforests: anticancer drugs from rosy periwinkle (Catharanthus roseus), steroids from Mexican yams

(Dioscorea composita), and antihypertensive drugs from serpent-wood (Rauwolfia serpentina). The discoveries continue to grow.

Management or Destruction

You have just heard me extolling the virtues of the forests, not just their beauty, but also their utilitarian value, and the promises they hold for mankind in the future. However, I am not here for that. I am here because all is not for the best in the best of all possible worlds.

I have already pointed out the rate of forest loss worldwide to be alarming. There are several factors behind this unparalleled destruction and loss of forests. I must state quite frankly that forest loss and degradation are not confined to just the tropics – it is a worldwide problem. Old growth forests everywhere are threatened. The principal cause, particularly in the poorer nations is due to agricultural expansion. Subsistence farmers in developing countries account for more than 60% of the loss of tropical forests annually, but that is not to say all forest openings have bad impacts. Malaysia opened up quite a bit of its land, especially the rich lowland forests for agriculture and plantation crops, and they remained the bulwark for our economic growth. Today such agricultural expansions are still going on. The method of forest opening is still torch and fire. Because of the scale of the openings, forest fires and associated haze problems are becoming common. Whether or not all these are perpetuated further is the important question.

Opening lands for cattle ranching is devastating the forests in tropical America and Africa. Overgrazing has resulted in further degradation of the land. Fuelwood gathering is another cause. About half the world's population depends on wood as their main source of household energy. Much of the wood comes from natural forests and trees outside forest areas. Infrastructure development, especially building of dams has covered millions of hectares of forests. A World Bank Report stated that in 1950 there were 5,270 large dams; today there are over 36,500. The price is most often paid by forests – they are flooded out.

Lastly, let me touch on about the most contentious issue, viz. commercial logging. Another factor behind deforestation is commercial logging. Annually about 5 million hectares of commercially productive closed forests are logged. However, it is not the leading cause for deforestation, only accounting for about 20 % of total deforestation. In most tropical countries selective logging is used. I have been told that this is resulting from highgrading, whereby all the commercially valuable trees of high quality are removed, and the remaining crop is impoverished. Moreover the method of logging, using heavy ground machinery, causes much damage to the residual trees left behind, as well as to the soils and waterways. The loggers return too early to remove the residuals as well. Following logging, there is very little reinvestment in terms of planting, releasing regeneration, and protecting the forests from illegal encroachment. Even more disturbing is the fact that while the poor people suffer the consequences of logging, such as loss of minor forest produce, game, fish, flooding problems downstream and erosion of soils, the wealth accruing from logging flow into the hands of a few only.

Sustainable Management – The Solution:

In the first place what do we mean by sustainability? There are numerous definitions, and all seem to be on the basis of what we know about it at that time. Distilled to its simplest form, if an activity is sustainable, for all practical purposes, it can continue forever. On this basis, we certainly cannot say we are managing and utilizing our forest resources sustainably, even using the simplest of definitions. In this context, I asked my forestry friends how to achieve sustainable forest management. They had no difficulty or hesitation in giving a prescription. The following would be the actions:
First, plan the allocation of land for the different purposes. Land must be allocated according to its ecological suitability, while taking into account the social and economic factors. Nations should put aside forests for maintaining their water supply, preserving genetic resources, protecting their soils, and also demarcating forests which have the potential for yielding timber and other products. Also ensure lands set aside for agriculture are suitable for sustainable agriculture.

The second would be the need to establish a comprehensive system of protected natural forests. They should represent the full range of forest types, and the areas should be large enough to buffer them from disturbances from outside. Such legally protected areas would maintain the ecological functions, conservation of species, maintenance of genetic resources, provide opportunities for scientific research, allow indigenous cultures to maintain their life-styles, and offer opportunities for wilderness appreciation.

As a third action, nations should establish and maintain an adequate permanent production forest estate. This would, besides conserving the life-support systems and biological diversity, provide a sustainable yield of timber and non-timber products. They should be variably managed, from those that are lightly harvested to others that are intensively managed to enhance their yields of timber. The harvesting should be done on a sustainable basis by using methods and techniques that will not impair the productivity of the forests. These forests provide resources, money and employment, while retaining the ecological services and biological diversity.

The fourth action would be increasing the area of planted forests. With the growth in human populations and rising demand for better quality of life, we will never meet all the needs adequately from the natural forests. Planted forests can concentrate timber production in areas close to markets and the yields are many fold higher. Plantations should also be located on degraded lands and those retired from agriculture.

The penultimate action would be increasing the national capacity to manage forests sustainably. I have been told that the most reasonable production from natural forests cannot exceed 1.5 cubic meters of timber per hectare per year. The annual volume of tropical timber in the international timber trade is in excess of 60 million cubic meters. This would mean 40 million hectares of forest should be under sustained yield management. The demonstrated area under sustainable management is only 1 million hectares. This does not include domestic consumption of industrial wood. Clearly, there is a huge gulf to be crossed. Everyone agrees that this unsustainable industrial exploitation of tropical forests must end. The same may be said of even the forests in the United States, Canada and Russia. Some of the conditions that require greater attention for sustainable management include: i) creating legally guaranteed permanent forest estates, ii) training of staff in ecology and management, iii) applying the appropriate local cutting cycles or allowable cuts, using suitable harvesting techniques, ensuring environmental safeguards, iv) imposing adequate controls on all aspects of harvesting and forest treatments after harvesting, v) adopting environmental policies that protect the ecological services and biological diversity, and vi) effective monitoring to make sure all the above are met.

The last action for achieving sustainable forest management would be involving the communities that live in or near forests in decisions about forest conservation and development. Because they live in the forests, they have a strong incentive to maintain the forest and use it sustainably. However, in most tropical countries governments have taken authority for managing forests from local and indigenous communities who used to manage them in their own ways formerly. If these communities' needs are not met, and they are denied a fair share of the wealth from the forests, they will have no incentive to conserve the forests.

What is Missing?

If the mantra for sustainability is so simple, and so easily met, how come we have not achieved it? In fact, most of the basic information for managing forests on a sustainable basis is already available. Yet, as noted earlier, only a small percentage of the tropical forests are managed sustainably. What went wrong? What is missing?

Simply stated, our hearts are not in the right place. Further, we use a number of economic theories to justify our heartless actions. The people of every country have a right to exploit their natural resources for economic development. There can be no argument on this count. It is the manner in which we pursue this that we should be concerned with. If a forest is to be cleared for providing land for the poor, to increase their opportunities, few can quibble about it. The concerns would be issues like the suitability of the land for agriculture and setting aside adequate lands for protection and production functions. The FELDA schemes in Malaysia are about the finest examples of such development. They seem to have exceeded the original goals, and some of the settlers have become wealthier than most of us.

However, more often than not this is not the case. Take a look at industrial logging. Usually a few individuals, mostly in the upper-income group and in possession of financial and political clout, end up getting logging concessions. The wealth of the state, which belongs to the people, passes to these few individuals. What do the people get – ruined forests, reduced game and fruit and other products, silted up rivers, muddy waters, flooding downstream, increased incidence of disease, and so forth. The future generations are denied the opportunity. Why should the poor take the brunt of such activity? Why should society pay the social costs? The polluter should pay principle was never implemented, run away profits are frequent, and common people suffer.

Having looked further into some more issues, I have cause to think that the developed countries are hypocritical when they carry on protesting about the loss and destruction of tropical forests worldwide. They argue relentlessly about the value of the tropical forests, which indeed belong to the global community, which contain most of the earth's biodiversity, which are the major carbon sinks that if lost would lead to global warming, and which are the earth's life support systems. No one denies this. But there is a flip side to it too. One hectare of oil palm earns more money than a similar area of forest at present. Are we going to deny the citizens of tropical countries the right to a better quality of life? Who will pay for the opportunity costs which will be the case if the forests are left undisturbed? Or is the developed world having a free ride at the expense of the tropical countries? In this equation the poor will end up supporting the profligate and non-sustainable life-styles of the rich.

The issue of biodiversity takes us further down the path of insincerity. For thousands of years, people in the tropics have learned the medicinal and pesticidal properties of a number of plants and animals and conserved them. Chemical and pharmaceutical companies from the industrialized countries have suddenly "discovered" them, and artificially synthesized the chemical compounds. While these companies have built huge fortunes from them, what have the people who preserved the plants and the traditional knowledge gained? Nothing. The industrialized countries, instead of punishing the tropical countries with timber boycotts, instead of arguing about market forces and demand and supply, should instead value the tropical forests for what they represent and find ways to pay for their conservation and preservation.

Let me give you another tragic but comical example of how the industrialized world conducts its business of saving the forests. The G7 (now G8) group of countries met in Italy in 1987, and underlined its "own responsibility" toward tropical forests. In 1990 they met in the USA and declared "to take action to increase forests while protecting existing ones." In 1991, they met in the United Kingdom where they "remained concerned." In 1993, in Tokyo they wanted "international agreement" to protect forests. In 1997, in Denver, they called on all countries to "eliminate illegal logging," and stated that forests "continue to be destroyed and degraded at alarming rates." In 1998, in Birmingham, they called for an "Action Program on Forests." Like so many UN resolutions, there is sound but no action. Since the Denver summit, an area the size of Germany has been destroyed.

At this point, I would like to move away from litigious issues and look at each and everyone of us, whether from poor, emerging or rich countries. We are part of this earth, and we all have a role in sustaining the natural resources on earth, whether it be forests, wood, water, or wildlife. We all are earnest to see improvements in the quality of human life while conserving the vitality and diversity of the earth, its forests, its creatures, and its regenerative and sustaining capacity. We have no options but to live sustainably. It means living in harmony with other people and with nature. We must share with each other and care for the earth. We can not take more from nature than nature can replenish. It means adopting life-styles that are sustainable.

Finally, no nation is today self-sufficient. We have to learn to protect the globally shared resources, the oceans and forests, the atmosphere and the biosphere. Therefore, we need to develop an ethic of care at the global, national and individual levels. All nations stand to gain from worldwide sustainability, or will be threatened if we fail. We have to change. A famous philosopher once remarked, "To pluck a flower is to kill a star." Let us reverse it, "To plant a tree is to rekindle the universe."

Thank you.

Science in Service to Society
Matching Research to Society's Needs

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This past July, vandals trampled a few acres of cornfield in a New York agricultural research station, another in a long series of attacks around the world on genetic engineering research. The vandalism took place at the Cold Spring Harbor Laboratory, and the field was where Dr. Barbara McClintock conducted her pioneering studies of plant genetics in the 1940s. Fortunately, the attack set back the current research, which focuses not on genetically modified crops but on natural plant breeding, by only a few weeks (Cooper 2000).

This attack exemplifies a growing problem. Scientific research finds itself embroiled in an increasing variety of social controversies: human genetics, global warming, endangered species and worldwide deforestation. These are but a few of the fields where science plays an active role in setting national and sometimes global policy. Debates over these policies scrutinize the supporting and opposing scientific work for the slightest defect, and sometimes go beyond rhetorical attacks, as the researchers in New York and others have learned.

The romanticized idea of the scientist in her ivory tower, working to better all humankind but unfettered by social, economic or political concerns, leaves her, and other scientists who hold to that paradigm, ill-prepared to deal with these controversies. Even a casual reading of the history of science clearly indicates this model was never true (e.g., Galileo's trial, recantation and house arrest, noted in Bradbury 1999). Indeed, as Robert Merton (1957) noted more than forty years ago, the attempt to cloak oneself in the purity of science may simply exacerbate these problems:

Precisely because scientific research is not conducted in a social vacuum, its effects ramify into other spheres of value and interest. Insofar as these effects are deemed socially undesirable, science is charged with responsibility. The goods of science are no longer considered an unqualified blessing. Examined from this perspective, the tenet of pure science and disinterestedness has helped to prepare its own epitaph.

Yet the tenets, methodology and disinterestedness of science are a fundamental part of a broader set of behaviors that constitute the conduct of scientific research, and have made it possible for science to make significant contributions to social progress. Scientific research such as Dr. McClintock's, for example, helped fuel the remarkable increases in agricultural productivity over the past several decades and holds the same potential for forestry. This presents scientists with a dilemma — in a world where people have conflicting values and look to science for guidance, how can scientists discharge their social responsibility while remaining true to the model of science that has made so much progress possible?

In our paper, we argue that the social responsibility of the scientist is to develop better ways for society to achieve its goals, and to elucidate and quantify the tradeoffs society faces so better policy choices can be made in the pursuit of these goals. We then resolve the dilemma by offering a model of science for today's contentious world. Our model retains the tenets of science that most researchers hold dear: systematically examining a situation, repeated testing which attempts to reject hypotheses through rigorous experimentation, and, because of an understanding of the limitations of their method, cautiously drawing conclusions from the results (Hempel 1996). However, we supplement these characteristics with two new ones: being "cognizant" (and, in fact, making use) of social concerns and aware of the limitations of "pure science and disinterestedness"; and being "transparent" in the description of her research methods and open to review and replication. If today's scientist is cognizant and transparent, we argue, she will be able to discharge her social responsibilities while remaining true to the tenets of science.

The remainder of our paper presents our argument for the "cognizant and transparent" scientist. In the next section, we present two examples of how science has become entangled in the real world. These examples underscore how scientific research can contribute to social progress, but also illustrate how social values and interests can affect that research. We then present two responses to the lessons drawn from our examples. The first incorporates the precautionary principle into a model of a precautionary scientist; the second is an elaboration of our model of the "cognizant and transparent" scientist. We argue in conclusion that the first model presents insurmountable problems, while the second has the potential to strengthen the conduct of scientific research.

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The Perils of Science in the Real World

In their simplest form, the fruits of scientific research contribute to social progress in two ways: they offer us "better" methods or products, and they help us identify and quantify the consequences of our actions. Finding better methods and products enables society to make technical progress by improving the utilization of its scarce resources; identifying and quantifying consequences promotes social progress by clarifying the possible ways society can utilize those resources. In taking this rather limited view, we do not deny the value of basic scientific research whose goals are not immediately connected to social concerns. Those forms of research, however, often end up contributing practically to social welfare through one of the two categories.

The connection between scientific research and society is not just from the former to the latter, of course. Social concerns frequently help determine the direction and extent of research through such avenues as funding and governmental mandates. Those concerns can work in more subtle ways, however, and make the scientist's task of fulfilling her social responsibilities more complex. Below, we offer two examples of this complexity.

Getting More from Less: Genetics and Industrial Forestry

In 1996, the world consumed almost 1.5 billion cubic meters of industrial wood products (Food and Agriculture Organization 1999). Until the latter half of this century, most of this wood production came from harvesting natural forests, often as part of the conversion of the land from forest to agricultural use. Today, about one third of the total supply comes from these natural forests, while more than half comes from actively managed forests (Sedjo and Botkin 1997).

Over the next decade, industrial wood demand is expected to grow to about 1.9 billion cubic meters (Food and Agriculture Organization 1999). Meeting this demand will be a challenge, but not one that is unmanageable. The important question is not if but how the demand will be met. Different approaches to forestry can produce equivalent amounts of wood with very different impacts on world forests (Farnum et al. 1983). For example, meeting today's demand only through harvests of natural forests would require up to 1.5 billion hectares of forestland, or up to 40 percent of the world's forests. Growing and harvesting wood from managed forests could decrease the amount of land needed tenfold; switching to high-yield plantations could decrease it still further, reducing the forestland devoted to industrial production to 2 percent (Sedjo and Botkin 1997).

This is one way that scientific innovations have contributed to technical progress: getting more from less. For a given amount of land dedicated to industrial forestry, scientific advances have allowed us to meet a growing demand for wood products; future research has the potential to do the same from an even smaller land base. Each increase in the production rates of industrial forests creates the potential for more land remaining in its "natural" state.

One method of getting more from less is forest genetics. Most genetics programs in forestry are based largely on traditional breeding methods with the goals of gene conservation, adaptability, growth production and wood quality. Typically, these programs identify large initial base populations for most commercial species, followed by extensive breeding, testing and selection efforts. Consider the incremental changes possible when selection emphasis is placed primarily on increasing forest growth in a generalized population, as shown in Figure 1. The solid bars on the left side of Figure 1 show changes in growth expected over successive generations of traditional breeding and increasing control of pedigree in the material to be outplanted. Research associated with genetics programs has targeted orchard, nursery and operational field performance to ensure the genetic populations are well managed and genetic potential is fully expressed and captured in the plantation.

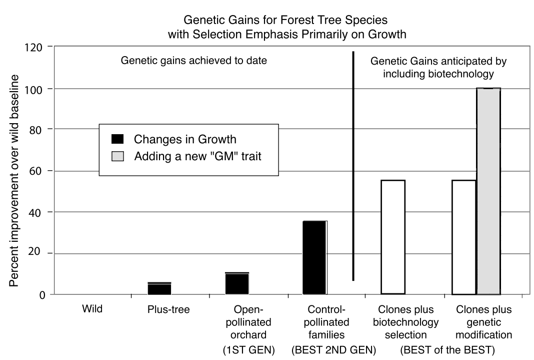

Figure 1. Realized and potential gains from forestry genetics programs.

The right side of Figure 1 shows the genetic gains that are anticipated by including the new tools offered by forest biotechnology in conjunction with clonal deployment. Biotechnology holds the promise of gene identification and transformation processes that will allow more efficient selection and transfer of entirely new desirable traits to existing superior genotypes. Some of the traits of interest currently being investigated for forest trees include: lignin composition, herbicide and insect resistance, climatic adaptability (drought and cold), and wood quality; i.e., specific gravity or fibril angle (Sedjo 1999).

Increased yield from applied forest genetics is but one example of what societies have done for centuries: managed their forest resources to pursue the goal of getting more from less. The transformation of forestry from a practice to a science arguably boosted our ability to pursue that goal (Farrell et al. 2000). Some elements of society, however, often led by strong special interest groups, question whether current scientific advances, particularly those described above, will lead to further progress or to ecological disaster. As Merton (1957) noted, scientific research cannot be isolated from the social passions of the day, passions that at times threaten to slow or even derail that research.

Genetic engineering, and even natural plant breeding, have been particularly vulnerable to this situation. In the first six months of 2000, for example, vandals broke into research facilities almost a dozen times, destroying experimental wheat crops and strawberry plants in California, oat crops in Minnesota, canola and maize crops in Belgium, grass plots in Oregon, potato crops in New Zealand, pineapple crops in Australia, and forest plots in Canada (Bioengineering Action Network 2000). In another case, this vandalism amounted to a tragic farce — the "genetically engineered poplars" destroyed in a 1999 attack were, in fact, raspberry plants being used in cane disease research (McOmber 1999). The facility, located in Washington State, now sports a sign — "NO GMOs" — in the hope of warding off future attacks.

These examples illustrate how a simple case of getting more from less is rarely simple in today's complex society. The genetic researcher is intent on straightforward tasks — how to increase the accuracy of selection, decrease the time to breed and select, increase overall yield, ensure adaptability, or reduce rotation age. These are appropriate and valid scientific questions, of course, but they are also inextricably bound to other questions of a less benign nature — will the genetic manipulations affect nearby, unmanipulated stands, or have possible adverse effects on wildlife (Losey et al. 1999)?

Dismissing these questions as "alarmist" misses the point. To the extent that scientific research materially affects the rest of the world, unintended consequences of that research are always possible and sometimes detrimental. Indeed, they have been common throughout history as the scientific method has evolved. As long as scientists fail to consider and understand the passions that these consequences sometimes evoke, they will continue to be surprised by reactions such as the attacks by anti-genetic engineering vandals. This misconstruction of the concept of scientific "detachment" will slow progress both in social and scientific endeavors.

In no way do we support vandalism or persecution as a constructive reaction — attacks like the one in New York are criminal and should be stopped, period, - but surely there are better responses than to post "NO GMOs" signs; indeed, exactly what kind of sign should be posted by researchers who do conduct GMO research?

Getting More and Less: Modeling and Forestry Regulation

Consider a second example from a different aspect of forestry. In Washington State, a government agency — the Forest Practices Board (hereafter referred to as the Board) — regulates forestry practices. Because of the effects forestry can have on fish habitat, the Board pays special attention to riparian areas, with greater constraints placed on forestry practices adjoining fish-bearing streams. Beginning in the 1970s, the Board used aerial photography to type the waters of the state, including a designation as fish-bearing or fish-nonbearing, and promulgated regulations protecting riparian areas based on this typology. For two decades, this system remained in place despite the absence of any study of its accuracy.

This changed in 1997, on the basis of evidence on the system's errors gathered by a team of biologists from Native American tribes, who have fishing and other rights established by treaties with the U.S. government. In response to this data, and with the support of the industry, the Board passed an "emergency" rule specifying a new typing system. The "emergency" system relies on a simple set of stream characteristics, measured on the ground, to predict the presence or absence of fish. (Measuring the actual presence or absence of fish is a much more difficult data-gathering task which may in fact entail some danger to the fish.) Recently, this emergency system has come under criticism, leading to development of a third system by scientists from Weyerhaeuser. This model consists of a broader set of predictive variables, uses more sophisticated mathematical techniques, and incorporates geomorphic information gathered from Geographic Information Systems (Fransen et al. in preparation).

Because all three systems implicitly or explicitly consist of a predictive model, they inevitably produce two types of errors: a false positive occurs if the system predicts the presence of fish when fish are absent, and a false negative occurs when the system predicts the absence of fish when fish are present. The sum of these two types of errors is a measure of the system's accuracy.

As noted above, our story covers three models: the original system, based on aerial photography; the current ("emergency") one, based on a simple predictive model; and a proposed one, based on a more sophisticated predictive model. In the table below, we list the total error associated with each system, but keep their identities hidden for the moment to help illustrate our argument:

System	Total Error
A	12.3%
B	5.9%
C	5.6%

At first glance, the "best" system is obvious: System C has the greatest accuracy, making an incorrect prediction only 5.6% of the time. Under our first notion of science — trying to get more from less — that system would be the "best," wouldn't it?

This conclusion, however, would be based on a concept of "best" that implicitly assumes the two components of total error are equivalent — a judgment that lies outside the purview of science, and one that, in general, is wrong. Errors in a model's predictions are not simply tallied in an experimental notebook. In Merton's words, they "ramify into other spheres of value and interest." A false positive triggers regulatory protections that are, by this system's internal logic, more than necessary; the costs of those protections are borne by the forest landowner. Conversely, a false negative fails to trigger enough protection and leaves fish at potential risk; the costs of this failure are borne by the fish, the public-at-large and, importantly, the Washington state Native American tribes. (In making these statements, we are assuming that the protective prescriptions are "correct" if applied where fish are present. Another important error, whether the prescriptions themselves are correct even if applied in these places, is beyond our current scope.)

Because these parties have different values and interests, each has a stake in not just the overall accuracy of the predictive model used in the regulatory system, but in the distribution of the error as well. This stake illustrates a second way that science contributes to social progress: identifying and quantifying the consequences of different policy choices. In this case, the choice is between three systems for determining stream types. These consequences include the two types of errors, not just their sum. In the table below, we list each of the systems in chronological order and identify the components of the overall errors (recall that a false positive imposes costs on the forest landowners, while a false negative imposes potential risk to the fish):

System	Model	Error	
		False Positive	False Negative
B	Original Model	0.0%	5.9%
A	Current ("Emergency") Model	11.9%	0.4%
C	Proposed Model	4.1%	1.5%

As the table clearly shows, the distributions of the errors in the three cases are significantly different. Once viewed in this way, the "best" system is no longer obvious. If yet another predictive model lowered both types of errors, for example, to no false positives and 0.2% false negatives, this fourth system would obviously be better than the current three. This model would be an example of science getting more from less, which we have already discussed. However, sometimes the best science can do is to clarify the consequences of actions for social policy makers, not improve the range of those consequences. In this case, science can illustrate how society can get more and less: fewer false positives but only at the cost of more false negatives, or vice-versa. In cases such as the three systems above, determining the "best" system is not possible on a scientific basis alone. The values and interests of the recipients of the individual errors must be consulted, which is a social process, not a scientific one.

This example also illustrates how the results of research, given the political and social conditions, can redound to impact the researchers themselves. The parties bear different benefits and costs of an action — the typing of streams — under scientific scrutiny. The incentive to conduct further research is, in part, determined by those benefits and costs as perceived by the organizations which fund those scientists. When the evidence showed that the original system imposed potential risks to the fish, advocates for the fish used scientific data to put pressure on the Board to adopt a system that would rectify this imbalance. The Board did just that, but the system it adopted turned out to move the errors toward the opposite extreme, one in which the costs were borne largely by the forest landowners.

Because the emergency rule is still in effect, the advocates for the fish are quite content with the current system, despite its relatively low accuracy, because they do not bear the burden of those errors. Further research, then, is not a high priority for them. For the forest landowners, the opposite is the case.

As a result, they have pursued a new system that would bring the regulations back toward a balance. This model, which we have labeled System C, is currently under consideration by the regulators. If adopted, it would lessen the errors borne by forest landowners but would increase, albeit by a small amount, the errors borne by the fish. The resolution of this situation remains unclear.

By one reckoning, the examples above illustrate the danger of mixing science and politics. Let the scientists do their research, this point of view would say, and sort out the political, social and economic implications later. Only then can science find its true voice and serve society to its fullest capacity. By another reckoning, these examples illustrate the shortsightedness of that view. Scientific research often takes place not in a vacuum but in a lively cauldron of values and interests. Isolating the former from the latter is impossible; pretending otherwise will indeed help write the scientist's epitaph. In the next section, we discuss how the model of "good" science can incorporate this reality.

The Promise of Science in the Real World

We are, therefore, back to the dilemma: whither scientific research? If not a retreat to the ivory tower, then where? One response is for the scientist to embrace the social values and interests that affect the research environment but lie outside the formal sphere of science. This response has its advocates and detractors within both scientific and policy circles. Below, we offer an example of responding in this manner: "precautionary science," in which the precautionary principle is incorporated into scientific practice (Barrett and Raffensperger 1999). We then offer a critique of this model, followed by our own proposal for what can be called "cognizant and transparent science."

The Precautionary Scientist

Although expressed in various ways, the precautionary principle is captured in the following statement: "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically" (Wingspread Consensus Statement on the Precautionary Principle 1999). This principle has found numerous applications in international law, including the Rio Declaration on Environment and Development. Through the fruits of its research or sometimes through research itself, science arguably can be an activity that "raises threats of harm to human health or the environment." For that reason, we consider one way of responding to our dilemma: precautionary science.

What would a precautionary scientist look like? One view is given in Barrett and Raffensperger (1999, all quotes below), who describe a precautionary scientist as one who:

- enlists individuals beyond disciplinary and even scientific bounds as "co-problem-solvers";
- focuses her investigations on "indirect, secondary, cumulative and synergistic interactions" rather than on direct effects;
- emphasizes "indirect and acausal relationships, such as correlation, pattern and association";
- addresses "uncertainties … which render precise experimental replication problematic if not meaningless";
- does not insist "that all valid data are quantifiable and replicable and that all theories are predictive across wide-ranging circumstances"; and
- prefers to conclude "there is an effect when there is none than to falsely claim there is no effect."

Extrapolating from these characteristics, how would the precautionary scientist fare in our two examples above?

In the first case, a precautionary genetics researcher would begin with a presumption that any experimental products will be harmful in some way and seek evidence of the product's safety. She might define safety as "absence of harm," which practically speaking would set the burden of proving the product's safety quite high. In contrast, she would accept evidence of a product's harm from a broad spectrum of sources, not just classic experimental work. Such evidence would not have to address cause and effect, and would not have to be either quantifiable or replicable.

In the second case, the precautionary stream-type modeler would push the distribution of error toward false positives — better to claim there are fish when there are none than falsely claim there are no fish. She would enlist the broader community of interests as co-modelers and accept individual exceptions and anecdotal evidence as data of quality on a par with that gathered through formal survey protocols.

Clearly, this model takes the scientist far afield. By choosing different levels of rigor for evidence which indicates safety or harm, she usurps society's authority to make this decision with her own scientific investigations; and by skewing the distribution of error in a particular direction, she is taking sides in a dispute among stakeholders. In short, the precautionary scientist as advocated by Barrett and Raffensperger is quite content to dissolve the barrier between science and social values and interests by actively embracing the latter.

This approach, therefore, encounters a fundamental problem — whose values and which interests should the precautionary scientist embrace? For every activist intent on forestalling the deleterious effects of genetically engineered crops, there is a nutritionist interested in providing nourishment at a lower cost. And for every person whose livelihood derives from harvesting fish, there is an architect touting the environmental benefits of wood as a building material. Because scientific research impinges on a diverse set of values and interests, incorporating a particular subset into the conduct of science is itself a value choice — one that the scientist has no license to make.

We believe this complete merger of social values with scientific technique is an ill-advised response to the dilemma we have posed in this paper because it inevitably undermines the scientific method employed and thus diminishes the contribution which science can make. Applied literally and rigorously this approach cannot properly be called science.

Retaining the Tenets of Science

In contrast to merging social values with science, acknowledging the importance of values, interests and passions, as well as the wisdom of proceeding cautiously, does not overthrow the existing tenets of science. Indeed, these acknowledgments point to a stronger role for science, not a weaker one. By helping to form a social consensus on what possibilities exist, science lays the foundation for a more informed, democratic debate over which of those possibilities should to be pursued. Further, by improving the set of possibilities itself, science can reduce clashes that stem from conflicting values and interests.

In short, to borrow from the age-old distinction made by David Hume (1888), the strength of science lies in its ability to promote social consensus over what "is"; beyond that, society, not the scientist, must determine what "ought" to be. Consider, for example, the following characteristics of the scientific method (which do not exhaust the full set, of course).

A scientist:

- understands the necessity of the testability of a hypothesis, of repeatedly trying to prove her hypotheses wrong; and that a test result which does not reject her hypothesis in no way constitutes proof of its correctness (i.e., she understands the fallacy of affirming the consequent);
- directs her research toward the formation and testing of theories which go beyond prediction and help explain underlying mechanisms;
- recognizes the importance of testing under a wide variety of environmental conditions, and does not make claims that extend beyond the inference space of her testing;
- insists that all ancillary assumptions are clearly stated and have been widely tested, and she makes these assumptions transparent in her documentation;
- is rigorous in estimating both false positive and false negative errors (more generally Type I and Type II errors), and she designs experiments with sufficient precision to address both; and
- documents her results, submits them to rigorous and critical peer review, and encourages others to repeat her work.

These characteristics give scientific research an almost mechanistic quality, with the individual scientist as interchangeable as any standardized part in a machine. Yet the reason this model is so attractive is exactly that quality: if any scientist anywhere can run the same experiment and produce, statistically speaking, the same result, society's confidence in that result is bolstered.

This is why the model of the precautionary scientist, in our view, is a step backward. The precautionary scientist expands the boundaries of science into the sphere of social values and interests — into the realm of the "ought." If her values perfectly mirrored those of the rest of society, such an incursion would save us all time and energy — why not let the scientists tell us what we ought to do? However, the diversity of values in society makes this happenstance impossible, and so the scientist's injection of her own values into her science undercuts confidence in its accuracy and hinders the ability of scientific research to make its contributions to society.

The Cognizant and Transparent Scientist

As we have continually noted, purging scientific research of all values and interests is a futile, often counterproductive task. Because scientists are human, not mere mechanisms, their work will always involve choices, and those choices will always be informed and shaped by that humanity. Acknowledging the inseparability of science and social values and interests, however, does not prevent us from striving to keep the two spheres distinct. Unable to remain solely within the sphere of science, the scientist can still use her incursions into the other spheres to enhance the quality of her science, and take care to signal how her research has been shaped in the process.

She can conduct research in a manner that we call "cognizant and transparent." Our scientist is "cognizant" because she is aware of the social context in which research takes place, and is diligent in cautiously approaching choices that have important social consequences. She is informed by the challenges of the other spheres, and uses the knowledge she gains to explore new paradigms, test different hypotheses, and examine her results in even more self-critical ways.

In her own sphere, our scientist is "transparent" in how she conducts her research because, like Hansel and Gretel in the ancient fairy tale, she leaves a trail of "bread crumbs" — clear documentation — for others to follow. She identifies at each step the choices made in experimental design, data-gathering protocols, significance thresholds, and so forth. This transparency allows for independent verification of her results, a cornerstone of science, which her "precautionary" counterpart would let crumble.

Drawing a parallel to the precautionary scientist, what would a cognizant and transparent scientist look like? She would certainly be diligent in following the elements of the scientific method we have just listed above. In contrast to the precautionary scientist she would be one who:

- enlists individuals beyond disciplinary and even scientific bounds to help frame problems, but retains a scientific focus for identifying and testing solutions;
- focuses her investigations on measurable effects but acknowledges the possible existence of immeasurable effects;
- emphasizes relationships underpinned by theoretical or causal relations, but remains open to investigating relationships expressed through correlation, pattern and association;
- addresses uncertainties which may not be subject to precise experimental replication but distinguishes them from uncertainties that are subject to such testing;
- characterizes data by their ability to be quantified and replicated, assigning higher confidence in a greater ability but reporting the gamut of data types collected; and
- is equally rigorous in quantifying the potential level of both false negatives and false positives; and emphasizes one over the other only at the direction of social policy-makers leaving clear documentation of how this emphasis is achieved.

So, how would this second type of scientist handle our two examples?

In the first case, the cognizant and transparent scientist would use constructive social criticism to formulate, for example, hypotheses covering the effectiveness and safety of genetically modified organisms. In research on genetic modifications, the null hypothesis can be expressed either as "the treatment is not effective in producing the desired result" or it could be expressed as "the treatment has no unsafe impact on the environment." In contrast to the precautionary scientist, who would skew the choice toward the "unsafe" side, the cognizant and transparent scientist would recognize and test for both effects, using the appropriate experimental and statistical techniques. This scientist would be open to new measurements that would be useful in directing further research and forming new hypotheses. She would conduct her tests in a wide variety of places and over many years before claiming credibility for her results.

In the second case, the cognizant and transparent scientist would strive to improve the accuracy of stream-typing models, but not weigh errors against fish (that is, the environment) more heavily than errors against landowners, as the precautionary scientist would. She would consider the errors separately rather than summing the two because she is aware of the different implications of each; and she would push her research in one direction or the other only to serve an explicit social policy decision. She would seek the guidance of tribal, industrial and governmental individuals in shaping questions; and, while retaining leadership and control over the process of gathering data and testing hypotheses in her own experiments, she would encourage others to test her models in new watersheds and in different years. She would understand and accept the correlative nature of the models she produces, but would use current knowledge and theory in their formation in order to have them explain mechanisms for the results as well as just predicting them.

What distinguishes the cognizant and transparent scientist is simply a greater understanding of the geography of the modern world of science and policy. This understanding brings with it an awareness of the gray areas where the sphere of science and the sphere of social values and interests intersect with each other. There is never a clear dividing line between the two spheres, of course, but neither do they overlap completely. Being both cognizant and transparent, our scientist combines social awareness with the tenets of rigorous science. As a result, she treads carefully in the gray areas but does not shy away from them. The result does not magically make the controversies over science and policy disappear, of course, but it helps build greater confidence in the science itself and may even lessen the degree of controversy.

Erasing the Epitaph

When scientists and their research become embroiled in a controversy, we believe they should avoid the temptation to retreat back into their laboratory; neither should they go to the opposite extreme, abandoning the tenets of science by infusing their research with a particular set of values and interests. The choice of one set of values inevitably comes at the expense of others, and places the scientist beyond the boundaries of her training and discipline; it undermines society's confidence in all science, a discouraging and damaging side effect.

The conflicts facing science today are not historically unique. When Merton (1957) warned scientists against writing their own epitaph forty years ago, he could not have known that his advice would still apply today, perhaps with greater force. The scientific method has evolved for the past few centuries under conditions similar to the ones we are experiencing today — indeed, scientific research has rarely been conducted in an environment free of controversy. Having adapted to fit these conditions, science will always have much to contribute. If its practitioners follow the model we offer, they can strengthen the practice of science and, we hope, continue the long history of scientific contributions to social progress.

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Changes in Environment and Society

How did changes in forests influence society?

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It is quite plain; let us start at the very beginning, when our primitive ancestors lived in the canopies of trees and in caves, when forests, prairies, and a few natural deserts covered the entire planet. It can be said that there was too much forest for so few people, until the first great revolution of human history took place: the agriculture, that started with the clearing of forests or, in other words, destroying trees as the first act of civilization. Man was not only the father of this revolution, but very much its child; Domesticating plants and animals not only supplied the nutrients that helped to build the human brain, but also because the shift from gathering, hunting, and fishing to a farmer that uses tools –beginning with his head– around a more productive and continuous source of food and bio-protective supplies (clothing and housing), compels the function of thinking to build the organ of thought. As stated by the rules of physiology, an organ not only performs functions, but also the lack of functioning implies its atrophy; (The need to respond to environmental pressures effectively triggered the evolution of such organs.)

So human civilization began cutting down trees; and the first way in which the biped cave dweller became man was destroying the forest. Now we recognize that solar energy is directed to the industrious entrepreneur of the photo-chemical industry called the chloroplast with domesticated plants' leaves converting light and carbon dioxide, as the sole raw materials, but supported by the soil as a physical support and supplier of some mineral salts, water as a solvent, and air for breathing.

However, let us consider the admonition of Paracelsus –who was also an alchemist– in the sense that the dose makes the poison. This is because now the major threat to humanity is widespread deforestation resulting from the advance of agriculture into forestlands in the name of development and the welfare of humanity; this is not only putting at risk the forests and the different goods and services they provide to allow life on the planet, but also agriculture itself, which closely depends on them.

As a matter of fact, landing with these concepts on the splendid cultural artifact that is a city with all the facilities as now we are (Putra World Trade Center, Kuala Lumpur), simultaneously to the clearing of forests for croplands, the care of plants and animals forced man to settle down on what will become the germ of urban phenomenon: cradle of civilization and human culture, although it always said under the reserve of Paracelsus' dose, in the meaning that it is already the city that is threatening to become the grave of both.

What are the implications of deforestation for society?

To start, I would like to highlight what I stated at the International Symposium on Possibilities for Sustainable Forest Management in Tropical America, held in Santa Cruz de la Sierra, Bolivia, from July 15 to 20, 1997, and sponsored by BOLFOR, CIFOR and IUFRO:

"Before anything, let me tell you that when I was a child, there was no greater pleasure for me than walking through the "real forest" –which was the way the virgin forest was called– and playing with my brothers. This is similar to what the Nobel Prize winner for Literature, Pablo Neruda, describes in his memoirs "I Confess I have Lived" about the forests of Temuco and his childhood in Chile……. William Cordero has introduced me as a poet and, in fact, I do write poetry or, at least and this is not my fault, I feel like a poet; so I have always asked myself, with the obvious differences taken into account, whether Neruda was fascinated by forests because he was a poet, or if he became a poet due to his fascination with forests.

From my point of view and –I repeat– with the obvious differences taken into account, I just say in De Profundis (a poem which in Latin means from very deep inside) that I came to this world gifted with too many blessings / that I became indebted / for ever / with life:

in the middle of coffee plantations and trees
at the shore of a shady stream
of giant blue butterflies
with the elemental vapors of weeds
the evanescent steams of rain
and the savage fragrance of cosmogony in the
wild rotten matter
with its mushrooms added
with its bugs added
with its intrusive and gluttonous roots
its enigmas
its mysteries
the humid and fleshy offspring that engender
the serene forest
royal residency of true fantasies

under the brilliant mess of birds
and the tender pestilence of the crib
where Mom used to milk the daily cow”.

“At the shore of a shady stream / of giant blue butterflies”, the verses went and, in fact, these were two literal things: a shady stream and giant blue butterflies. I remember that my brothers and I used to spend whole mornings in the river and its tunnels of trees and mysterious meanders, fishing or catching strings of crabs… this is what I translate in “El Yangunturo” (one of my books of poems) as the Grace of innocent times / parenthesis of circumstance / habitat of transparent joy / den of the elementary being. Well, the fact is that many years later I returned to my hometown and that same stream, now completely stripped of its vegetation, had become a sewer and with it a part of me also died. Therefore, if anyone wants to point an accusing finger at the person who designated the banks of streams and other water bodies, as well as the hills, as ecological easements in the new Bolivian forestry legislation, that finger should be pointed at not other than me, and my lost stream somewhere in Peru.

At any rate, there certainly is not a better representation of the different manifestations of the miracle of life than forests. Obviously, there is also the ocean, but it is easier to walk into a forest than to dive into the sea. The tragedy lies in that there is no real forest anymore, either surrounding Temuco or my hometown, and the same has happened all over the world around cities, towns, villages. As a result, we have literally generated, in only fifty years, billions of human beings that are born and die without having the chance to what I call the “experience of the forest”, which is like dying without God or without having been born.

This is the root of human tragedy: when we speak to people about the need, as a mandate of intelligence, for conservation and sustainable use of forests, it is as if we were talking about the beauty of colors and the subtlety of tones to blind people, or about the music of Vivaldi or Debussy to deaf people. Naturally, politicians could be included among those blind and deaf people; politicians who have never been in a forest, as a source for basic goods and services for the people whose world they rule, but who, nevertheless, make decisions, every day, that affect the future of forests (or even better said and what is actually the worst as a fact, about no future for forests, and always, of course, in the name of a better future for the world).

A practical piece of advice would be: Stop talking to people about protection and environmentally sound use of forests; instead, take them into such forests, where they can get the “experience of the forest” that will make to grow in them eyes to see and ears to hear.

Undoubtedly, the main value of forests lies in their spiritual significance for the human soul, since a genuine quality of life has to become being genuinely vital. This is something that does not have a price in the market and is not a commodity, but it is indeed the most priceless service, since there is no way to pay for it. So this is, I say, a gift of forests: and only for that they already merit legal protection, since they are the most vital resource that we have at our disposal on Earth.

The Existential Categories of Man

Before continuing, let me explain something that is apparently obvious and thus it is assumed to be a tacit universal topic shared by all human beings, although it seems to have been completely forgotten by everyone, just because no one uses anymore to make emphasis about it. The question is: “Which are the existential categories of man as a distinct being, if not from the universe, certainly from the planet?”.

First, it is obvious that man is a living being –no matter how much he really behaves as such and enjoys each of the daily miracles that life offers–, and that is what makes man different from inert or motionless objects; but also, and together with his other existential categories, different from the nature and purpose of life forms in animals and plants.

Second, man is an intelligent being and, as such, is able to plan, decide, and build his destiny; to the point that awaking and developing his potential capacities looks like the inherent epitome of human understanding. Well, man is an intelligent being: and what is at stake regarding the concerns we are addressing, is that man is the only species, among more or less ten million other species conservatively estimated as human partners in the planet, who can do things in a deliberated way and, therefore, the only one with environmental responsibilities. As time passed and taking into account the environmental record of the world, there is no doubt that this is just the field of his less intelligent performance.

Third, man is a historical being, a being that creates history and cultural heritage, as well as he inherits it from his ancestors; and, as soon as he can be a hand-maker of himself, a being that develops his own capabilities at the same time that contributes to that social process we know as human history. This is the difference between this builder-man or homo faber and other builders in the animal kingdom, such as bees, for example, and whose architect of perfect symmetry is the genetic code drafted by the nucleic acid as a mere brunch of responses stimulated by environmental factors and fitted in the framework of survival instinct. However, let us remember here that bees never forget that there are no beehives without flowers and no flowers without plants and no plants without soil, water, breathable air, and other animals to disperse and pollinate the plants. This means that the bees' instinctive understanding prevents them from forgetting that negative changes in the environment are closely linked to negative changes in their society. This is the point we are going to address later on, talking about this builder-man as the best reflection of the historical existential category of human beings –and jointly with asking ourselves how much intelligence is really an intelligence that is increasingly going down even below the proper instinct of survival; precisely as we rush to build our beehives –the cities–, we are forgetting that we are completely dependent on nature.

Fourth, man is a cultural being, because he produces culture and has to live in time and place according to inherited culture, giving social answers in its range of permeability to atypical behaviors.

Fifth, man has needs, which means that he requires external elements, just as animals and plants do, but with additional needs that evolve together with his cultural and historical character. And the relevant issue regarding the topic that joins us here is that, as Karl Marx warned, man is a machine that generates needs; where the historical increase of needs –and even mere desires whose worse expression is the phenomenon of consumerism– produces an environmental impact on the natural resources of the planet, that is greater than demographic explosion itself. So do not ask only how much has human population increased since 1950, but also how much human needs and desires have also augmented in the same period, charging the incremental costs in the natural resources of "our only earth" (as was the motto for the 1972 Stockholm United Nations Conference, followed by "act locally think globally" which was the motto for the 1992 Earth Summit in Rio de Janeiro). For instance, if we are alarmed because since 1950 human population has jumped from 2,500 million to 6,000 million, we should be even more alarmed to learn that, in the same period, use of fresh water has increased fourfold compared to the population growth rate. No less alarming are the environmental indicators regarding impacts on soils, forests, and fisheries –including loss of biodiversity–, air –including acid rain–, atmosphere (ozone depletion and the greenhouse effect), and even in outer space, where we already have placed quite a bit of garbage. Not to mention, of course, impacts on and of non-renewable resources, like oil and other fossil fuels.

Sixth, man is a social being and here I simply quote the essay on "The Environmental Function of Property and Human Actions" which was included in my book entitled "Environmental Law.- Proposals and Essays" (1990): "By existential category we mean the simple fact that we are not social beings by our own will, but by existential determinism. We can be considered human only sharing with others. There have been many ways to refer to this category along history. For example, Cicero said that, by nature, man is used to forming groups; Voltaire said that man's instinct drives him to live in society, as it drives him to eat and drink; Aristotle states in "The Politics" that one who does not need to live in society is either a God or a beast; and twenty three centuries later, Jacques Monod, winner of the Nobel Prize for Physiology and Medicine in 1965, expressed that man is a social being by genetic transmission and cultural heritage. For the jurists' opinion, we just need to recall what Luis Recasens Siches understood by the word man. "The term man –he said– implies a reciprocal existence from one to others; a community of men, a society". Thus, the social being is implied in the word man".

Finally –and under reserve of inter alia– man is an ecosystemical being, in the sense that, quoting the above mentioned document, "the part of the ecosystem together with other biotic and non biotic elements that are in the biosphere; and whose actions are subordinated and subordinating to the ecosystem; that he is impacted by environmental factors and causes environmental impacts; that he is the last link of a number of food chains, etc.".

Therefore, there is nothing worse for a human being than refusal to recognize the existential categories to which he belongs. That is what is happening with humans who are alienated from nature and have lost their sense of belonging to and depending on nature (namely, his ecosystemical existential category), losing thus their sense of vitality, as the less intelligent expression of an intelligent being living without coexisting with life and the sources that nourish it: and where ultimately we must find the first rotten root of the loss of horizon for our social, historical, and cultural categories in the process of building human history. It is where we will end as a result of the destruction of forests; so, before we look into material losses that this destruction will certainly bring to humankind, we have to highlight the destruction that man himself implied in a process in which each new blow of the axe in the woods is equivalent to a new stab in a process of ontological suicide.

This is, in fact, the first unfortunate change in human society due to changes of forests into deserts: alienated from nature and absorbed by the landscape of human coexistence in stagnant compartments, in the cement and steel jungle of the cities, which grow at a pace that, even in developing countries such as Peru, has shifted since the 1950s from 70-30 to 30-70 as the ratio between rural and urban populations. The human soul has also been devastated, man has alienated himself from other beings and, what is even worse, from his inner self. Having lost our sense of belonging to the ecosystem, is it not strange that we give only what we have as a sense of sociability –comparing with the goods and services that are exchanged among trees in order to build the forest that makes each of them into a complete individual reality? We built social and antisocial societies where the incapability of interacting in society –certainly not for becoming Gods– is a logical consequence that in each individual member of the social body there is as much the vitality for exchanging, as the need to get in touch with life in the forests. This is the antisocial paradox of a gregarious being that forgets his links with nature! This is not the only drama: together with the urban phenomenon, during the same period, and with the technological advances in modern agriculture, also the relationship between farmers and land has changed abruptly, and now they have become hired hands of an industry that uses biological machines for converting hi-tech inputs into products.

I strongly believe that it would be impossible to build a properly humanistic society without recovering the sense of existential vitality, whose two major sources of inspiration are the seas and the forests, and where the best weapon we can use, since not many of us can be scuba divers, is to let people to have the "experience of the forest".

The fate of the forests is decided in cities where the alienation from nature is so obvious that citizens have forgotten that their entire lives depend on natural resources, yet they have no inkling of the way food is produced, fibers of the clothes they wear are made, the electricity they enjoy just at the turn of a switch is produced, or the water they can get just opening a faucet is provided, and, therefore, how these are exhausted.

Evidence of Alienation

The best evidence of this alienation is supported by these two pathetic facts:

On one hand, city based environmental movements present foresters and forestry operations as the bad guys in terms of forest destruction when we all know that the war we are really losing is against deforestation for crop lands. We all know that not even the worst forestry practices cause as much impact as the best farming practices. Here fits an anecdote on the technical validity of their discourse: I own a piece of land that is located about two hours away from Santa Cruz de la Sierra –capital of the major timber producing department in Bolivia– which I bought with the idea of establishing a Private Reserve of Natural Heritage (on which I will elaborate later) and I called it "Creator Spiritus" –in Latin the spirit of creation– and where I find that spirit or the closest thing to it. Well, every time I take this kind of environmentalists –and their "air conditioner discourse on rural issues"– to my forest and we walk into it, the same thing happens over and over: they fill their lungs with pure air that has a wild fragrance and, astonished, almost slobbering and with their eyes popped out, they enjoy and celebrate the advantages of a "pristine forest". So I tell them that this piece of land is actually as much a virgin as a prostitute retired after 60 years of uninterrupted work, but this is not noticeable since she practiced her trade only with foresters, not with farmers. As a matter of fact, that is the big difference between Creator Spiritus and the surrounding area: that my Saturday girlfriend (the woman retired from a dissolute living only with especially discreet clients, foresters) remains almost normal, with her trees standing, and, after the years, it is pretty hard to find differences between the virgin and the dissipated forest, because only under the fallen leaves you can find the rotten stumps of trees as evidence of former romances; meanwhile, in the surroundings, there are many abandoned brushy fields, some cultivated fields and pastures, and streams that have become dead puddles.

On the other hand –as further evidence of alienation from nature–, we have groups of city environmentalists demonstrating on the main square, wearing masks and asking the government to forbid slash and burn agriculture, and the renewal and disinfecting of the grasslands by fire. Well, I am the son, grandson, and great grandson of farmers and I myself own a coffee plantation –and let me tell you that it is the latest in fashion design, in terms of the lace and loops required for the agroforestry look–, so being an old hand at the trade I can quite confidently say that fire is the cheapest tool farmers can use, and the worst environmental damage is not a result of controlled burns, but of uncontrolled fires. The best way of proving this is that last year 13 million hectares were burnt in Bolivia, and of these only a hundred thousand were cleared for agricultural use and maybe a couple of million were burnt in savannas and grasslands. What I mean is that while the serious environmentalists try to implement regulations for clearing and controlled burning –obviously only in lands previously allocated for agricultural uses–, the others, those that portray loggers and foresters as the bad guys, scream for a law that stipulates zero burning. I would back their demands for passing such a law, but only with a small condition: I would challenge each one of these "zero burning" environmentalists to clear by hand, without fire, just one hectare that has been opened to expand the lands for feeding and dressing people. At that very moment I swear, by the chastity of my Saturday girlfriend –Creator Spiritus–, that I will not give up until this law becomes a reality.

Meanwhile, I will keep working with BOLFOR and supporting the Forest Service (Superintendencia Forestal) in trying to implement regulations for clearing and controlled burning; and, if we succeed, I assure you, no urban environmentalist will ever notice the smoke. I mean that if we reach the target we are aiming for, namely that the only areas burnt are those that peasants, farmers, and cattlemen really do want to burn. For us who know the value of this extraordinary environmental victory, the "zero burning" goal appears only as a distraction factor for our cause, a factor that, in the eyes of rural people, takes any credibility away from those urban green-asphalt movements.

The End of the Skin

The concept of "experiencing the forest", is a main tool for the process of social evaluation of forests and all the goods and services that make ecological viability a sine qua non condition for the planet's vital economy. The new forest legislation in Bolivia (Ley 1700 from July 12, 1996 and General Regulations approved by Presidential Decree No. 21453 on December 21, 1996) provides for the creation of Private Reserves of Natural Heritage. These allow any landowner to establish within his property, up to 5,000 hectares, for a minimum of ten years, in a voluntary and unilateral way: a public document explains the values to be protected, the initial status in order to have an objective reference for monitoring, the rules for control and vigilance to be applied, and communicates the decision to the Forest Service. In turn, the Forest Service approves the designation through a resolution conditional to annual certifications of validity, since all of these areas are exempted from taxes on rural property and have legal protection from being classified as unused lands or from seizure for such a reason.

The idea is to create a constellation of areas with standing forest –including interpretative trails, identification of trees, internal streams, etc.–, that multiply the chance of selling the "forest experience" and the smell of rotten trunks and fallen leaves, as a breath of God, for massive consumption by people who cannot afford what is offered to elite consumers who visit national parks as they would do exclusive boutiques.

The easements in private lands (such as steep slopes, riparian protection strips, wetlands, lakes and ponds, etc.), created by the above mentioned legislation, could act as branch offices of a franchise to give life to the human spirit and reconcile it with nature, as a precondition for its reconciliation with humanity. It would be nice if foresters could include eco-tourism programs in addition to their forestry activities.

From having cleared all the trees to stop hunger, to going hungry due to excessive forest clearing.

To recapitulate the concepts I presented at the beginning of this paper, the process of civilization, which started when the first tree was cut, can lead to disaster when the clearing of forests takes place in areas that are not suitable for agriculture or cattle ranching due to their tendency to different types of degradation, such as erosion. This is the seed for later tragedy in the case of environmental refugees. Haiti, for instance, is not the poorest country in the Americas by mere chance, but for having 50% of its territory turn into bedrock as a result of the clearing of its hill forests for croplands, which have lost their soil to erosion and now it lies at the bottom of the sea. I will not insist on talking about something that you already know: water supplies are dependent on forests and many countries, cities, and towns, all over the world, are now suffering the consequences of destroying watersheds and water catchments, to a point where wars might start due to water scarcity–or in other words by all the trees that were cut no matter where, when, nor how many–. On the other hand, the paradox is that clearing forestlands and protection forests, including ecological easements, exposes us to the risk of losing areas currently in agriculture. For instance –and of course this is neither the only nor the worst case, but the one I have witnessed– in the Bolivian lowlands, the Rio Grande has experienced severe siltation due to sediments originated by widespread deforestation, at such a fast rate that perhaps in less than a decade the riverbed might reach the top of one of the major bridges that cross it (1.5 Km), with all the implications for increased flooding risk and soil drainage problems in an area that supplies most of the soybean produced in Bolivia. Towns like Pailon (the Bolivian capital of soybean) and Okinawa (a Japanese colony) are now below the level of the riverbed; approximately three meters in the first case and almost six in the second. On the other hand, large rivers such as the Ichilo, Yapacaní, and Chimoré have experienced severe shifting in their riverbeds, which have extended up to 500 meters. No doubt this is a trend that can be observed throughout the Amazon basin.

As you can see, taking into account the environmental tragedy implied by the conversion of production and protection forests to croplands, to think of foresters as the bad guys is so banal as to pretend that the major problem for poor people is that they cannot have caviar and champagne. So the main priority is to oppose conversion and, then, ensure that production forests are managed in a sustainable way; these should also be a priority for the Forest Service. That is to say that, compared to the environmental disaster that unplanned land conversion might cause, even selective logging becomes a trivial subject, since at least in this case the forests remain standing and continue to provide ecological services;

not ignoring, of course, the severe damages that such poor timber harvesting practices would cause in the remnant forest in terms of genetic erosion.

Conclusion: Land Planning According to Land Use is, in This Case, the DosePrescribed by Paracelsus.

I teach my students that the best environmental management tool is land planning and that the second best is environmental assessment. The queen and the princess. And, therefore, if both were effectively implemented, we wouldn't have the severe environmental problems we are experiencing. Indeed, virtually all the forestry and agrarian laws that were passed in the last 50 years have used land planning as the axis for its normative structure. The problem is that in very few cases we have succeeded in enforcing it –or making a reality of what is written on paper and printed on maps–, organizing the country in protection lands, forestlands and agricultural lands; and doing this in the right place and the right way.

I would like to finish my presentation by recalling some of the progress that has taken place in Bolivia in terms of forestry, which I bring for you to take home, as a gift of my beloved adoptive homeland.

The new forestry law in Bolivia established Land Use Plans (Planes de Ordenamiento Predial) as a tool to bring to the farm level that which was established in a macro/planning level for departments or eco-geographic regions. So, the law stipulates that when changes in use from macro to micro level take place there should be a "principle of benignity for changes in use", meaning that it is permitted only to change to forestry or protection uses those lands allocated, at the macro level, for crops or cattle ranching, but not the other way around. Also established by the law was the principle of In dubio pro forest (if in doubt favour the forest) not only for preventive classification of forestlands and protection lands without being subject to studies for macro level classification, but also to resolve conflicts of potential uses that may arise during the process of classification (for example, the same land could be suitable for forestry uses due to the high quality of standing timber and also be apt for farming due to the good quality of soils; in that case, In dubio pro forest is the mandate of law). This land use planning (approved by the Agrarian Service –Superintendencia Agraria–) is a mandatory tool where ecological easements are defined, in order to be monitored by the Forest Service, and registered as a real state burden, being a requirement for selling rural property or to apply for farming loans. This tool is part of a group of tools that drive the National Forestry Regime, such as forest management plans; programs to control timber supply and processing (to prevent illegal trade of forest products by controlling processing centers in the cities, rather than prosecuting timber poaching activities that could be spread in vast land areas); the Forest Service itself (with an institutional design based on immunity from political pressure and vested interests); certificates of origin for timber to control timber harvesting; authorizations for land clearing and controlled burning; the character, by juridical fiction, of auxiliary agents of public authority by engineers and technicians working privately; juridical security for owners and stewards of land and forests (intruders can be thrown out in 72 hours); means of social accountability, etc.

Bolivia is undertaking an extraordinary effort to make this aircraft take off and reach cruising altitude by having all the engines working –which are the tools mentioned above–, in order to care for the essential element of natural heritage that, in the long run, would decide the destiny of the Bolivian people: its forests, including biodiversity, and lands in general. This may not be the story of Alice in Wonderland but I believe that, considering the scarcity of materials and even of qualified human resources, to have reached almost 800,000 hectares of internationally certified forests as managed in a sustainable way, to lead all tropical countries in this subject, and to have been the fifth country in the world with approved international standards for certification, means that something has been done the right way.

In the name of this combative people who struggle in the middle of the loneliness of their isolation that swims in an ocean of forgetfulness, my greetings and exhortation to build humanity, building the culture of the tree in the human soul.

People Issues in Forest Management

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Introduction

It is an honor for me to speak to you today in place of Dr. Carol Colfer of CIFOR. Dr. Colfer sends her regrets and shared some of the remarks she planned to cover in her speech. The title of her speech was "Cultural Diversity in Forest Management." I have read her speech to make sure to cover the points she would have made. Amazingly, I found that although she and I may use different words and different approaches, we would be speaking about the same subject and that is, the importance of people issues in forest management and the need to consider social factors in planning for sustainability of the world's forests.

A View of the World Forests

Much of what is known about the state of the world's forests is summarized in a paper by David J. Brooks, "U.S. Forests in a Global Context," which can be found on this home page http://www.fs.fed.us/global/pub/links/global.html. The picture that is painted is a shrinking forest resource, increasing world population, much of which is poor, and loss of forest cover due to a host of reasons

Shrinking Resources. Forests cover about 4 billion hectares of the earth's surface or about 30 percent of the land area. Because the definition of forest is fairly liberal-land with trees taller than 7 meters and having a density of about 20 percent or more-we expect that the actual forest cover is less. One half of the world's forests and 80 percent of the world's population is in Asia, Latin America, and Africa. Many of the tropical forests happen to also be in developing countries, and are mostly in the tropical zone.

In the past 20 years, increasing public attention has been given to a variety of global environmental issues, including climate change, ozone depletion, and loss of biological diversity. In the United States, the attention to these issues has often surpassed the concern for the availability of timber or industrial forest products. The concern for deforestation over the last 50 years was focused mostly on the loss of tropical forests, although temperate and boreal forests have received their shares of attention.
Population. "Too many people, too little land" is a common lament in many parts of the world. The distribution and population growth rates will increase pressure on global forests in the coming decades for both industrial products and environmental services.

Poverty. More than half of the world's population and two-thirds of the population of developing countries still live in rural conditions. More than 80 percent of the world's population is relatively poor, and relies on forests for basic sustenance - principally fuel and land for growing crops. These factors explain a rapid loss of tropical forests (170 million hectares of tropical forest between 1980 and 1990).

Land Use Change. In addition to uncontrollable harvesting of timber for basic needs such as fuelwood, land use changes for agriculture, industrial, and urbanization purposes contribute significantly to the reduction of forest cover. It is also important to note that fuelwood is still the world's most important use of timber (90 percent of timber production in developing countries and about 50 percent worldwide).

Analysis of world trade on imports and exports was given in Brooks' paper. It shows that the United States is a net exporter of pulp and paper products and is a net importer of solid wood products from tropical countries. The consumption patterns of the wealthy nations and the need to sustain economic growth led by the United States will continue to be a factor in the flow of wood materials around the world.

What are the people issues?

As a research community, we are playing an important role in the sustainability of the world's forests. In the debate about sustainability, where the environment and people are intricately linked, often the focus has been on the ecological element without sufficient attention to the equally important social and economic components. Whether we are interested in cultural diversity, or the contribution of cultural diversity in forest management, 1 believe it is worthwhile for us to discuss people issues that need to be taken into account in forest management.

Some United States Issues. There are several issues in the United States that may be rather unique and may deserve attention from all government, academic, as well as private sector research perspectives. They are:-

Tribal relations. Robert Tippeconnic (1995) gave a good overview of Native American perspectives and philosophy toward nature and their relationship with the place, the land, and resources in North America. Native Americans are indigenous people of the United States, including Native Alaskans and Native Americans. Today the U.S. Government recognizes 547 Native American tribes. The largest is the Navajo Nation in the States of Arizona, New Mexico and Arizona. These tribes own about 23 million hectares. Today, they have a unique relationship with the U.S. Government. As sovereign governments, tribes have much to say about the welfare of tribal members and the management and use of tribal lands and resources. Some tribes, in ceding their lands to the U.S. Government, reserved the rights to fish, gather, hunt, and graze livestock. However, there are still many situations where certain claims by tribes are still unresolved.

Underserved communities. The population of the United States is getting increasingly diverse. There is a realization that forest management must take into account the needs and desires of all segments of society, including underserved populations and communities. Coincidentally many of the underserved happen to be ethnic minority and poor communities. Forest Service research is trying to understand ethnic participation in resource management and use. Also, there is a need to increase the use of natural resources by the underserved community. A model of such work is the social science research on cultural diversity of Los Angeles County residents using the national forests (Tierney, Dahl and Chavez, 1998).

Environmental justice. The President issued an executive order directing "Federal actions to address environmental justice in minority populations and low-income populations." According to this law, all populations should be provided the opportunity to comment on land management proposals before decisions are made. All populations are allowed to share in the benefits of, and are not affected in a disproportionately high and adverse manner by government programs and activities affecting human health or the environment. This assurance is implemented as part of the National Environmental Policy Act (NE-PA) compliance procedures (USDA Departmental Regulation, 1997).

Subsistence/dependence on natural resources. Many shifts in forest policy are possible because of the social and economic structure of highly developed industrial economics. Many forest-dependent communities of the Pacific Northwest have been able to adapt to these shifts, thanks to a reasonable prospect of re-employing labor displaced by reduction in commodity uses of the forests. The United States as a whole has been able to adapt because the consumer impacts of reductions in commodity production can be mitigated by technological developments and by the ability to import commodities. In other words, wealthy countries have more decision space in setting forest management policy. This is not true with many communities in the United States that do not have options (e.g., Appalachia and many remote areas where there are no alternative employment opportunities).

Developing World Issues

Upland development. Throughout the mountainous areas of Southeast Asia and Southwest China, poverty, population growth, environmental degradation, social marginalization, and economic dependency are now interacting to create a downward spiral that is currently reaching crisis proportions, both socially and environmentally (Neil Jamieson, Le Trong Cuc, and Terry Rambo, 1998). Interestingly, this phenomenon is not unique but is quite common to many mountain communities around the world.

Loss of indigenous knowledge. The reliance on forests for subsistence is highest in the mountainous areas, especially in the tropical forest areas. Often, the ethnic minorities are also residents of mountainous zones. As a case in point, 51 ethnic groups live in the uplands and mountainous regions of Vietnam. As population increases in the lowlands, and the need for land increases, there is an upward migration of lowland people to higher elevations looking for land to grow crops such as tea and coffee. The tribal and ethic minorities are being forced to move higher up, or be totally marginalized. Coupled with the degradation of watersheds and loss of biodiversity, the loss of indigenous cultures and the richness of their knowledge is a major concern.

Involvement of local people to solve environmental problems. Realizing that centralized decision making does not promote sustainable forest management, the governments in the Asia-Pacific region are experimenting with decentralization and devolution of forest management responsibility to local government (Philippines), to local units in China, Laos, and Vietnam. There are different approaches and also debates about what degree of decentralization (of administrative functions) and devolution (of power) is desirable (Enters et al., 2000). However, it has been shown in many areas that the best way to create jobs, prevent illegal logging and poaching, reduce shifting cultivation, and invest in long-term management of forests is the practice of community forestry. Incentives to manage for both forest cover and economic well being will be the driving forces for sustainable forest management. In many cases, the communities already have the infrastructure, such as women and youth unions, that can be mobilized to accomplish goals that cannot otherwise be attained.

Fair and equitable distribution of resources. A look at distribution of land and resources reveals that the axiom "too many people, not enough land" may not be totally correct. The real issue is in the distribution of land and resources. Besides land, the other significant resource is water. Many population centers are built around waterways or depend on availability of water at the expense of poorer and rural communities. Environmental justice still has a long way to go worldwide.

Agroforestry. At the interface of farming and forest management, the combination of crops and trees has to be part of the landscape. Agroforestry is extremely important for the management of buffer zones between farming communities and natural forest reserves. Although the science and knowledge base of agroforestry is improving with experience in general, much experimentation and learning is needed to be adaptable to local conditions.

Managing ecotourism. Ecotourism is an important opportunity to improve economic conditions for communities near centers of high and fragile biodiversity such as the buffer zones around biological reserves. Successful ecotourism schemes require partnerships between many levels of government and local people, non-government organizations and people skilled in networking. Unfortunately, human weaknesses such as greed and unreasonable control lead to lack of the trust needed for successful partnerships.

What Forests Services Research & Developement is Doing to Respond

The Forest Service International Programs staff has a strategy of several focus countries where several programs are managed. To name a few, the programs are fire management, forest monitoring/remote sensing, forest health/invasive species, migratory species/habitat management, watershed management protected area/ecotourism, sustainable forestry practices, policy analysis and development, and disaster assistance. The various countries where the Forest Service has programs include Brazil, Mexico, Venezuela, Indonesia, India, China, Vietnam, Russia, and more.

Forest Service scientists have been involved in international work, and several FS representatives at this IUFRO Congress have been leaders in their field of expertise. The role that FSR&D plays is to provide technical assistance with many areas of expertise such as fire management, insects and disease, silviculture, wildlife management, forest products technology, inventory and monitoring, etc. There are many more areas that we would wish to be engaged in but still lack the capacity to respond.

Challenges to IUFRO

In the words of Neil Jamieson (East-West Center) who has spent a lifetime in international work, the ground is littered with failed projects. What can we, as a science community, do that adds value to what is most needed? 1 suggest more attention on a few research areas that seem most appropriate:

Preservation and Restoration of Indigenous Knowledge. Together with biodiversity and forest cover, indigenous knowledge of land management is disappearing everyday as the fragile mountain ecosystems are degraded. The need to capture the knowledge base of the environment and how to sustain it is more urgent than ever before.

Community Forestry. Engaging people's participation is a noble goal that requires a great deal of effort. However, without research to understand what people want and their ideas for co-management of the land, the projects will not be a success.

From the economic development point of view, more research is needed in the areas of agroforestry and special forest products that provide options to local people, regardless of country or region of the world. The values of non-timber forest products will expand options to manage for timber species and for larger trees.

Although plantations are a small fraction (3-5 percent) of all forests, they are managed intensively to meet the needs for timber, and non-timber forest products. Use of indigenous species plantation should be encouraged to avoid drastic landscape change and non-native species invasive problems.

Special research attention should be given to sustainable forestry in the highlands where the ecosystems are at highest risks. Special skills and social science to resolve conflicts are badly needed to deal with various interests from different groups and governments

Finally, research can help develop opportunities to enhance environmental and economic sustainability with well-designed ecotourism schemes.

Closing Statements

I began this speech with a fairly bleak picture of the state of the world's forests. I am, however, going to end with a note of optimism. I believe that research and development will play a larger role in sustaining the world's forests. I believe that our contributions go beyond technological and ecological fields. There is a whole realm of social and people research that we will bring to bear on policy and management. Dr. Colfer would agree with me in her prepared speech: "...we have to move on from forestry culture that excludes people. The world's forests as they exist today are the product of millennia of interactions between people and their environment."

I would suggest that we work together to develop a deeper understanding of the cultural diversity that is inextricably linked to our environment. We also need to be more engaged with local communities to develop the solutions that are adaptable and relevant to the long-term sustainability of their culture and environment.

Thank you and have an exciting discussion on this topic.

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Cultural Diversity in Forest Management

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Introduction

As an anthropologist, I feel particularly honored to have been invited to make this address to IUFRO's Congress 2000. I have spent much of my life among people who have sophisticated and productive ways of managing forests and I have been frustrated at the fact that foresters have often failed to recognize the knowledge of these communities and the role they can play in modern sustainable forest management. The cultural diversity that impinges on forestry through the variety of traditional management strategies extant in the world's forests is extraordinary. Local communities' forest management practices have been the subject of anthropological investigation for a number of years (Conklin 1957, and numerous anthropological pre-cursors). But only recently have there been serious attempts to bring the knowledge of foresters and that gathered from local people by anthropologists and other social scientists together in a productive and synergistic way.

Just as we have come to recognize the significance of biodiversity in recent years, it is now incumbent upon us, in my view, to acknowledge the potential of cultural diversity. In this presentation, I begin with two examples of local forest management systems. I then discuss the ethical and practical reasons for attention to such systems, particularly pragmatic ways by which this kind of knowledge can benefit foresters and the forestry profession. I conclude with some suggestions relating to ways we might improve our ability to tap local knowledge, organization and creativity in solving today's pressing forestry and environmental problems.

Cultural Diversity

If we look at the remaining forests of the world, we can find a huge variety of human patterns of behaviour, belief, and preference in these forests. From my perspective, these differences represent a true treasure trove of knowledge and potential that we are not using at our peril.

My communities leads me to think we can make better use of this human resource. I give two illustrative examples that I know well, below; but these are replicated in myriad combinations and forms, many times over if we consider the world at large. I selected these two examples because they represent two purported extremes, from a group considered by some to be "under-developed" (from Indonesia) to a community in the "developed" world (the United States)—yet they share significant problems that relate to issues of cultural diversity.

I first went to the Indonesian community of Long Segar, East Kalimantan, in 1979, and have maintained contact with that community ever since. I began working in the American Quilcene (in the State of Washington) in 1972, and have made periodic visits back, with the most recent being in 1997. Neither the forests nor the people have fared particularly well in either location. I should stress at this point that I am pointing no fingers—the reasons for what is happening in forests and among people of diverse cultures around the world are complex, without simple villains.

Long Segar, East Kalimantan, Indonesia

Long Segar is a village of Dayak swidden cultivators who reside along the Telen River in the middle of the Indonesian province of East Kalimantan (for a fuller description, see Colfer with Dudley 1993; Colfer et al. 1997).[2] In 1979, when I first moved to Long Segar for a year of research, the village was surrounded by tropical rainforest deemed valuable by foresters and loggers primarily for its abundant, uniform, light hardwoods—the dipterocarps that fed the world's plywood mills.

The Uma' Jalan Dayaks who lived there depended on that forest for a much wider variety of goods and services. Their swidden system involved the cutting of 1-2 ha plots each year, for rice cultivation, supplemented by a variety of other secondary food and medicinal crops (peppers, cucumbers, corn, etc.). Soon after the harvest of the rice crop, the people could begin to look forward to the maturation of some longer term crops like cassava, banana, papaya, which kept bearing for a year or more. Gradually the field would be "invaded" by the natural regrowth, in which medicinal plants thrived, along with a number of edible ferns, palm hearts, and so forth. As the forest began to take shape again, fruit trees, domestic, semi-domestic, and wild, began to mature. After a few years, the fruits could be harvested. Along with such fruits, rattans, bamboos and other fibres grew to harvestable size, while the forest evolved into a suitable habitat for mammals, large and small. Eventually the trees grew large enough to harvest as timber and the forest took on the characteristics of old growth (cf. also Mackie 1986; Chin 1985, for more ecological studies of this system in nearby communities).

[2] The Long Segar example is particularly relevant in the Malaysian context, since many Long Segar patterns are similar to longstanding Malaysian, particularly Bornean, examples (cf. Brookfield et al.1995; Chin 1985; Freeman 1970; Geddes 1961; Kedit 1993; Langub 1993; Metcalf 1974; Morris 1976; Padoch 1982; Roseman 1991, to name a few).

This agroforestry system created a patchwork or mosaic of forest stands at different ages surrounding the village, allowing for a diverse range of plants and habitats appropriate for a variety of animals. Each family had access to land in several stages of regrowth, allowing diversity of diet. These different micro-habitats, available to each family, were typically not equally affected by any particular natural disaster, forming a safety net when disaster struck (whether drought, floods, fires, or pests and diseases of various kinds).

The system, in a context of low population density, also maintained ecological functions, protecting the soils and river quality by keeping the soil covered most of the time, and contributing to aesthetic values like clear water, shade, diverse animal life, and natural beauty.

The traditional management system involved rules of use. Individual families had rights to particular plots (initially obtained by cutting a rice field), transferred to their offspring of both sexes. Yet the village retained a voice in decisions about land and resource use in the village territory. Decisions to make rice fields in a particular place involved discussion among the families owning adjacent plots and there were mechanisms for resolving related disputes within the village. There were regulations to preclude the wanton destruction of valuable trees; and rules that allowed individuals to claim particular trees for which they had an intended use (partially detailed in Colfer et al. 1997).

Knowledge about ecological matters—plant and animal identification, patterns of behavior among animals, seasonal variation in availability of forest products, appropriate habitats and growth requirements for different species, etc.—among the general populace was substantial. Particular sub-groups within the community tended to have more knowledge about particular topics: Women knew more about medicinal plants (cf. Leaman et al. 1991); men, about hunting (cf. Puri 1997; or among the Iban, Wadley et al. 1997).

Now, in the year 2000, much of this forested habitat has disappeared. First it was commercially logged under the direction of the Indonesian government and Georgia Pacific (later P. T. Kiani Lestari). Then one part was allocated for a several thousand ha transmigration area; another area was handed over to the timber company for plantation development (cf. Colfer with Dudley 1993); local people were urged to shift to permanent tree crops; and in 1997-98, the whole area burned, leaving grasslands, vines, and disheartened, hopeless people (cf. Colfer 1999)

Quilcene, Washington State, USA [3]

In the mid 1970s, Quilcene was a small but thriving logging community on the Olympic Peninsula of Washington State (see Colfer 1977; or Colfer with Colfer 1978). The area was forested (hemlock, Douglas-fir, spruce, cedar), owned and managed by a complex mix of individual and industrial land owners, the US National Park Service, the US Forest Service, and the State of Washington.

The community was composed of, and divided by, two "camps": "Locals" and "Public Employees", marked by different values and ways of life. The "locals" were stereotypically born and raised in the area (though some in-migrants adopted the "local" lifeway and "passed" as locals), with logging being the symbolic heartland of the local "subsistence system" (see also Colfer et al. 1999, for a brief overview of Quilcene stakeholders and their characteristics).

"Locals" had an interest in and knowledge about the local environment, including a whole host of experience with local natural resources. They knew when and where to find huckleberries and the prolific blackberries, various kinds of mushrooms, and other forest foods—often canned or frozen by the women. Some harvested wild salal and other forest plants for sale in the cities to florists. Hunting was a popular sport among the men (deer, elk, mountain goats were favorite prey) and fishing was a passion for others (salmon, rock cod). Gathering oysters, crabs, gooeyducks and other clams from the exposed tidal areas were regular activities for young and old.

"Public employees' were those families whose primary wage earner was employed by one government agency or another (including local school teachers). They were reputed to be better educated than the locals; but they were also labeled disrespectfully as "paper pushers" by local community members. US Forest Service employees were the symbols for this category. Knowledgeable about technical forestry, their job descriptions did not really allow them to recognize the myriad functions to which local forests were put. The emphasis was on logging and managing the forests for sustainable timber production. Other functions were substantially lower in USFS priorities.

By the late 1990's, much of the Olympic Peninsula's old growth forest had been logged, and environmentalist pressures put a stop to logging there. Young local families had moved out; the once thriving community of loggers had

[3] There are a number of useful books that discuss some of these issues: White (1980), Van Syckle (1980), Lien (1991); Satterlee (1992). Dietrich (1992) provides the best summary of the issues.

become a self-described "sick community" of retired people and public employees (Dietrich 1992 notes the same process in nearby Forks). Like in Long Segar, the cultural integrity of the community has been attacked at its core; and the old growth forest has also been decimated.

I cannot trace the exact links between the attack on the integrity of these cultures and forest loss; nor can I identify any one group of people solely at fault. I suspect there are other factors, like global power and wealth inequities, high population growth, corrupt governance, that are affecting both people and forests. But these two cases represent a more widespread and depressing pattern that contains important warnings for all of us interested in the fate of people and forests.

Ethical Issues in Which Foresters Play a Part

Prabhu et al (1998) have argued that the whole idea of sustainable forest management is intimately connected with our value systems—meaning that we cannot reasonably ignore cultural diversity (one important source of differing values). Addressing these values head-on makes a certain amount of sense. Besides the probable fact that most foresters do not want to play a continuing, though often unknowing, role in the kinds of human and ecological problems outlined in the previous section, there are a couple of issues that should strengthen our interest in integrating cultural diversity issues in forest management in a more meaningful way.

The first issue is one that has been used routinely when defending our concerns over biodiversity. Just as we do not yet know which aspects of biological systems and which particular plants may prove useful, even vital, to humans in the future, so we do not know which aspects of human systems may prove important for our future viability as a species. The fact that many communities, and the integrity of their ways of life, are directly dependent on maintenance of forest ecosystems is the central link between this issue and the forestry profession.[4] I do not argue for protecting cultures in some pristine state, as one might collect zoo specimens. Rather I suggest that recognition of the complexity and dynamism of human systems is a necessary first step for foresters of this millenium. Such recognition can foster respect for local human systems and help us make effective use of the global cultural and intellectual wealth represented by forest-based cultural diversity.

A second ethical issue relates to what many consider a human right: for forest people to have a say in the direction and speed of change to which they are subjected. This issue is also often phrased in terms of global concerns about democracy. In many forests, the inhabitants are marginalized within their own societies—by poverty, low educational standards, lack of infrastructure, ethnic discrimination, etc.—and do not have the means to make their views and preferences felt.

The scale of these ethical issues ranges widely, from concerns pertaining to the whole human species, to concerns pertaining to individuals in communities. In the next section, I turn to a scale we are usually more comfortable with—that of individual forests and individual communities. This scale is perhaps the one at which we have the most potential to effect benign changes.

The Utility of Cultural Diversity for Foresters and Forestry

Whether your interest is in enriching the future of humanity by maintaining cultural diversity or protecting a particular forest by using cultural diversity, I argue that it makes sense for foresters to work with local communities.

I turn now to the pragmatic reasons foresters may be interested in what cultural diversity has to offer. Many foresters have become increasingly interested in looking at forestry from a more holistic perspective, recognizing and better managing the multiplicity of products that forests produce—beyond timber (cf. Jerry Franklin's "New Forestry"). However, such a goal requires new methods, new approaches that are a bit alien to conventional forestry. I believe that local communities can provide important hints about these issues, with their long experience of multiple uses of their forests.[5] And—for those who are interested—making use of such experience and knowledge can contribute substantially to protecting cultural diversity.

I propose three principle ways that local communities, in all their diversity, can contribute significantly to formal forest management—whether primarily for timber production, for conservation purposes, or for multiple use forestry. These suggestions simply build on existing, usually informal, management of the world's forests.

[4] To put this issue in a contemporary and controversial light, the Malaysian Government has often publicly criticized the negative aspects of human systems in America (e.g., governance, economics, morality). Supporting and encouraging cultural diversity represents one practical mechanism for countering potential adverse impacts of globalization and possibly western-dominated cultural homogenization.

[5] Other fields are ahead of forestry in taking advantage of this expertise. In agriculture, for instance, there is a vast literature on collaboration between scientists and farmers (farming systems research and development); in gender and diversity studies, the relevant and often neglected knowledge of women and other marginalized groups has been demonstrated repeatedly; in health and family planning, the use of and cooperation with traditional practitioners has blossomed in recent years.

Knowledge

First, many local communities have a vast store of knowledge, based on generations of day-to-day experience with their environment. This knowledge is typically unavailable in any immediate sense to newcomers (such as forestry professionals and other formal forest managers). This knowledge can be holistic, such as practical understanding of how local ecology functions.[6] Kenyah and other Bornean Dayaks have agroforestry systems that make use of natural processes of regeneration after forest clearing for environmental and economic services; that they have a holistic understanding of their own systems has been demonstrated in numerous ethnographies.

Leach and Mearns (1996) have compiled a series of analyses of large scale and long term development efforts built on inaccurate understanding by outsiders of African ecological contexts—contexts that are in many cases understood and manipulated by local people to their advantage. Such major misunderstandings are common when managers, politicians, and researchers do not listen to local people.[7]

Fairhead and Leach (1996), for instance, have done exhaustive historical studies showing that rather than an invasion of savannahs from the north, in northern Guinée, as is commonly assumed, local people have in fact been central actors in extending forest islands into that savannah. This is a West African example of the kind of overall understanding of ecological processed mentioned above.

Box 1 (excerpted from Fairhead and Leach 1996:109)

"People value forest islands around their villages for numerous reasons, whether for the protection they provide " convenient sources of forest products or for suitable microclimatic conditions for tree crops. Historically, forests reinforced fortification, and parts of them continue to house men's and women's initiation and ritual activities. Inhabitants therefore encourage forest island development more or less deliberately, principally by altering fire and soil conditions so as to favour forest regeneration (Leach and Fairhead 1993; 1994). Collecting thatch and tethering cattle on the village margins remove flammable grasses and help create a firebreak. When necessary, this can be supplemented by a targeted burn in vegetation on the settlement margins early in the dry season to reduce the effects of later, more damaging fires. Gardening, villagers assert, tends to create soil structure and water relations favourable for tree establishment. Sometimes settlements are founded on old garden sites, or their margins are deliberately gardened for a limited period to help forest establishment. The village-edge soils are also fertilized by the excreta of domestic animals and people, and by hearth ash and other wastes scattered there. For all these reasons, savannas on settlement margins tend gradually to develop dense semi-deciduous moist forest vegetation. Initial fire-resistant tree species gradually cede to more fire-intolerant ones, pioneer forest species cede to those typical of later forest successional stages, and biodiversity increases over time.

At times, villagers have accelerated the formation and establishment of forest islands by planting trees. Before the twentieth century, for instance, silk cotton (Ceiba pentandra) and other fast-growing tree species were commonly planted as part of settlement fortifications. Islands have also been modified and expanded to create tree crop plantations, whether for the kola anciently valued and traded in this region, for coffee which became an important cash crop from the 1940s, or for the fruit trees and bananas currently favoured by villagers. Villagers also enrich forest islands with useful food, medicinal or construction species, by transplanting wildlings or encouraging their growth from suckers or cuttings.

For inhabitants, then, forest islands are far from the relics of a disappearing 'nature'; instead they are strongly associated with settlement, existing because of it and its everyday activities."

Box 2: (excerpted from Cline-Cole 1996:129)

"Environmental protection and fuelwood production, the two pillars of introduced forestry, rate much less highly as goals in indigenous forestry. The latter places a much greater premium on fruit and food production and shade provision, with environmental protection and fuelwood production being considered of only subsidiary importance. Similarly, although introduced forestry favours a few "dedicated or single-use exotic, species, local inhabitants perceive that, overall, with the exception of the (naturalized) exotics neem (for shade) and mango (for fruit), indigenous multi-purpose species are much better suited to the dominant goals of insider forestry. Such species make up 18 of the 20 species reported as the most frequently occurring farm trees in the drylands (Silviconsult 1991). And, while the Kano State forestry establishment, for instance, speaks of "a total lack of [seedlings and tree] care

[6] As with formal scientific knowledge, local knowledge is incomplete, partial, sometime wrong.

[7] It is important to stress here that listening to local people is different from doing whatever local people want. What I propose involves listening to them, and then working together to develop cooperative and adaptive management that builds on what is good from both local and formal management perspectives, striving to solve problems.

and protection…and [a] general ignorance of the importance of the uses of trees on the part of collectors" (KSAC 1987:6), there is increasing evidence that forestry management practices like the protection of naturally regenerating seedlings, transplanting of wildlings and farm-tree planting continue to be widespread in the drylands (Lockwood 1991; Silviconsult 1991)."

In Box 1, Fairhead and Leach summarize the view local people have of their forest-savannah mosaic in the northern margins of Guinée's forest zone, and how and why they contribute to its expansion:

Cline-Cole (1996) reports similar differences in perception of ecological problems and their solutions, in a Nigerian example, see Box 2.

Ethnographic descriptions of traditional systems abound (cf. for example, the collection by Croll and Parkin 1992, for Africa; Clay 1988, or the Redford and Padoch 1992 collection for South America).

Another kind of knowledge is what has come to be phrased "indigenous knowledge" by many. See for instance, the journal, Indigenous Knowledge and Development Monitor, published in the Netherlands. There is also a worldwide network of Indigenous Knowledge (IK) Centres, listed in this journal. IK usually refers to specific, technical kinds of knowledge, such as forest products in the area and their uses that may be unknown to outsiders, behaviour of local animals, growth habits of local plants, and interactions among local species.

Almost any ethnography that addresses natural resource concerns of the people studied includes some aspects of indigenous knowledge. However, foresters and other natural scientists may be reluctant to confront the jargon and sometimes dense prose of social scientists.

Local knowledge has been approached more directly by anthropologists in the sub-discipline of ethnoscience since the 1950s (Conklin 1957). This research has included local taxonomic classification, keys, componential analyses to determine how local people differentiate among classes. It has drawn from psychology, linguistics, and ethnobotany; and more recently has shared conceptual approaches with the field of artificial intelligence. The results of these studies form an excellent starting point for foresters interested in gaining access to some of the benefits of cultural diversity directly.

The University of Wales in Bangor has an Ecological Knowledge Research Group that publishes studies on agroforestry-related, knowledge-based systems. They strive to integrate local people's knowledge more effectively into interdisciplinary and development contexts. Their computer-based approach, which strives to tap the underlying logic and rules of indigenous knowledge systems by integrating the methods of ethnographers and knowledge engineers (e.g., Southern 1994; Joshi 1997; Walker et al. 1997), also holds promise for application in forestry contexts.

Institutions and Organizations

The second way in which cultural diversity can contribute directly to forest management derives from the existence of indigenous or local institutions and organizations (cf. Ostrom 1990, 1994; Blunt and Warren 1996). All cultures have institutions, whether we mean by that term, organizations or rules and regulations. Local organizations are natural entry points into communities; they represent patterns of interaction that can serve as communication and mobilization channels; and they can serve as sources of information and inputs by local people into the planning, implementation and evaluation processes necessary for effective management.

In many forested contexts, local people's traditional rules and regulations—which functioned in the past to regulate and monitor access to resources—have been weakened by ineffective state efforts to establish control (cf. Peluso 1994; Dove 19??; Cline-Cole 1996; Colfer et al. 2000). However, in many areas, sufficient strength remains on which to build, if external managers were to support local efforts in this regard.

Human Resources

The third way in which cultural diversity and forestry come together pertains to the human resources local people represent. In the broadest terms, their creativity is currently unavailable in most forest management contexts. Although local people are there, their input is not sought, their views and potential solutions not heard.

However, to get more specific, one particular role they could, but normally do not, play involves monitoring. Problems of both local communities' and other external actors' (like loggers, plantation companies, conservation projects) failing to comply with regulations are commonplace.

In West Kalimantan, where I worked with local communities to co-manage a wildlife reserve in the early 1990s, we found that logging companies were not complying with the governmental regulations stipulated in their contracts. The government did not have the funds, personnel, or even expertise, to monitor such contracts; the result was that the timber companies had a free rein. This example was by no means unique.

Involving local communities in the monitoring activity—assuming they could also be involved in setting the regulations to be followed by all parties—could ensure routine availability of monitoring personnel, with a motivation to monitor effectively.[8] Simply letting local people know the existing regulations would be a first step in many areas, like West Kalimantan. Going beyond that, to joint regulation setting, could result in progress toward a more equitable division of benefits from forest use than is currently the case in many forests.

Conclusions and Actions

So what does all this imply? When I think of forest management I carry with me a number of assumptions. I assume, for instance, that we want to maintain the environment, ensure continued production of forest products, and maintain and hopefully improve the quality of human life in and around forests. I also have concluded that in both forested and human contexts, the normal state of affairs is dynamic and changing, that complexity is and will continue to be the order of the day. Finally, I assume that sustainability of all these things involves serious value judgments—on the part of all stakeholders.

If we are interested in all these things, I think there are some implications for the training of future scientists and managers (both social and biophysical). We all need to learn more about each other's disciplines, and learn more open-minded attitudes that can enhance our abilities to work together. Foresters would benefit from more exposure to what we already know about cultural diversity, particularly as it relates to forestry issues; and social scientists could do a better job of contributing their expertise if we understood more about biophysical sciences. Both would benefit from reductions in jargon. These are long term goals….and the truth is, the forests and the cultures they have spawned are being degraded and disappearing at frightening rates.

We have concluded at CIFOR that we must orient some of our research to improving forest management by trying to integrate the culturally diverse knowledge and institutional systems, and local human resources with other extant systems of management—now. We are hypothesizing that more collaboration among stakeholders and more institutional learning (adaptiveness) will result in better management. To test this, we have selected a range of forested sites in forests in Asia, Africa and Latin America (varying by forest quality, stakeholders, management goals, devolution status, and other dimensions); and we have developed or identified a set of tools, methods, and approaches that we are making available to research partners, including local people. We are using "fuzzy", qualitative methods (like participant observation, participatory action research, and future scenarios analysis), quantitative methods (like Multi-Criteria Analysis, multi-dimensional scaling, surveys), and computer assisted methods (Multi-Agent Systems (CORMAS), Criteria and Indicators Modification and Adaptation tool (CIMAT), and Analytic Hierarchy Process (AHP)) to bring about more adaptive and collaborative management in our research sites. We are monitoring and comparing these processes.

We are taking a two pronged approach—trying to make changes, while observing what we are doing—knowing that our ability to remain objective will be questioned. However, we have concluded that the complexity and dynamism of social and forest contexts, combined with the urgency of finding solutions to the world's forest management problems, require drastic measures. Our approach is novel and throws up many challenges, but presents rich opportunities for learning about how people transform new information into knowledge and action. We think it is essential that we begin to have a better understanding of how to strengthen the adaptive capacity of human societies. Ultimately, these sorts of approaches embodying collaborative learning and adaptation must succeed.

Greater attention needs to be paid to the link between research and its impacts. As noted above, the forests are disappearing quickly and the diverse cultures within them are under attack. More creative means must be found to make research findings—whether indigenous knowledge, effective institutional arrangements, locally adapted monitoring systems, or specific silvicultural techniques—available quickly to those who can use them. If we do not create or identify innovative strategies for increasing our impact, we are in danger of serving only to document the loss of two kinds of global heritage: our forests and our cultures.

Most fundamentally, we have to move on from a forestry culture that excludes people. The world's forests as they exist today are the product of millenia of interactions between people and their environment. The more we study

[8]Cf. some of the Joint Forest Management experience in India (e.g., Poffenberger and McGean 1996), Nepal's organization of user groups to manage forests (e.g., Hobley 1996), Philippine experience with Ancestral Domains and the work of the Department of the Environment and Natural Resources (e.g., Cornista and Escueta 1990) represent good Asian examples, reported in the Asian Forestry Network series coordinated by Poffenberger (see also Carter 1996). The best known African example of course is Zimbabwe's CAMPFIRE, where communities have been involved in wildlife protection for some time now (Child and Peterson 1991). In Latin America, McGrath et al. 1999 discuss similar issues in relation to fisheries management.

even the most remote and pristine forests, the more we realize that the

hand of humanity is everywhere. The present biodiversity of our forests is a product of the co-evolution of forests and people. More importantly, in all societies, rich and poor, there are people who value forests. Many people, myself included, feel better and safer and more fulfilled when diverse forests occupy a significant place in our landscape.

I suspect that, on that note at least, I will find unanimity among those gathered here today.

Acknowledgements

Special thanks to Dennis Dykstra, Ken MacDicken, Ravi Prabhu, and Jeffrey Sayer for their constructive critical comments on earlier drafts of this paper. They, of course, bear no blame for any errors that may remain.

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IUFRO Awards and Honours

IUFRO Scientific Achievement Awards (SAA)

The IUFRO Scientific Achievements Award Winners

Dr. Angelstam, Per Krister, Sweden
University of Agricultural Sciences, Grimsö Wildlife Research Station
- For scientific achievements in the field of ecological structure and processes in natural taiga-landscapes.

Dr. Bhat, K. M., India
Kerala Forest Research Institute, Division of Wood Sciences
- For his fundamental and applied research in the fields of forest products, wood sciences and technology.

Dr. Dancik, Bruce, Canada
University of Alberta, Department of Renewable Resources
- For his outstanding contributions to forest genetic research, sustainable forest management practice and leadership in forest policy development.

Dr. Kangas, Jyrki Juhani, Finland
Finnish Forest Research Institute, Kannus Research Station
- For research achievements and world-wide recognition in the areas of optimization methods, modelling expertise and participatory and interactive planning of multi-functional forestry.

Dr. Lee, Su See, Malaysia
Forest Research Institute Malaysia, Kepong, Kuala Lumpur
- For scientific contributions to forest pathology as applied to diseases of fast-growing plantation trees and to dipterocarp ectomycorrhiza research.

Dr. Price, Colin, U.K.
University of Wales, Bangor, School of Agriculture and Forest Sciences
- For contributions to science and distinguished research achievements in the field of theory and application of forest and environmental economics.

Dr. Reed, David D., USA
Michigan Technological University, School of Forestry and Wood Products
- For his research on forest biometrics as applied to the quantitative assessment of impacts of stress on forest trees and stands.

Dr. Vertessy, Robert Alexander, Australia
CSIRO Land and Water Canberra; Cooperative Research Center for Catchment Hydrology (CRCCH)
- For scientific contributions in the field of deterministic modelling of forest catchment hydrologic processes and in the area of hydrologic field measurement techniques.

Dr. Wingfield, Michael J., South Africa
University of Pretoria, Forestry and Agricultural Biotechnology Institute
- For research achievements in the field of plant pathology and the establishment of the Tree Pathology Cooperative Programme.

Dr. Yeh, Francis Cho-Hao, Canada
University of Alberta, Department of Renewable Resources
- For pioneering achievements in the field of molecular, population and quantitative genetics of forest trees.

Prof. Dr. Gensiruk, Stepan Antonovych, Ukraine
Ukrainian State University of Forestry and Wood Technology, Department of Forestry
- For his research achievements in dynamics of forest changes in mountainous areas and formulation of ecological system for managing nature reserves.

Outstanding Doctoral Research Award (ODRA)

Dr. Hui, Gangying, China
Chinese Academy of Forestry Beijing, Research Institute of Forestry
- Dissertation in 1998, at the University of Göttingen on Integrated Growth and Yield Model System for the Tree Species Cunninghamia lanceolata.

Dr. Kropil, Rudolf, Slovakia
Technical University Zvolen, Department of Forest Protection and Wildlife Management
- Dissertation in 1994, at the Technical University Zvolen, on Structure and Production of Breeding Bird Communities in Selected Natural Forests in Slovakia.

Dr. Muschler, Reinhold G., Costa Rica
Tropical Agricultural Research and Higher Education Centre
- Dissertation in 1998 at the University of Florida, on Tree-Crop Compatibility in Agroforestry: Production and Quality of Coffee Grown Under Managed Tree Shade in Costa Rica

Dr. Skovsgaard, Jens Peter, Denmark
Danish Forest and Landscape Research Institute, Hørsholm
- Dissertation in 1997, at the Royal Veterinary and Agricultural University,
on Management of Sitka Spruce without Thinnings.

Dr. Sudin, Rahim, Malaysia
Forest Research Institute Malaysia, Kepong
- Dissertation in 1996, at the University of Sheffield, on Development, Properties and Durability of Oil Palm Fibre Cement Composites.

Dr. Wei, Rung Peng, Canada
University of Alberta
- Dissertation in 1995, at the Swedish University of Agricultural Sciences, on
Prediction of Genetic Diversity and Optimizing Selection in Breeding Programs.

Dr. Radeloff, Volker Christian, USA
University of Wisconsin-Madison, Department of Forest Ecology and Management
- Disturbance regimes and landscape scale management in the northwestern Wisconsin Pine Barrens, USA.

Honorary Membership

Honorary Membership is IUFRO's highest award; it acknowledges persons who have rendered particularly important services to the Union. The award consists of a certificate, in Latin, commending the individual for excellent work carried out for IUFRO.

Prof. Dr. Franz Schmithüsen
The Swiss Federal Institute of Technology The ETH, Zurich, Switzerland

Dato' Dr. Salleh Mohd Nor
Tropbio Research Sdn. Bhd., Malaysia

IUFRO International Council

The International Council IUFRO

The International Council (IC) is the supreme authority regulating the affairs of the Union and guiding its Executive Board. According to the IUFRO Statutes, each country, in which IUFRO has a Member Organization, has one delegate and an alternate member in the IC, irrespective of the number of the member institutions. The IC meets in practice only when a World Congress is in Session and acts as a General Assembly of the Union.

The IC traditionally has two meetings at the World Congress. This arrangement allows the delegates to re-discuss Agenda items, e.g. change of Statutes, after elaboration in country delegations or, in the case of Congress Resolutions and Recommendations, gives the IUFRO Secretariat time for translation into the four IUFRO languages. The meetings were held on 8 and 11 August, 2000, at the Legend Hotel, Ballroom 1, Kuala Lumpur, Malaysia.

The President of IUFRO officiates as the Chairman and the Secretary of IUFRO as the Secretary of the Meeting. 50 plus one per cent of all the countries represented in IUFRO (at the time of the XXI IUFRO Congress, 55 authorized representatives) are required for a quorum. The voting procedure of the International Council is as follows: Any modification of the Statutes of the Union must be adopted by a majority of two thirds of the valid votes cast. (At this Congress the figure was 37 votes in favour.) Decisions not affecting a change of Statutes must be supported by a simple majority of the IC Members present. Each country represented in the IC has one vote.

The President's report covered all major achievements and highlights of the last inter-Congress period. A brief summary reads as follows:

- The Executive Board took account of the Resolutions of the XX IUFRO World Congress in Tampere, Finland.
- It drew up a Strategic Plan for the Union.
- It issued Bidding Rules for IUFRO Congresses.
- It established the Terminology Project based at the IUFRO Secretariat.
- It developed and expanded an incomparable web site.
- It increased the number of IUFRO publications, including creating a new series published jointly with CAB International (CABI), the IUFRO Research Series.
- It established the Global Forest Information Service, an Internet-based meta-data service to coordinate world-wide access to forest information.
- It strengthened and enhanced the work of the Special Programme for Developing Countries and the IUFRO Secretariat.
- The Executive Board commissioned an external Review of the IUFRO Secretariat, SPDC and Terminology Project.
- A common format for Agenda papers submitted to the IC was developed.
- Three Honorary Memberships were proposed to and later agreed by the IC by ballot vote. Honorary Membership was conferred on:
  Howard Kriebel, USA (handed over at the Division 2 Meeting in Beijing, China, in 1998)
  M N Salleh, Malaysia (1999, but handed over formally at the IUFRO Congress)
  Franz Schmithüsen, Switzerland (2000, and handed over at the Congress)
- It prepared amended IUFRO Statutes for decision by the International Council.

The IC Meeting approved the Resolutions of the XXI IUFRO World Congress, addressed to all Member Organizations and governmental authorities responsible for forest affairs in IUFRO countries. The Resolutions addressed six topics: Role of Forests and Trees in Human Welfare; Attention by Policy-Makers; Role in Intergovernmental Processes; Research and the Input of Forestry Activities; Information; and Research Capacity. The Resolutions were translated into the four official IUFRO languages and distributed to Congress participants at the Closing Ceremony.

The IC Meeting decided on the venue of the XXII IUFRO Congress. According to the newly adopted Bidding Rules the offer to the IUFRO members of Australia, to hold the Congress in Brisbane, in August 2005, was accepted.

The IC decided on and approved new IUFRO Statutes. Important points were:

- Change in IUFRO's English title – from "Forestry" to "Forest". It reads now "International Union of Forest Research Organizations".
- Introduction of the post of "Executive Secretary".
- Clarification of the roles of President and Executive Secretary, to maximize transparency and minimize overlap while enhancing management of the Union's business.
- Change of focus for the International Council to provide advice to the President and Board and to facilitate its work in guiding IUFROs policy.
- Meetings of the International Council outside the Congress may be called by the President. He may call

such meetings for decision-making purposes, physically or electronically or by mail.
- Introduction of voting by proxy in International Council business to maintain international equity, recognizing that some members are unable to attend all meetings and to obtain a quorum of voters for major issues.
- Removal of gender-specific text.
- Creation of new categories of awards to enhance the recognition of high-quality scientific research.
- Addition of the category of "Sustaining Member" for organizations or individuals providing substantial financial support to the Union.
- Cessation of Board membership for members from Regions and increase in the number of General Members of the Board in order to achieve a more equitable representation of geography, gender, nationality and scientific discipline.
- New names for the Vice Presidents:

  Vice-President Science for the former Vice-President Programme and
  Vice-President Policy for the former Vice-President Administration.

After the second IC Meeting the traditional IUFRO President's Reception took place. On Saturday, 12 August, a Tree Planting Ceremony at the "Taman Tasik Permaisuri", "Queen's Lake Gardens" at Cheras was attended by the IC Members. Five species of Malaysian native tree species had been selected for tree planting.

The IC Meeting was attended by 55 IC Country Representatives at the first part on Tuesday, 8 August, and by 57 IC Country Representatives at the second part on Friday, 11 August, 2000. 109 countries were entitled to representation, see the list below.

Heinrich Schmutzenhofer
IUFRO Secretary

List of Countries in which IUFRO has an International Council Representative

As of August 2000, valid for the XXI IUFRO World Congress

Albania
Algeria
Argentina
Armenia
Australia
Austria
Bangladesh
Belarus
Belgium
Benin
Bhutan
Bolivia
Brazil
Brunei
Darussalam
Bulgaria
Burkina Faso
Canada
Chad
Chile
China
China – Taipei
Colombia
Congo
Congo
Dem.Rep (New Zaire)
Costa Rica
Côte d'Ivoire
Croatia
Cuba
Cyprus
Czech Republic
Denmark
Ecuador
Egypt
Estonia
Ethiopia
Fiji
Finland
France
Germany
Ghana
Greece
Guatemala
Honduras
Hungary
Iceland
India
Indonesia
Iran
Iraq
Ireland
Israel
Italy
Japan
Kenya
Korea (Rep)
Latvia
Liberia
Lithuania
Luxembourg
Madagascar
Malaysia
Mali
Mexico
Morocco
Namibia
Nepal
Netherlands
New Zealand
Niger
Nigeria
Norway
Pakistan
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Poland
Portugal
Romania
Russian Federation
Senegal
Slovakia
Slovenia
Solomon Islands
South Africa
Spain
Sri Lanka
Sudan
Swaziland
Sweden
Switzerland
Tanzania
Thailand
The FYR of Macedonia
Togo
Trinidad and Tobago
Tunisia
Turkey
Ukraine
United Kingdom
United States
Uruguay
Vanuatu
Venezuela
Vietnam
Yugoslavia
Zambia
Zimbabwe

IUFRO Five-Year Report

Five-Year Report of IUFRO

Report by Professor Jeffery Burley

President of IUFRO

In my period as President I have reported annually in detail to IUFRO's Policy and Planning Committee and to the Executive Board on my Presidential activities; these reports are available in the minutes of the meetings of these bodies. In addition, after each Executive Board meeting, I have written to members of the International Council and to Directors of Member Organisations to inform them of the major outcomes of the Executive Board meetings and of other significant activities in which IUFRO has been involved. The reports of the two Vice-Presidents and Treasurer will cover the programme, administrative and financial activities of the past five years.

Therefore, for this meeting of the International Council, I will highlight activities leading up to items on this agenda that require IC approval; for these and other agenda items, IC members should have received the background papers.

As it began its work in 1996, the Executive Board took account of the resolutions of the 20th IUFRO World Congress in 1995 and the changes that were then occurring in forest policy, management and research; it drew up a strategic plan for the Union. In addition to planning the 21st Congress and a large number of meetings of research units and Task Forces, the Executive Board considered the structure, aims and activities of our Union to carry out this strategic plan. It noted that environmental stresses and increased human demands on natural resources require knowledge and decisions that address social, economic and environmental needs; the scope of these requires more interdisciplinary science and stronger linkages among all stakeholders. These in turn require stronger links between policy and science, more widespread dissemination of research results and a wider membership of the Union itself from institutions and individuals concerned with research in forests but not necessarily in forestry per se.

The Executive Board therefore:- (i) expanded the number of cross-disciplinary Task Forces to eight; (ii) obtained official observer status in a number of international fora and agencies; (iii) enhanced the work of the Special Programme for Developing Countries; (iv) strengthened the Secretariat (with great support from the Government of Austria and the Federal Forest Research Centre in Vienna) to support the scientific work of the Divisions and the policy work of the EB; (v) developed and expanded an incomparable Web site; (vi) increased the number of IUFRO publications, including creating a new series published jointly with CABI (the IUFRO Research Series), and (vii) established the Global Forest Information Service, an Internet-based metadata service to coordinate world-wide access to forest information.

In addition, IUFRO comprised nearly 700 Member Organisations with 13,000 scientists; these contributed to 268 research units, 8 Task Forces, 1 Special Programme and 1 Project that organised 334 meetings in 65 countries of which 41 were developing and emerging economies. These resulted in, inter alia, 91 sets of proceedings. In addition, 9 Occasional Papers, 6 IUFRO World Series books and 4 IUFRO Research Series books were published. The IUFRO News appeared quarterly in English and four-monthly in Spanish while, of course, an annual report was published each year.

The Executive Board commissioned an external review of the Secretariat, Special Programme and Project; this was chaired by Honorary Member and former Vice-President Administration, Jim Cayford, and comprised eminent members including the late Abdou-Salam Ouedraogo of IPGRI who tragically died in an air accident while on official IPGRI duty. The report of this exhaustive and intensive review, coupled with the EB's view of external and internal developments, led to the proposals for the new EB structure and committee structure shown in the attached four figures; in order to allow a prolonged and substantive discussion of future strategies and structures, this will be considered as agenda item 12 at the second IC meeting although discussion of the revised Statutes and Internal Regulations that resulted from these proposals will be considered in both meetings (as items 7 and 8).

Figure 1 shows the functional needs of IUFRO and highlights the need for the scientific, disciplinary activities of Divisions to associate more closely with those of other international professional societies, while at the same time seeking interdisciplinary activities stimulated by Task Forces to support intergovernmental and national policy requirements.

For ease of comparison, Figure 2 and Figure 3 show the current and proposed Board structure. Although these do not have to be approved per se by the IC, they illustrate the thinking that led to the proposed revised Statutes and Internal Regulations. Figure 3 in particular contains four salient features:-

(i) IUFRO should develop clear strategies and programmes for science and policy, each under the leadership of a Vice-President;

(ii) in order to involve the IC ever more closely in the policy guidance of the Board, the current Members from Regions and Presidential Appointees are replaced by up to 10 General Members to be approved by the IC. These would seek to balance the geographic, scientific and gender composition of the Divisional Coordinators and Deputies;

(iii) while the Treasurer will continue to be located in Switzerland and the Secretariat in Vienna, it is clear that collectively they provide the administrative and financial support for the Union; it is proposed to rename the Secretary post as Executive Secretary to reflect the vast amount of daily work in managing theUnion;

(iv) together all these changes will free the President for more strategic thinking and for even greater representation of the Union externally.

The Executive Board established an Ad Hoc Committee to revise the Statutes and Internal Regulations in the light of these planned developments. This Committee was chaired by Karel Vancura, met several times, corresponded frequently and produced draft versions that were discussed by the Policy and Planning Committee and by the full Executive Board at several meetings. Before approving the Statutes, the IC should pay particular attention to those dealing with categories of membership, the replacement of Members from Regions with General Members; the scope of Divisions; the nature of Task Forces, Special Programmes, Special Projects and Chapters; the nature and location of the Secretariat and Treasury; and the change of title from Secretary to Executive Secretary. The Internal Regulations do not require formal IC approval but they are included on the agenda for information and discussion.

It is notoriously difficult to prepare Congress Resolutions that are innovative, stimulating, relevant to those they seek to address, and acceptable to those who attended a congress. The draft submitted to the IC was prepared by the President and the Resolutions Committee and in addition it has already been considered by the PPC and EEB. The IC must approve their style and content so that they can be prepared and translated for announcement and distribution at the closing ceremony.

Figure 1. Functional needs of IUFRO

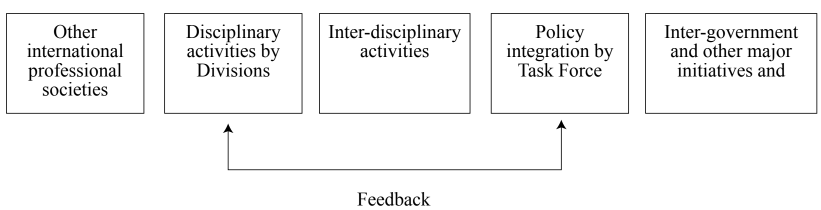


Figure 2. Current EB structure

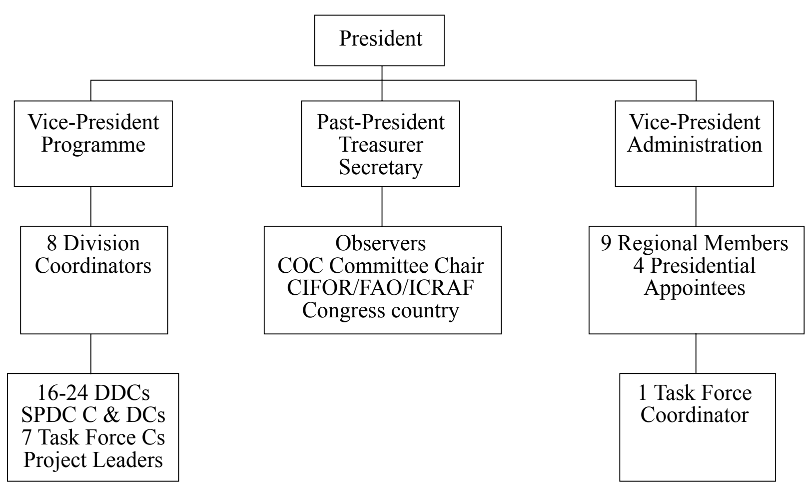
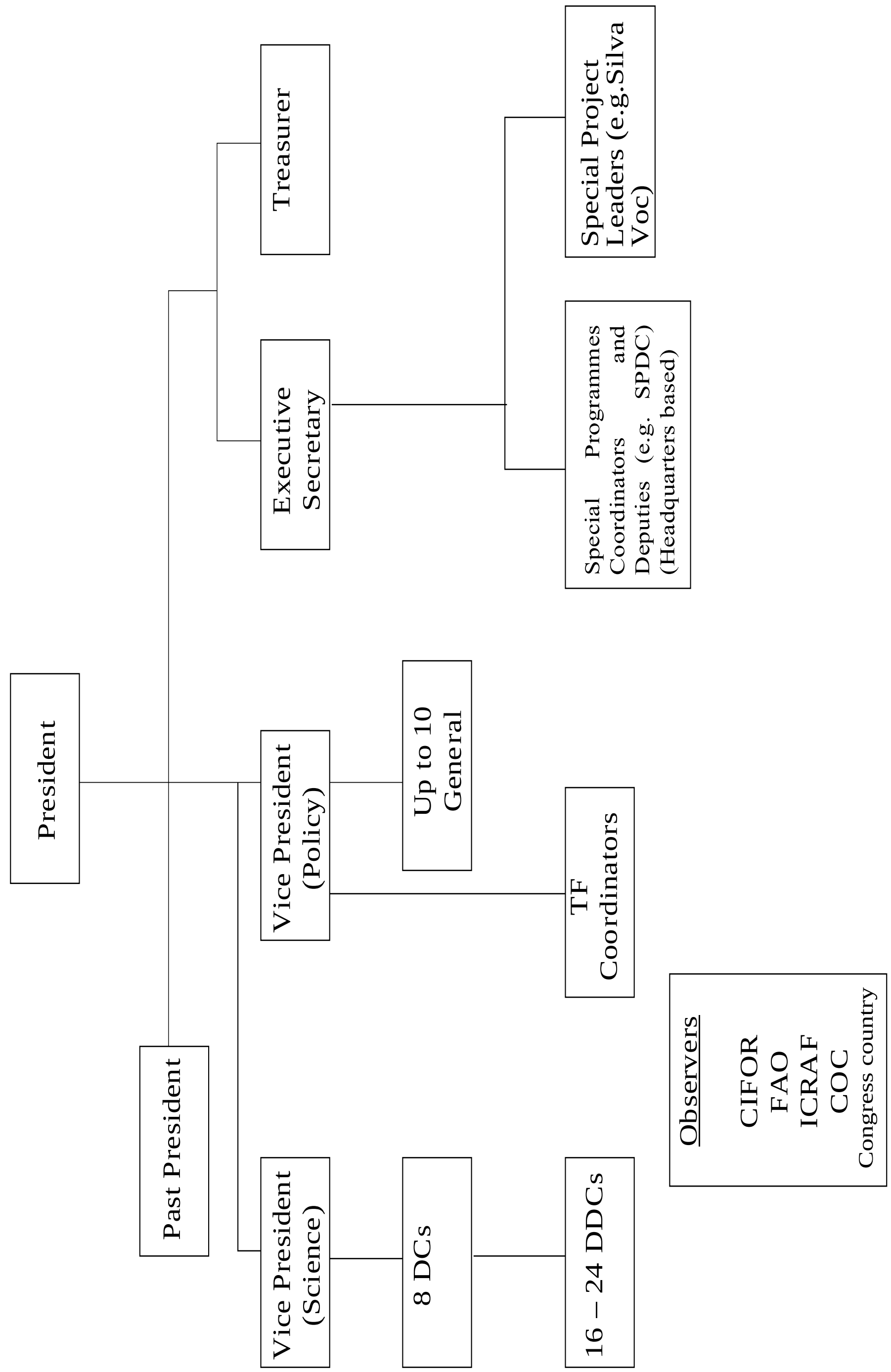


Figure 3. EB Structure proposed



Report by Dr. Risto Seppälä

The Vice President (Programme)

The Vice President Programme (VPP) is responsible for chairing the Programme Committee (PC) and supervising the Special Programme for Developing Countries (SPDC). The PC includes Division Coordinators and their Deputies as well as the Coordinators of research-oriented Task Forces (TF). It approves the terms of reference for new Research Groups and reviews periodically the programmes of the Groups. The PC also develops ideas for new Task Forces.

Two new Divisions were created at the beginning of the 1999-2000 period, and Divisions have also made changes in their internal structure. No new Divisions will be proposed for the next period.

The number of Task Forces has increased considerably during the current term. In all, nine TFs have been established, seven of them reporting to the PC. Four of the existing TFs will continue in the next period.

The SPDC continued to assist in the development of human resource capacity in developing countries and countries with emerging economies. After a successful four-year period, the SPDC Coordinator Robert Szaro returned to his home country, the U.S., and a new Coordinator will hopefully start at the beginning of 2001. During the current term the SPDC has had two Deputy Coordinators, one in Africa and one at the IUFRO headquarters in Vienna.

The most important single task of the PC is to plan the structure and contents of the scientific programme of IUFRO World Congresses. For the Kuala Lumpur Congress the PC established a Congress Scientific Committee (CSC) led by Eric Teissier du Cros whose contribution has been crucial to the success of the Congress. This is the first time in IUFRO's history that a special CSC has been in- charge of the scientific programme.

The structure of the Kuala Lumpur Congress is different from that of the previous IUFRO Congresses: the majority of contributions are scientific posters whereas in earlier congresses oral presentations dominated. Another new feature is that most of the programme is based on an open call for papers instead of invitations which have only been applied to Plenary and Sub-Plenary Sessions this time .

In principle, all accepted scientific contributions to the Congress have been reviewed with the aim to raise the quality of presentations. However, as the review system has not yet been fully operational, this aim will be only partially achieved.

In order to emphasize the importance of a synthesis approach, the IUFRO Executive Board requested that every IUFRO research unit should prepare a State-of-Knowledge Report (SKR) indicating what we know and what we do not know. At the Kuala Lumpur Congress many units will deliver their SKRs.

During the current period most Divisions have had Interdivisional or All-Division-Meetings, while the Task Forces held their meetings, too. The first Latin American Regional Congress took place in 1998. Although the importance of these major mid-term congresses is increasing, most IUFRO meetings are at the level of divisional units. Over 300 meetings have been held this term by the Research Groups and Working Parties.

A considerable amount of proceedings and other publications have been generated from these IUFRO meetings. Sales of IUFRO's Occasional Papers and World Series publications have been good. In addition, a new IUFRO Research Series publication was launched in 1999.

Some Task Forces have actively contributed to international processes. In fact, two most recently established IUFRO TFs originated from the intersessional activities in support of the Intergovernmental Forum on Forests (IFF). In addition to the impact of IUFRO on international processes, the individual scientists of the Union have made major contributions to international meetings, such as the World Forestry Congress.

This report tries to be short and therefore it can describe only a few highlights of the IUFRO programme activities. Most of the work, including the most important ones, has been done in the respective Divisions and in their corresponding units, as well as in the Task Forces. IUFRO's more than 700 office-holders are the core of the Union, and its future will depend on the success of their activities.

The work of the VPP and the PC would not have been possible without the support of the IUFRO Secretariat. The whole Vienna staff has shown extraordinary dedication to the Union, but we owe our special gratitude to the IUFRO Secretary, Heinrich Schmutzenhofer, whose capacity remains unmatched also in difficult times.

Report by Dr. Jacob L. Whitmore

Vice President (Administration)

Background

In accordance with the Internal Regulations of the Union, the Vice President (Administration) (VPA) is responsible for chairing the Administration Committee (AC) which also includes the Treasurer and at least four other members of the Executive Board (EB). During the 1996 – 2000 period, the AC included the Treasurer, the Secretary, all Members from Regions, the four Presidential Appointees, with the VPA as Chair.

The main functions of the AC are to:-

- Review periodically the financial status of the Union,
- Recommend to the EB an annual budget setting forth major fund commitments,
- Recommend to the EB investment policies appropriate for the Union,
- Propose new or improved administrative procedures and operational guidelines for the Secretariat or any one of the Union's administrative or technical bodies.
- Provide leadership in developing strategic guidance for the Union, in the form of strategies and new ways of doing business; and
- Assist the EB in communications that enhance membership and general public awareness of the Union

In addition to Chairing the AC, the VPA also served as Deputy Chair of the Nominating Committee (NC), Member of the Policy and Planning Committee (PPC), the Statutes and Internal Regulations (S&IR) Ad Hoc Committee, the Resolutions Committee and the Finance Committee, and Chair of the Ad Hoc Congress 2005 Committee. The Public Relations Committee, also Chaired by the VPA, was rather inactive during this term, but many of its functions were covered by sub-committees within the AC.

Administration Committee

At the XX IUFRO Congress in Tampere, Jerry Sesco was elected as VPA by the International Council (IC). However, at the beginning of 1997 he was given a new, non-research position in his agency and resigned the VPA post. Jacob L. Whitmore was then elected as VPA to fill the remainder of the term. Most activities of the AC, summarized in the sections below, were not greatly affected by this transition, largely because Dr. Sesco had reached the 'final draft' stage for, or at least had set in motion, many of the AC activities planned for this term.

IUFRO Strategy

In December 1995, the new VPA-elect was requested to draft an IUFRO Strategy, with input from EB members. This was a continuation of efforts which begun prior to April 1993. A revised draft was presented to the 1996 EB by Dr. Sheila Andrus, Assistant to Vice President Sesco, with a final version presented at the 1997 EB. A summary was included in the IUFRO Brochure, presented at the World Forestry Congress at Antalya.

Congress Bidding Rules

The AC initiated guidelines for the procedure of bidding for future Congress venues. A draft of these was presented at the 1996 EB by Sheila Andrus, and further modified at the 1997 EB. The Secretary distributed the final version to all member organisations (except Malaysia), in anticipation of Congress 2005.

Increase / Vitalize Membership

The membership of this ad hoc committee was established at the 1996 EB, to be chaired by Prof. Prem Khosla. Primary focus was on regional or national levels; costs/benefits of IUFRO membership; financing member subscriptions; and donors' roles in support of member institutions. A strategic plan was developed, aimed at increasing membership.

Improvement of Cooperation with the IC

The 1996 EB set up an Ad Hoc Committee on Informing the IC, as well as looking at the role of the IC. It was agreed that the EB should depend more on the IC for advice, public relations and membership. With the help of Dr. David Flinn, guidelines were spelled out on how to better inform the IC on issues to be raised at the IC meeting in Kuala Lumpur. Feedback from the IC on how well informed they were prior to this meeting would help guide the next EB.

International Relations Task Force

This TF was created by the 1996 EB. Its purpose was to a) inform the EB of current issues and initiatives dealing with forestry and their implications in research, b) identify IUFRO's expertise in relevant forestry topics, important in association with mega-tendencies, so that it may get involved through its various working parties and research groups, c) prepare state of the art reports and a shopping list of research needs, and d) assist in improving IUFRO's image and in establishing collaboration with international agencies and initiatives. Led by Ruben Guevara, a report was presented, which may serve as guidance for the next EB.

Honors and Awards Committee

Members of this Committee included J. Burley, D. Flinn, A. Furuberg, R. Guevara, J. Prado, C. Sales, M. N. Salleh, H. Schmutzenhofer, L. Sennerby-Forsse, and A. Winkler, with J. Youngquist as acting chair. The selected members represented both the Programme and Administration Committees and reported to the Executive Board through the Administration Committee. In summary, there were 3 persons nominated for Honorary Membership, 11 selected for the Scientific Achievement Award, and 27 selected for the Distinguished Service Award. There were two new awards created, and 7 people were selected to receive the Outstanding Doctoral Research Award, and 9 people will be selected at the Congress for Best Poster Awards. The IUFRO Honors and Awards booklet will be updated to include these additional forms of recognition.

IUFRO Net, Internet Networking

Near the end of 1995, a paper was developed entitled "IUFRO-Net: an electronic network to enhance and facilitate communication within IUFRO". It spelled out homepages, mailing lists, newsletters, meetings and proceedings or other publications as components of that communications goal, and proposed a IUFRO-Net Task Force. The members of this new Task Force were identified at the 1996 PPC meeting, and the Task Force, led by Dr. Lauri Valsta, presented a report at the 1997 EB. The members of the Task Force have been extremely dedicated and productive during their tenure, and have contributed greatly to the Union's improved communications abilities.

Increasing Visibility

This ad hoc committee agreed to produce an IUFRO Brochure, in time for the World Forestry Congress, and thanks to the efforts of David Flinn, Prof. Ladislav Paule, and others, this was accomplished. Several inserts were also prepared, including one per Division, a summarized IUFRO Strategy, and an application for membership form. The Brochure was prepared in English, French and Spanish.

Agreement with WSL Re: Treasury

Early in the term, our Treasurer Dr. Schlaepfer left WSL, and it became apparent we would need to concern ourselves with the future location of the IUFRO Treasury offices. Contact was made with Dr. Mario Broggi, new Director of the WSL in Birmensdorf, who agreed that WSL would continue to provide Treasurer/Treasury services to IUFRO.

Fund Raising

An ad hoc Fund Raising Committee was established at the 1997 EB, with Dr. Ruben Guevara as Chair. Fund raising strategies were presented in a report at the 1998 EB. Such strategies included the need for IUFRO to tackle certain world problems, with its membership, in a systematic manner, and in the process to raise some funds for IUFRO Programs. The report also included strategies for IUFRO to work with the private sector, in partnership, seeking mutual benefits through sponsorship of seminars, conferences, workshops, publications and projects. It was concluded that these strategies must be implemented by the Secretariat, and the Board, with participation of key, well-connected individuals in key member organisations.

Finance Committee

At the suggestion of the Vice President (Programme), the AC was requested to consider "the need for a Finance Committee for fund-raising under the aegis of the Administration Committee", at the 1996 EB. Such a committee was established at the 1998 EB, with Dr. John Youngquist as Chair. Terms of reference, an investment policy framework and reporting relationships were developed and approved at the 1999 EB meeting. This information can be found in the minutes (appendix 16) of the 38th EB meeting. The result so far has been better definition of IUFRO's investment strategies, as well as investment in September 1999 of a sizeable portion of IUFRO funds in an investment account with Credit Suisse.

Financial Operations

The AC reviewed annual budgets and financial statements prepared by the Treasurer and the Secretary as well as annual audits. It also reviewed proposals concerning subcription rates, and applications for membership. In all instances, recommendations were made to the Executive Board concerning these, and other financial issues. The AC has noted repeatedly the financial soundness and health of the Union.

Statutes and Internal Regulations

The AC oversaw the Ad Hoc Committee for Revision of the Statutes and Internal Regulations (S&IR), led by Dr. Karel Vancura. Having begun in mid-1997, Dr. Vancura's task was especially difficult due to recommendations by a Review Panel (see below) which required much of the pre-1999 S&IR work to be re-done. The revised S&IR, as recommended by the EB, were sent out to the IC in May, 2000. The International Council will need to vote on these S&IR, the week of the congress.

Review Panel

President Burley established a Review Panel at the 1998 PPC, led by previous VPA James Cayford, to visit the Secretariat and make recommendations regarding the Secretariat and the SPDC. The VPP and VPA drafted TOR for the Review Panel, and with the President, participated in the Review. The AC examined each of the Panel's recommendations and made its own observations to the EB on each. As mentioned above, the S&IR had to be re-revised based on EB approval of individual Panel recommendations. One of the Panel's recommendations changes the role of the VPA to a Vice President (Policy), and re-names the VP (Programme) as Vice President (Science).

Nominating Committee

A Nominating Committee was proposed at the 1997 PPC meeting, with the mandate to consider a "person's initiative and input, his/her ability to attend meetings, as well as the international distributions of the candidates". Membership of this committee was approved at the 1997 EB meeting, with the Immediate Past President, Dr. Salleh, as Chair. All EB members were requested to recommend nominees for the new EB/EEB, and over 80 names were submitted. Most of these agreed to serve, if elected. Nominations from the Divisions regarding Division leadership were given special attention. The revised S&IR call for up to ten General Members to replace the current Presidential Appointees and Members from Regions, and the slate of nominees reflects this. The slate of nominees, as recommended by the EB, was sent out to the IC in June, 2000. The International Council will need to vote on these nominees, the week of the congress.

Congress 2005

Bids to host Congress 2005, based on the new Congress Bidding Rules, were received by May 1998. It quickly became obvious that of these, Australia was the more serious contender, and the 1999 EB recommended Brisbane, Australia as the venue for the IUFRO World Congress, to be held 8—14 August, 2005. The IC will need to vote on this matter, the week of the congress.

Concluding Remarks

As is true with most organisations, certain IUFRO officers tend to take on a much larger than average share of the workload. These are the extraordinary people who ensure the success of an organisation, who are usually ready to apply themselves even more to the tasks at hand for the benefit of all, in spite of being already overloaded with work. As is often the case, these people are often not recognised publicly for their accomplishments. The EB members know them all too well; indeed some of them are EB or EEB members. Their contribution is a major reason for the health and well-being of IUFRO since 1995.

One of these must be mentioned here, as he served as back-up to the VPA for AC and other VPA duties. David Flinn energised the AC, the PPC and the EB with his insight and can-do attitude. Many of us assumed and hoped he would move up within the EB for next term, but must respect his reasons for not doing so.

In addition to the above, the Austrian Staff specifically, and the contribution of the Austrian Government in general, must here be recognised. The professionalism and dedication of those at the Secretariat is another major reason for the success of IUFRO during this current term.

To all of these fine people, and especially to Rita Z'berg of Birmensdorf for her superlative work on the IUFRO Treasury, we owe our gratitude.

Report by Dr. Lisa Sennerby Forsse

Division 1 Coordinator
Silviculture

Coordinator	:	Lisa Sennerby Forsse,
Deputy Coordinators	:	John Parrotta
		Menachem Sachs,
		Rodolpho Salazar,
Web master	:	Jerry Vanclay

Introduction

In Division 1 Research and Development is focussed on studies of forest and ecosystem management in natural and artificial silvicultural systems in the boreal, temperate and

tropical zones. The use and communication of results from R&D are based on a common appreciation that the use of silvicultural methods when tailored to a given site makes it possible to achieve environmentally and economically sound sustainable management.
The activities are organised in nine Research Groups, (RG):-

- Stand Establishment, Treatment and Amelioration
- Improvement and Silviculture of Oaks
- Tropical Silviculture
- Short Rotation Forestry for Biomass Production
- Improvement and Silviculture of Beech
- Forest Vegetation Management;
- Unevenaged Silviculture
- Agroforestry and
- Restoration of Degraded Sites.

Under the main theme of each RG there are Working Parties (WP) dealing with different topics. Under the present 9 RG's there are 30 WP's which adds up to a total of 39 units within Division 1. Division officers total about 100 representing more than 40 nations.

Changes in Division Leadership During the 5-year Period

In 1997 Dr. Les Whitmore was appointed new Vice-President for Administration of IUFRO and Deputy Coordinator Professor Lisa Sennerby Forsse was elected new Division 1 Coordinator. She was at that time research manager for Silviculture and Environment at the Swedish Forestry Research Institute, SkogForsk, in Uppsala, Sweden, and adjunct professor in Silviculture and Short Rotation Forestry at the Swedish University of Agricultural Sciences. Dr. John Parrotta from the International Institute of Tropical Forestry in Rio Piedras, Puerto Rico, was elected to replace Sennerby Forsse as Deputy Coordinator of Division 1.

Web Pages

During this period the Divisions web pages have been completed and each unit has its own homepage. The Coordinators of each unit are supposed to submit a short statement about their unit and give information about already achieved as well as planned activities. It is important that the information on the homepage is regularly updated.

Events 1996-2000

During the period, Division 1 and its Research Groups and Working Parties sponsored 57 symposia, workshops, conferences and study tours with an even distribution of meetings over the five years. Out of the 57 meetings, 21 meetings were held in developing countries and 3 meetings were held in countries with economies in transition. The number of publications recorded by the Secretariat is 12 and the probable number of publications is about the double.

Interdivisional Meetings

1997

Divisions 1 and 8: Managing Productivity in Plantation Forestry. Concepcion, Chile. May 5-9, 1997.
Divisions 1 and 8: Conference on Tropical Secondary Forests: Science, People and Policy. Turrialba, Costa Rica, 10-12 November 1997.

1998

Divisions 1, 4, 6 and 8: Forest Ecosystem and Land Use in Mountain areas" in Seoul, Korea, October 12-17.
Divisions 1, 3, 6 and 8: "Conference on New Approaches to Integrated Management of Primary and Secondary Forests for the 21st Century". Belem, Para, Brazil. 1998. Co-sponsored by EMBRAPA-CPATU/CATIE/WWF/ CIFOR.
Divisions 1 and 8: "Conference on Tropical Secondary Forests: Science, People and Policy". In Turrialba, Costa Rica, 10-12 November 1998.

1999

Divisions 1 and 8: "Silvicultural problems in mountain regions". In Davos Switzerland September 6-10.
Division 1 and 2: "Silviculture in Latin America". In Santo Domingo, October 18-22.

2000

The XXI IUFRO World Congress: In Kuala Lumpur, Malaysia, 7-12 August.
11 meetings were held by different Division units at the Congress in K.L

Other Events

Establishment of new Working Parties:
WP 1.15.04: Adaptive and social research in agroforestry. Coordinator: Christine Holding, Kenya.

WP 1.07.19: Forest dynamics and yield regulation systems for tropical/subtropical moist forest.
Coordinator: Armin Seydack, Dept of Water Affairs and Forestry, South Africa

Report by Dr. Eric Teissier Du Cros

Division 2 Coordinator
Physiology and Genetics

Between January 1996 and August 2000, Division 2 held 36 scientific meetings and published 10 proceedings. Some of these have been transformed into peer-reviewed books. During the Congress 2000, Division 2 held 10 Group Sessions. It was involved in one Plenary Session ("Matching research to Society Needs", by Christine Dean, a geneticist) and one Subplenary Session ("Management and Conservation of Forest Gene Resources", organised under the umbrella of the corresponding Task Force, by Veikko Koski and Francis Yeh, both Division 2 office holders).

Division 2 kept strong ties with its Siamese brother, the newly created Division 7, Forest Health, after a refined surgical separation in 1995 by Howard Kriebel, past Division 2 Coordinator. Many geneticists and breeders have participated in meetings organised by Division 7, particularly those where genetics and resistance are involved, for instance Research Group 7.01.00 “Physiology and Genetics of Tree/Phytophage interactions”.

Several Important Events Occurring During the 1996-2000 Term Should be Highlighted:

The whole Division 2 Conference was held in Beijing, China, in August 1998 and chaired by Csaba Matyas from Hungary. The local organisation was coordinated by Professor Hong Jusheng from the Academy of Forestry, Beijing, China. The event was called “Third IUFRO Consultation on Forest Genetics and Tree Improvement” and held with the technical collaboration of FAO. More than 100 scientists from 33 countries participated. They were geneticists, breeders, pathologists, entomologists and biotechnologists. A selected set of oral presentations was peer-reviewed and published as a book in early 2000 by Csaba Matyas, entitled Forest genetics and sustainability. Third IUFRO-FAO Consultation on Forest Genetics and Tree Improvement. August 22-28, 1998, Beijing, China. Kluwer Academic Publishing House at Dordrecht, The Netherlands. 287p. Conclusions and recommendations from the conference were published by Teissier du Cros, E., Matyas C., and Paule, L. in: 1999. Contribution of genetics to the sustained management of global forest resources. Third IUFRO-FAO Consultation on Forest Genetics and Tree Improvement. Conclusions and recommendations. August 22-28, 1998, Beijing, China. Forest Genetics, 6(3) 61-64.

China follow-up Congress Sessions. Two sessions were organised by Csaba Matyas for the Congress 2000 as a follow-up of the 1998 Beijing Conference. Their theme was "Future of Breeding and Plantations in a Sustainably-oriented World".

A Honorary Membership. Howard Kriebel has become a Honorary Member of IUFRO. His award was conferred on him by Professor Jeff Burley, IUFRO President, during the Division 2 conference. Howard is still very active in IUFRO as:-

- WD 2.02.15 "Five needle pines".
- Representative of Division 2 on the IUFRO Task Force on the Internet.
- Division 2 web moderator.
- Member of the Ad Hoc Committee for Revision of the Statutes and Internal Regulations.

Congratulations to the Former Division 2 Coordinator!

A Task Force. IUFRO was invited as an observer to the 10th Session of the FAO Panel of Expert on Forest Gene Resources (FGRs), in Rome, in September 1997. It was suggested that IUFRO could provide its expertise in two areas: (1) by creating a Task Force on forest gene resources and (2) by working on the terminology related to this topic (see SilvaVoc report). The principle of a Task Force has been accepted by the IUFRO Executive Board later in September 1997. The Task Force was established in January 1998. Its terms of reference were to:

- • Synthesize scientific information on :
- scientific knowledge necessary for the conservation of FGRs: management of base and breeding populations, maintenance of representative diversity, including rare populations,
- case studies on in and ex situ conservation,
- interactions between human activity and integrity of FRGs, including silviculture, forest operations, agro forestry, forest and landscape management, and others,
- effect of environmental factors on the integrity of FGRs: insect pests, diseases, air pollution, climate change,
- • Organise sessions, particularly during the IUFRO Congress 2000,
- • Prepare publications on all these items.

The Task Force was chaired by Veikko Koski (Deputy of Research Group 2.04.00) until August 2000 and includes representatives of all IUFRO Divisions. Some of these are links with other interested organisations, including FAO, IPGRI (International Plant Genetic Resources Institute) and CIFOR. It is now chaired by Per Ståhl. The Task Force held a Subplenary Session during the Congress 2000 and is currently preparing a State of Knowledge Report.

Coordination. During the 1996-2000 term, the Coordinator and his two deputies have shared responsibilities, as follows:

- Research Groups 2.01.00 (Physiology) and 2.09.00 (Seed

physiology and Technology): Bob Luxmoore, Deputy Coordinator for Physiology.
- Research Groups 2.02.00 (Conifer Breeding and Genetic Resources) and 2.08.00 (Hardwood Improvement, Culture and Genetic Resources): Ladislav Paule, Deputy Coordinator for Genetics.
- Research Groups 2.04.00 (Genetics) and 2.10.00 (Legislation on Forest Reproductive Material): Eric Teissier du Cros, Coordinator.

Additionally, since Eric Teissier du Cros was asked to chair the Congress 2000 Scientific Committee, Bob Luxmoore, with the help of Ladislav Paule, was in charge of the Division 2 scientific programme for the Congress 2000.

The new coordinating team for the 2001-2005 term will be:

- Ladislav Paule, Coordinator
- Bob Luxmoore, Deputy Coordinator for Physiology
- Zohra Bennadji, Deputy Coordinator for Genetic improvement
- Csaba Matyas, Deputy Coordinator for Genetics and Biotechnology

New Working Parties. Two Working Parties have been created:

- 2.08.06: Genetics of Nothofagus, Roberto Ipinza, Chile, Coordinator
- 2.04.10: Genomics, David Neale, USA, Coordinator

Report by Dr. Dennis P. Dykstra

Division 3 Coordinator,
Forest Operations and Techniques

Overall summary	
Total meetings held	61
Meetings held in developing countries	35
Meetings held in countries with economies in transition	5
Publications produced	14

List of meetings by year, 1996-2000

1996

Co-sponsored the “Seminar on Harvesting and Wood Transport” at the University of Paraná in Curitiba, Brazil, 19-23 May 1996.

“International Mountain Logging and Pacific Northwest Skyline Symposium”, [organised in collaboration with FERIC, the Forest Research Institute of Canada, and the University of British Columbia], Campbell River, BC, Canada, May 1996

“Seminar on Environmentally Sound Forest Roads and Wood Transport” [organised together with the FAO/ECE/ILO Joint Committee on Forest Technology, Management and Training], at Sinaia, Romania, 17-22 June 1996.

Co-sponsored the 1996 annual meeting of the Council on Forest Engineering (COFE). Marquette, Michigan, USA. July 1996.

“Mechanisation and Workforce Research Methods”, coordinated by 3.07.00 and 3.07.05, at Garpenberg, Sweden, 18-23 Aug 1996.

“Harvesting, Wood Delivery and Utilization” co-organised with the Canadian Woodlands Forum of the Canadian Pulp and Paper Association a conference on “Certification: Environmental Implications for Forestry Operations” at Quebec City, Canada, 9-11 Sep 1996.

“Safety and Health in Forestry”, organised by the FAO/ILO/ECE Joint Committee, Hueningen, Switzerland, 5-12 Oct 1996.

Nursery Establishment Operations for Difficult Sites. Co-sponsored by 3.02.01 and 3.02.03. Himachal Pradesh, India, 6-12 Oct 1996.

1997

“Planning and Control of Forest Operations for Sustainable Forest Management” in Madrid and at the Valsain Forest in Spain, 16-19 June 1997.

“Natural Substances for Health and Beauty” held in Riga, Latvia, 19-21 June 1997.

“Effects of Timber Production and Harvesting on Product Quality”. With the Forest Products Society. Vancouver, BC, Canada, 22-26 June 1997.

“Simposio Internacional sobre Posibilidades de Manejo Forestal Sostenible en América Tropical”; interdivisional meeting organised jointly by Divisions 1 and 3 together with the BOLFOR Project and CIFOR, Santa Cruz, Bolivia, 15-20 July 1997.

“Sustainable Management of Small-Scale Forestry”. 3.08.00, 6.11.02 and co-sponsors, including Kyoto University, the Japanese Forest Economic Society, the City of Kyoto, Kyoto Prefectural Government, Shiga Prefectural Government, IUFRO-Japan, the Japanese National Afforestation Promotion Organisation, Japan Forestry Association, Japan Forest Technical Association, Forest Policy Research Institute, Japan Wood Products Information and Research Centre, and the European Forest Institute. Kyoto, Japan, from 8-13 Sep 1997.

“Forest Operations in Himalayan Forest, Consideration of Ergonomic and Socio-Economic Problems,” joint seminar 3.06.00, 3.07.00, and 3.11.00 in Thimpu, Bhutan, at 20-23 Oct 1997.

"Timber Harvesting and Forest Transportation" co-sponsored by the Federal University of Viçosa at Vitoria (Espirito Santo), Brazil, from 8-12 Dec 1997.

1998

"Human Factors in Forestry" with the Human Factors Group of Liro Limited at Rotorua, New Zealand, on 17 Feb 1998.
"Harvesting with Quality" joint seminar with the Federal University of Paraná at Curitiba, Brazil, 24-29 May 1998.
Division 3 Officers' Midterm Meeting, Zurich, Switzerland, 12-15 July 1998
"Integrating Environmental Values into Small-Scale Forestry" in Vancouver, B.C., Canada, from 16-20 Aug 1998.
"Third International Conference on Forest Vegetation Management", 3.11.00 and 3.11.03 in Canada 24-25 Aug 1998.
"International Conference on Indicators for Sustainable Forest Management" organised in cooperation with the IUFRO Sustainable Forest Management Task Force. Melbourne, Australia, 24-28 Aug 1998.
"Improving Working Conditions and Increasing Productivity in Forestry". Joint FAO/ECE/ILO Committee on Forest Technology, Management and Training. Zvolen, Slovakia, 9-12 Sep 1998.
"Forests and Forestry Research for the Third Millennium," Zvolen, Slovakia, 11-14 Oct 1998.
"Environmental Aspects in Forest Transportation Infrastructure" ad-hoc session on forest operations in the Division 8 conference "Environmental Forest Science". 3.04.00, 3.06.00. Kyoto, Japan, 19-23 Oct 1998

1999

"International Mountain Logging and 10th Pacific Northwest Skyline Symposium" co-sponsored by 3.06.00, 3.07.00, 3.10.00 and the Oregon State University Forest Engineering Department in Corvallis, Oregon, 28 Mar – 1 Apr 1999.
"Management Alternatives for Thinning Stands from Harvesting and Economical Points of View" was held in Ennis, Western Ireland, 5-7 May 1999.
"Timber Harvesting and Transportation Technologies for Forestry in the New Millennium" with Forest Engineering Southern Africa (FESA), Pietermaritzburg, South Africa, 10-11 June 1999.
Forestry Engineering for Tomorrow (with the Institute of Agricultural Engineers UK and the American Society of Agricultural Engineers), Edinburgh, Scotland, 28-30 June 1999
Forest Operations of the Future (with the Joint FAO/ECE/ILO Committee on Forest Technology, Management, and Training), Pessac, Bordeaux, France, 20-24 Sep 1999
"Interactions between nursery management and silvicultural operations" held 28-30 Sep 1999 at Auburn University, Alabama, USA
"Emerging Harvesting Issues and Technology at the End of the Century" 3.04.00, 3.06.00, 3.07.00, together with the University of Zagreb's Faculty of Forestry, the Croatian Forest Research Institute (Jastrebarsko), and "Hrvatske _ume" Inc. (Zagreb). Sponsored by the Ministry of Science and Technology, the Ministry of Agriculture and Forestry, the University of Zagreb, and the Academy of Forest Sciences in Opatija, Croatia, 27 Sep – 1 Oct 1999.

2000

"Developing policies to encourage small-scale forestry" (3.08.00 together with James Cook University), Cairns, Queensland, Australia, 9-13 Jan 2000.
"Logistics in the Forest Sector" (3.04.00, 3.06.00, 3.10.00 hosted by the University of Helsinki and the Industrial Insurance Company), Helsinki, Finland, 15-16 May 2000.
"New Approaches for the Management of Neotropical Primary Rainforests by Industries and Communities (1.00.00 and 3.00.00 together with EMBRAPA, CIFOR, CATIE, and CIRAD-Forêt), Belém, Pará, Brazil, 4-8 Dec 2000.
XXI World Congress
6-12 Aug 2000 Satellite meeting on "Forest Operations in the Tropics", 6 Aug
Research Group Sessions and Business Meetings organised by 3.02.00, 3.04.00, 3.05.00, 3.06.00, 3.07.00 (2 sessions), 3.08.00, 3.09.00, 3.10.00 (2 sessions), 3.11.00; Divisional Business Meeting (21 meetings)
Co-organised Subplenary Session A6, "Criteria and Indicators for Sustainable Forest Management: A Perspective at the Level of the Forest Management Unit", 7 Aug
Co-organised Subplenary Session C1, "Environmental Change and Forestry", 7 Aug
Co-organised Subplenary Session C2, "Societal Change and Forests", 8 Aug
Organised Subplenary Session B4, "Evaluation of Technologies for Society's Needs", 9 Aug
Co-organised Research Session TF3, "Criteria and Indicators: A Tropical Perspective at Stand Level", 12 Aug

Report by Dr. Klaus v. Gadow

Division 4 Coordinator
Inventory, Growth, Yield, Quantitative and Management Sciences

The Inter-Congress period was characterized by numerous meetings organised by different IUFRO units, including many interdivisional and inter-unit events. The official count of the total number of meetings, the number of meetings conducted in developing countries and meetings in countries with economies in transition is shown in table 1. The average number of meetings per Division IV unit for the 5-year inter-congress period is almost 3 (dividing 77 meetings by 26 IUFRO units) which means that on average each unit conducted a meeting every 1.7 years. There was also an increase of activities in developing countries and in countries with economies in transition.

Table 1. Division IV Meetings and Publications 1996 – 2000.

Year	Number of meetings			Number of Publications
	Total	in developing countries	in countries with economies in transition	
1996	18	5	2	8
1997	12	2	1	4
1998	11	1	0	1
1999	13	2	5	1
2000	8	2	0	8
XXI Congress	15			
Total	**77**	**12**	**8**	**22**

The very high level of activities imediately following the last World Congress is striking. Many people meet during the big events and this appears to spawn smaller professional ones. Division 4 officers made excellent contributions to the scientific program of the XXI World Congress in Kuala Lumpur and conducted important Business Meetings to elect new officers, to refresh and strengthen scientific networks and to plan future events.

Some Conference Highlights

1996

The Second international symposium on spatial accuracy assessment in Fort Collins, USA (Dr. H. Todd Mowrer)
The conference on Modelling regeneration success and early growth of forest stands in Copenhagen, Denmark (Dr. J.P. Skovsgaard)
The Monte Verita conference on Assessment of Biodiversity for Improved Forest Planning, October 1996, Ascona, Switzerland (Dr. Michael Köhl, Dr. Peter Bachmann and Dr Risto Päivinen)
The Non-market benefits of forestry conference in Edinburgh, Scotland (Dr. Hans A. Joebstl, Dr. Maurizio Merlo, Dr. C. Roper and Dr. A. Park).
The Conference on Effects of Environmental Factors on tree and stand growth in Dresden, Germany (Dr. G. Wenk)

1997

The conference on modelling growth of fast-grown tree species in Valdivia, Chile (Dr. Gonzalo Paredes)
The conference on Recent developments in accounting and managerial economics in Versailles, France (Dr. Hans A. Joebstl, Dr. Maurizio Merlo and Dr. G. Buttoud).

1998

The conference on Data management and modelling using remote sensing and GIS for tropical forest land inventory in Jakarta Indonesia (Dr. Keith Rennolls and Dr. Bapak Ir. Sumahadi)
The conference on Institutional Aspects of Managerial Economics and Accounting in Forestry in Ostia, Italy (Dr. Hans A. Joebstl, Dr. Maurizio Merlo, Dr. L. Venzi).

1999

The Remote sensing and forest monitoring conference in Rogow, Poland, organised by Dr. Tomasz Zawila-Niedzwiecki.
The Faustmann conference in Darmstadt, Germany organised by Dr. Sun Joseph Chang.
The conference on Long-term observations and experiments in forestry - focus on tropical forests in Turrialba, Costa Rica, organised by: Dr. Christoph Kleinn and Dr. Michael Köhl.
The Forest Scenario Modelling in Risk Analysis and Management conference in Joensuu, Finland, organised by Dr. Tuula Nuutinen.
The conference on Gaps and solutions in managerial economics and accounting in Forestry in Prague, Czech Republic organised by Dr. Hans A. Joebstl, Dr. Maurizio Merlo, Dr. L. Sizak.
The Forest Assets Valuation conference in Salzburg, Austria organised by Dr. Hans A. Joebstl, Dr. Maurizio Merlo

2000

The Forest Ecosystem Restoration conference in Vienna, Austria; organised by Dr. Hubert Hasenauer
The Information management conference in Munich, Germany; organised by Dr. Hans A. Joebstl, Dr. Maurizio Merlo and Dr. Martin Moog

FRA 2000 and GFIS

During the period 1996 until 2000 Risto Päivinen, Michael Köhl and Gyde Lund compiled various reports and background documents prepared for international expert panels covering remote sensing support for the global forest resource assessment (FRA 2000), estimating global forest change, and cooperation to implement FRA 2000. They represented IUFRO at 5 expert meetings and helped to organise 3 events in connection with FRA 2000.

Awards

For their contribution to IUFRO, which has substantially furthered the aims of the Union, Dr. Hans Jöbstl, Dr. Maurizio Merlo and Dr. Risto Päivinen each received the Distinguished Service Award.

Outstanding Doctoral Thesis Awards were presented to Dr. GangYing Hui from Beijing, China, and to Dr. Jens Peter Skovsgaard from Hoersholm, Denmark.

Publication Highlights

Köhl, M., P. Bachmann, P. Brassel, G. Preto (eds.), 1996: The Monte Verità Conference on Forest Survey Designs. "Simplicity versus Efficiency" and Assessment of Non-Timber Ressources, Birmensdorf, Swiss Federal Institute of Forest, Snow and Landscape Research (WSL/ FNP), Zurich, Swiss Federal Institute of Technology (ETH). 316 p.

Köhl, M., G.Z. Gertner (eds.), 1996: Statistical Methods, Mathematics and Computers, Poceedings of the Meeting of Section S4.11 held at IUFRO World Congress Tampere, Finland, August 1995, Swiss Federal Institute for Forest, Snow and Landscape Research, Birmensdorf, Switzerland

Imaña J, C Kleinn (eds). 1997: Proceedings of the Symposium on Assessment and Monitoring of Forests in Tropical Dry Regions. Nov. 4-8, 1996, Brasilia. 378 p.

Bachmann, P., M. Köhl, R. Päivinnen (eds.), 1998: Assessment of Biodiversity for Improved Forest Planning, Kluwer Academic Publishers, Dordrecht, 421 p.

Lund, H. Gyde (ed). 1998. IUFRO Guidelines for Designing Multipurpose Resource Inventories.

Päivinen, R., Iremonger, S., Kapos, V., Landis, E., Mills, R., Petrokofsky, G., Richards, T. and Schuck, A. 1998. Better access to information on forests. Report prepared for International Consultation on Research and Information Systems in Forestry, 7-10 September 1998, Ort/Gmunden, Austria: 19 p.

Buttoud G., Jöbstl H. and Merlo M. (eds.) (1998): Accounting and Managerial Economics for an Environmentally-Friendly Forestry. Proceedings, IUFRO-INRA Symosium, Nancy/France, April 21-23, 1997. Actes et Communications No. 15, INRA-Editions. Versailles 1998, 384 p.

Roper C.S. and A. Park (eds.) 1999: The Living Forest - Non-Market Benefits of Forestry. Proceedings, International Symposium on the Non-market Benefits of Forests, Edinburgh/Scotland, June 24-28, 1996. The Stationery Office, London 1999, 415 p.

Jöbstl H., Merlo M. and Moog M. (eds.) (2000): Information Management in Forest Enterprises. Proceedings (http://www.forst.tu-muenchen.de/EXT/LST/WIRTS/iufro/Papers.pdf), IUFRO-Symposium, Freising/Germany, April 6-8, 2000. Munich 2000, 128 p.

Jöbstl H., Merlo M. and Venzi L. (eds.) (2000): Institutional Aspects of Managerial Economics and Accounting in Forestry. Proceedings, IUFRO-Symposium Ostia/Italy, April 15-18, 1998. Viterbo 2000, 558 p.

Jöbstl H., Merlo M. und Sisak L. (eds.) (2000): From Theory to Practice - Gaps and Solutions in Managerial Economics and Accounting in Forestry. Proceedings, IUFRO-Symposium Prague/Czech Republic, May 13-15, 1999. Prague 2000, 260 p.

Zawila-Niedzwiecki, T. ed. 2000: Remote sensing and forest monitoring. Proc. Warsaw, Poland. Institute of Geodesy and Cartography. 101 p.

Jöbstl H. (ed.) (2000): Waldvermögensbewertung - Forstliche Erfolgsrechnung. Forest Asset Valuation – Forestry Performance Accounting. Proceedings, IUFRO-Workshop Salzburg/Austria, June 11-12, 1999. Vienna 2000, 178 p.

IUFRO 4.02, 4.11, 4.12 Newsletters - published in April and October each year since 1995.

Report by Mr. John A. Youngquist

IUFRO Division 5 Coordinator
Forest Products

The five-year time span from 1996 to 2000 has produced even more evidence that forests are being squeezed between the growing needs of people and a shrinking resource base. The pressure being placed on the resource also pushes technological developments to help divert those pressures. The trend to more efficiently use resources has accelerated to meet today's challenges. Key areas for utilisation research and development for Division 5 have included learning how to use the changing resource of materials in the forest, extending the resource, and implementing environmentally and socially friendly technologies wherever possible. IUFRO's Division 5 on Forest Products, which consists of 12 Research Groups and 25 Working Parties, has held a total of 51 topic specific research meetings during this 5 year time span, with 6 of them held in developing countries, and 2 of them held in countries with economies in transition. A total of 10 publications resulted from these meetings. The All-Division 5 Conference, held in mid-1997, focused on Forests Products for Sustainable Forestry, and was attended by 222 delegates from 42 countries. Discussions were held on research progress, research needs and concerns to improve 'agreements were developed to further collaborative action to carry forward key ideas and themes which were identified at the meeting. The XXI IUFRO World Congress carried 'meetings held between 1995 and 2000. A total of 97 oral papers and 271 posters were presented, and plans for collaborative research team efforts for developing leading-edge technological developments were put in place. Specific challenges that were highlighted at the Congress included: 1) determining efficient and environmentally friendly ways to extract, reduce, and convert virgin raw materials to products, 2) developing technologies to allow the re-use of materials and products, and 3) insuring that new technologies are transferred to users as quickly as possible.

Report by Dr. Niels Elers Koch

Division 6 Coordinator
Social, Economic, Information and Policy Sciences

Challenges to IUFRO Division VI for the Period 1996-2000

1) Social, economic, information and policy sciences from Division VI should be involved and integrated with the natural and technological sciences' activities in the other Divisions of IUFRO.
2) Criteria and indicators of socio-economic sustainability should be of major focus in our work in accordance with the different international resolutions on forestry.
3) Countries in transition should be better integrated in Division VI membership and programming.
4) Developing countries should be better integrated in Division VI, and we should help them obtain funding so that they can participate more fully in the work of IUFRO.
5) The new information technologies (e-mail, WWW, etc.) will be used to improve information exchange, and Division VI will play a leading role in that adventure, being responsible for information sciences (Research Group 6.03).
6) Division VI, also being responsible for nature conservation (Research Group 6.01), will work to emphasise nature conservation so that IUFRO plays an important role in the scientific work forming the basis for nature conservation.

Changes in Leadership and Organisation
Changes in Leadership

D6.00-00: Coordinator Niels Elers Koch, Danish Forest and Landscape Research Institute, has replaced Harold F. Kaiser, USA.
Deputy coordinators Max Krott, Institut für Forstpolitik und Naturschutz, Universität Göttingen, and Perry Brown, School of Forestry, University of Montana, have replaced Egon Gundermann, Germany, Niels Elers Koch, Denmark, and George Stankey, USA.
For more detailed information on changes in the leadership of the Research Groups and Working Parties, please see the Annual Reports.

Changes in Organisation
New Research Groups:

S6.15-00 New Research Group "Improving Education and Further Education in Forestry".
S6.16-00 New Research Group "Forest Sector Analysis".
S6.17-00 New Research Group "Ecological Economics in Forestry".
S6.18-00 New Research Group "Gender in Forestry".
S6.19-00 New Research Group "Ethnoforestry".

New Working Parties:

S6.03-01 New Working Party "Libraries and Information Services".
S6.03-02 New Working Party "Trends in Forest Terminology".
S6.03-03 New Working Party "Forest Decimal Classification".
S6.03-04 New Working Party "Latin American and Caribbean Information Systems Network".
S6.07-02 New Working Party "Social end Economic History".
S6.07-05 New Working Party "History of Hunting".
S6.11-06 New Working Party "Economic and Social Aspects of Forestry in Countries in Transition".
S6.11-07 New Working Party "Integration of Sociological Research with Forest Management".

Main Activities 1996-2000

All 11 Research Groups have been active during the period. Based on information from IUFRO´s www-server and information from the different Research Groups and Working Parties, a total of 71 meetings were held (including 6 meetings in developing countries and 7 meetings in countries with economies in transition) resulting in more than 17 publications. For more detailed information please see the Annual Reports.

The first ever all-Division VI conference was held in Pretoria and North-eastern South Africa from January 7-15, 1999. The conference focused on the timely topic of the contributions of science to the development of forest policies. Approximately 80 delegates from 19 countries attended with a particularly engaging group of delegates from eight African countries. In addition to the keynote, case study, and plenary presentations numerous research presentation and round table discussion sessions were held. These sessions offered the opportunity for researchers to present their work on the topic and for them to share ideas about research needs, research approaches, and policy developments.

During the period, a strong effort has been made to achieve a comprehensive presentation on the IUFRO net of the Division's units, their mandate and activities. Most Research Groups and Working Parties are now present.

Report by Dr. David F. Karnosky

Division 7 Coordinator
Forest Health

Division 7 was created in 1996 with four Research Groups: 7.01.00 (Physiology and Genetics of Tree/Phytophage Interactions), 7.02.00 (Pathology), 7.03.00 (Entomology), and 7.04.00 (Impacts of Air Pollution on Forest Ecosystems). The leadership of Division 7 included David Karnosky (Coordinator) and Deputy Coordinator Kazuo Suzuki (Japan), Bo Langstrom (Sweden), and Manfred Tesche (Germany). Within the Division there are a total of 31 Working Parties. These Working Parties held a total of 41 meetings in the past 5 years and produced some 12 major published proceedings.

Among the most significant activities of the past 5 years were the following events:

1. An All-Division 7 meeting entitled "Symposium on Sustainability of Pine Forests in Relation to Pine Wilt and Decline" was held in Tokyo, Japan, in 1998. The meeting included an open symposium for the lay public, a two-day scientific session, and a field trip to see the pine wilt problem. All through the meeting, the press and other media people were invited to attend and the meeting received a great deal of attention in the Japanese press. A major scientific proceeding resulted from the meeting.

2. The Research Group 7.04.00 continued to be very productive and active with major meetings including the 17th, 18th and 19th meetings of the "Specialists in Air Pollution Effects on Forest Ecosystems" were held in Florence, Italy (1996), Edinburgh, Scotland (1998) and Houghton, Michigan (2000). These meetings averaged over 150 participants and resulted in special issues in Chemosphere, Journal of Water, Air and Soil Pollution, and Environmental Pollution as three bound books. Kevin Percy (Canada), as well, has led the 7.04.00 Research Group.

3. Research Group 7.01.00, led by William Mattson (USA), held major conferences in France (Physiology and Genetics of Phytophage Interactions) and Hungary (Biology of Gall Inducing Arthropods) in 1997. Both conferences resulted in major proceedings. In addition, this Research Group convened in Brazil and Malaysia in 2000.

4. Research Group 7.02.00 and 7.03.00, led by Christian Tomiczek and Rene Alfaro, remained very active in our division, convening some 15 Working Parties and joint multiple Working Party meetings in the past 5 years. Among the most important publications from the Research Group was the "World Directory of Forest Pathologists and Entomologists", which was organised by D.D. Skilling and H.O. Batzer.

Report by Dr. Kyoji Sassa

Division 8 Coordinator
Forest Environment

It was decided to establish Division 8 at the Tampere Congress in 1995 and the new Division started its activities in 1996. The Coordinators (Kyoji Sassa, Kamis Awang, Timothy Boyle, Alain Franc) discussed the management of this new Division. It was decided to organise an all-Division Congress in order to understand the present structure and content of research and to consider what Division 8 should be like at the beginning of the 21st century. At first, Division 8 decided to organise its first all-Division meeting on "Forest Environment in a Changing World" in Yogyakarta, Indonesia, under the leadership of Dr. Timothy Boyle of the Center for International Forestry Research (CIFOR) in August 11-15, 1997. However, due to the surprisingly small number of registrations, these plans were dismissed.

1. All-Division 8 Conference on "Environmental Forest Science"

Then, a second attempt was made to organise it from 19 to 23 October, in Kyoto, Japan. The Coordinator applied successfully for a grant from the Japanese Ministry of Education, Science, Culture and Sports to organise the IUFRO Division 8 Conference on "Environmental Forest Science". The conference was very successfully organised. It aimed at integrating all fields of forest science and other related sciences dealing with the environment into an Environmental Forest Science and searched for promising research fields and topics in the 21st century. The number of participants was 139, including 61 foreign participants from 29 countries. The conference and the one-week field trip were very successful. The extended abstracts volume with the conference programme (262 pages) was published, and the full text volume (658 pages) was published by Kluwer Academic Publisher as "Environmental Forest Science", Forest Science Series, Volume 54 (ISBN 0-7923-5280-7). It is available from Kluwer Academic Publisher (Tel: +31-78-639-2392, Fax:+31-78-639-2254, E-mail: services@wkap.nl) and turned out to be a well sold book for Kluwer.

2. 1998 IUFRO Kyoto Appeal "Environmental Forest Science for Sustainable Development"

As a result of the panel discussion, participants, including IUFRO Vice President Risto Seppälä, Heinz Schmutzenhofer, Lisa Sennerby-Forsse, and representatives from UNESCO, FAO and the Science Council of Japan, concluded to release an appeal for cooperation and funding to related parties in the world: the ENVIRONMENTAL FOREST SCIENCE FOR SUSTAINABLE DEVELOPMENT - Appeal from the 1998 IUFRO Kyoto Conference. This appeal can be the basis for a new development of Environmental Forest Science and may attract the interest of related funding agencies. The text of the appeal was published in IUFRO News Vol. 28/issue 2, in 1999 and also in the IUFRO Annual Report 1998.

3.Cooperation with UNESCO on Landslide Research and Forest Hydrology

Division 8 cooperated with UNESCO in the organisation of the Kyoto Conference in 1998. At the same time, the landslide Research Group (8.04.03) was invited to apply for a UNESCO and IUGS (International Union of Geological Sciences) joint project: "International Geological Cooperation Programme (IGCP)" and IGCP-425 "Landslide Hazard Assessment at Cultural Heritage Sites and Other Locations of High Societal Value". The project group organised a symposium in Tokyo, 1998, a conference at UNESCO Headquarters in 1999 with support from D8; a UNESCO/DPRI-Kyoto University research cooperation agreement was exchanged at the end of 1999 based on IGCP-425.

The forest hydrology Research Group (8.03.02) organised a symposium on "Forests – Water – People in the Humid Tropics: Past, Present and Future Hydrological Research for Integrated Land and Water Management" as a satellite meeting of XXI IUFRO World Congress in cooperation with the UNESCO Project "International Hydrological Programme (IHP). Director-General Koichiro Matsuura of UNESCO attended the symposium and addressed the participants in the closing session.

4. Organisation of Division 8 Sessions in XXI IUFRO World Congress

During the Congress, Division 8 organised 2 Sub-Plenary sessions (A1: Water and Forests / 8.03 Forest Hydrology, and A2: Fire and Forests / 8.05 Forest Fire Research), 18 Group Sessions, 1 Panel Discussion, 5 Satellite Meetings (evenings), and a one-week Satellite Conference & Workshop before the Congress. There were 85 oral presentations and 118 poster presentations. A Division 8 Panel Discussion on "Environmental Forest Science and Division 8 in the 21st Century" and a Division 8 Business Meeting on "Review and Perspective of Research Group" were organised. As the result of discussions in these two Division 8 Plenary sessions, two new Working Parties were set up; two Working Parties were decided to be terminated; and it was decided to change the names and research aims of one Research Group and four Working Parties.

5.Organisation of the Interdivisional Meeting on "Forest Ecosystems and Land Use in the Mountain Areas"

This meeting was organised by Prof. Don Lee on 12-17 October, 1998, in cooperation with other Divisions.

IUFRO Officers 2001 - 2005

The IUFRO Officers for the period 2001 – 2005 as listed were approved by the International Council on proposal of the Executive Board at the General Assembly of IUFRO at the XXI Congress in Kuala Lumpur, Malaysia, August 8, 2000.

Board Members

President	Risto Seppala	Finland
Vice President	Eric Teissier du Cros	France
Vice President	Don Koo Lee	Korea

Division Coordinators

1	John Parrotta	US
2	Ladislav Paule	Slovakia
3	Dennis Dykstra	US
4	Klaus von Gadow	Germany
5	Cathy Wang	China – Taipei
6	Niels Elers Koch	Denmark
7	Kazuo Suzuki	Japan
8	Alain Franc	France

Members from Regions - General Members (according to new Statutes Valid in 2001)

		Region
Susan Conard	US	5
Ruben Guevara	Honduras/ Peru	6
Vitor Afonso Hoeflich	Brazil	6
John Innes	UK/Canada	1
Iba Kone	Kenya	7
Gordon Miller	Canada	5
Abdul Razak	Malaysia	9
Victor Teplyakov	Russia	3
Karel Vancura	Czech Republic	2
Yaoguo Xiong	China	8

Ex officio Board Members

Jeffery Burley, Immediate Past President	UK
Heinrich Schmutzenhofer, Executive Secretary	Austria
Mario Broggi, Treasurer	Switzerland
Russell Haines, COC Chair	Australia

Observers

FAO-representative – Hosny El Lakany

Members of the Enlarged Board

Division Deputy Coordinators

D1	Jerry Vanclay	Australia
	Björn Hånell	Sweden
	Florencia Montagnini	Argentina/ Costa Rica
D2	Csaba Matyas	Hungary
	Robert Luxmoore	US
	Zohra Bennadji	Uruguay
D3	Hans Heinimann	Switzerland
	Amaury De Souza	Brazil
	Mike Menzies	New Zealand
D4	Lauri Valsta	Finland
	Steen Magnussen	Canada
	Margarida Tomé	Portugal
D5	Howard Rosen	US
	Mahabala Bhat	India
	Paul Fung	Australia
D6	Perry Brown	US
	Susanna Benedetti	Chile
	Lucrecio Rebugio	Philippines
D7	Kevin Percy	Canada
	Jean-Claude Gregoire	Belgium
	David Karnosky	US
D8	Rahim Nik	Malaysia
	Albert Goettle	Germany
	James Boyle	US

The Coordinator of the Special Programme for Developing Countries

Position vacant

The Coordinators of Projects

Terminology Project SilvaVoc, Renate Prueller, Austria
Global Forest Information Service, (vacant)

The Coordinators of Task Forces

Environmental Change, John Innes, UK/ Canada
Forests in Sustainable Mountain Development, Martin Grosjean, Switzerland
Management and Conservation of Forest Gene Resources, Per Ståhl, Sweden
Water and Forests,. Rob Vertessy, Australia
Task Force on Science/Policy Interface, Richard Guldin, USA
Task Force on Public Relations in Forest Science, Max Krott, Germany

Congress Organisers

LIST OF IUFRO 2000 COMMITTEES

I. CONGRESS STEERING COMMITTEE

	Name	Agency	Category
1.	Abdul Razak Mohd. Ali	Forest Research Institute Malaysia	Chairman
2.	Aziah Mohd. Yusoff	Forest Research Institute Malaysia	Secretary
3.	Abdul Rahim Ismail	Immigration Department Malaysia	Member
4.	Abdul Rahim Nik	Forest Research Institute Malaysia	Member
5.	Abdul Razak b. Yaacob	Royal Customs & Excise Department Malaysia	Member
6.	Azmi Zainuddin	Ministry of Foreign Affairs Malaysia	Member
7.	Chew Yee Seng	Prime Minister's Department Malaysia	Member
8.	Habibah Hj. Abdul Manaf	Royal Malaysian Police	Member
9.	Haron b. Hj. Abu Hassan	Institute of Foresters Malaysia	Member
10.	Herman Anjin	Forestry Department Sabah	Member
11.	Lee Hua Seng	Forestry Department Sarawak	Member
12.	Micheal Rajoo	Malaysian Timber Council	Member
13.	Nik Adnan Nik Abdullah	Ministry of Primary Industries Malaysia	Member
14.	Mohd Rusli	University Putra Malaysia	Member
15.	Shaharuddin b. Mohammad Ismail	Forestry Department Peninsular Malaysia	Member
16.	S. Rajan	Malaysian Timber Industry Board	Member
17.	Wong Kam Wai	Malaysian Furniture Industry Council	Member
18.	Zailin Alwee	Malaysia Tourism Promotion Board	Member

II. CONGRESS ORGANIZING COMMITTEE (COC)

	Name	Category
1.	Abdul Rahim Nik	Chairman
2.	Salleh Mohd. Nor	Advisor
3.	Wan Razali Wan Mohd.	Advisor
4.	Mohd. Zamshari Abdul Rahman	Treasurer
5.	Lim Hin Fui	Secretary
6.	Azizol Abd. Kadir	Chairperson Exhibitions
7.	Abdul Rashid Ab. Malek	Chairperson Logistics & Security
8.	Baskaran K.	Chairperson Scientific Prog. & Poster
9.	Hoi Why Kong	Chairperson Finance
10.	Marzalina Mansor	Chairperson APP
11.	Mohd. Dahlan Jantan	Chairperson Post-Congress Excursion
12.	Lee Su See	Chairperson SAP
13.	Shamsudin Ibrahim	Chairperson In-Congress Tour
14.	Wan Rahmah Wan A. Raof	Chairperson PR & Publicity
15.	Lucy Chong	Member
16.	Kamis Awang	Member
17.	Mohd. Hamami Sahri	Member
18.	Sining Unchi	Member
19.	Wan Yusoff Wan Ahmad	Member
20.	Yahaya Mahmood	Member

III. CONGRESS SECRETARIAT

	Name	Category
1.	Abdul Rahim Nik	Chairperson
2.	Lim Hin Fui	Secretary
3.	Abu Zahrim Ismail	Member
4.	Aziah Mohd. Yusoff	Member
5.	Mohd. Azhan Shah Idris	Member
6.	Muhammad Farid Abdul Rashid	Member
7.	Wong Wai Kin	Member
8.	Zahari Othman	Member

ASSISTING CONGRESS ORGANISERS

	Name	Company
1.	Ahmad Kamil Abdullah Sani	Warisan Advertising Sdn. Bhd.
2.	Anthony Wong	Asian Overlands Services Tours & Travel Sdn. Bhd.
3.	Yap Shook Fung	Congrex (M) Sdn. Bhd.
4.	Steven Thong	Reeds Exhibitions Sdn. Bhd.

SUB- COMMITTEES OF COC

1. Scientific Programme and Posters (SPP)

1. Baskaran Krisnapillay (Chairperson)
2. Andrew Wong Han Hoy (Secretary)
3. Fadillah Zainuddin
4. E. Seopadmo
5. Ho Wai Mun
6. Hong Lay Thong
7. Khoo Kean Choon
8. N. Manokaran
9. Nor Rifiza Mat Riffin
10. Najib Lotfy
11. S. Appanah
12. Wong Lay Yiang

2. Scientist Assistance Programme (SAP)

1. Lee Su See (Chairperson)
2. Maziah Zakaria (Secretary)
3. Elizabeth a/p M. P. Phillip
4. Musni A. Mois
5. Chang Yu Syhun
6. Nor Azah Mohd Ali
7. Khozirah Shaari
8. Shahira Ishak
9. Woon Weng Chuen

3. Accompanying Persons Programme (APP)

1. Marzalina Mansor (Chairperson)
2. Siti Aisah Shamsuddin (Secretary)
3. Ruziah Ripin
4. Nor Azlin Yahya
5. Noorsiha Ayop
6. Nashatul Zaimah Noor Azman
7. Tsan Fui Ying
8. Roslan Othman

4. In-Congress Tours

1. Shamsudin Ibrahim (Chairperson)
2. Ismail Parlan (Secretary)
3. Ang Lai Hoe
4. Azman Hassan
5. Ho Kam Seng
6. Ismail Harun
7. Mohd. Zaki Abdullah
8. Rosdi Koter
9. Raja Barizan Raja Sulaiman
10. Safiah @ Yusmah Muhammad Yusof
11. Yahaya Mahmood
12. Laurence Kirton

5. Post-Congress Excursions

1. Mohd. Dahlan Jantan (Chairperson)
2. Mohd. Noor Mahat (Secretary)
3. Aminah Hamzah
4. Abdul Rasip Abd. Ghani
5. Abdul Hamid Salleh
6. Ahmad Azaruddin Mohd Noor
7. Hamdan Husain
8. Khali Aziz
9. Lok Eng Hai
10. Mohd. Farid Ahmad
11. Muhd. Shukari Midon
12. Mohd. Jaafar Shaari
13. Ong Tai Hock
14. Rosdi Koter
15. Saini Vermeulen
16. Yahaya Mahmood

6. Finance

1. Hoi Why Kong (Chairperson)
2. Rozaida Latip (Secretary)
3. Koh Mok Poh
4. Lillian Chua
5. Mohd. Nor Mohd Yusoff
6. Puad Ilham
7. Suffian Misran
8. Sharmiza Adnan
9. Shaharuddin Hashim
10. Zaiton Said

7. Exhibition

1. Azizol Abd. Kadir (Chairperson)
2. Mahmudin Saleh (Secretary)
3. Ahmad Fauzi Mohd Shariff
4. Mohd. Shahidan Mohd. Arshad
5. Mohd. Rizal Mohd. Kassim
6. Mohd. Radzi Ahmad
7. Mohd. Azlan Nafiah
8. Roszaini Abdul Kadir
9. Salbiah Man
10. Wan Rasidah Wan Abd. Kadir
11. Wan Asma Ibrahim

8. Logistics & Security

1. Abdul Rashid Abdul Malik (Chairperson)
2. Sim Heok Choh
3. Arshad Hj. Omar
4. Asmar Hj. Hassan
5. Mohd. Rasol Abd. Manaf
6. Maizurah Ishak
7. Mohd. Afendi Husin
8. Mohd. Zain Salim
9. Mohd Aziri Che Wil
10. Nurul Hilal Hj. Ahmad Tarmidzi
11. Norwati Mohamed
12. Norhara Hussein
13. Norini Haron
14. Nasir Dayat
15. Salamah Selamat
16. Salamah Alias
17. Sadali Sahat
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19. Yusoff Long
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